Abstract

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The purpose of this study was to investigate the nature of the relationship between middle school science learners' conditions and their developing understandings of climate change. I applied the anthropological theoretical perspective of figured worlds (Holland, Lachicotte, Skinner, & Cain, 1998) to examine learners' views of themselves and their capacities to act in relation to climate change. My overarching research question was: How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded? I used a descriptive single-case study design to examine the climate change ideas of eight purposefully selected 6th grade science learners. Data sources included: classroom observations, curriculum documents, interviews, focus groups, and written assessments and artifacts, including learners' self-generated drawings. I identified six analytic lenses with which to explore the data. Insights from the application of these analytic lenses provided information about the elements of participants' *climate change stories*, which I reported through the use of a storytelling heuristic. I then synthesized elements of participants' collective climate

change story, which provided an “entrance” (Kitchell, Hannan, & Kempton, 2000, p. 96) into their figured world of climate change.

Aspects of learners’ conditions—such as their worlds of school, technology and media use, and family—appeared to shape their figured world of climate change. Within their figured world of climate change, learners saw themselves—individually and as members of groups—as inhabiting a variety of *climate change identities*, some of which were in conflict with each other. I posited that learners’ enactment of these identities – or the ways in which they expressed their *climate change agency* – had the potential to reshape or reinforce their conditions. Thus, learners’ figured worlds of climate change might be considered “spaces of authoring” (Holland et al., 1998, p. 45) with potential for inciting social and environmental change. The nature of such change would hinge on the extent to which these nascent climate change identities become salient for these early adolescent learners through their continued climate change learning experiences. Implications for policy, curriculum and instruction, and science education research related to climate change education are presented.

A FIGURED WORLDS PERSPECTIVE ON MIDDLE SCHOOL LEARNERS' CLIMATE LITERACY DEVELOPMENT

By

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Chapter One: Problem Statement

Global climate change is “a defining challenge of our time” (United Nations, 2014, para. 4). The Intergovernmental Panel on Climate Change (IPCC) (2014) states that limiting the risk of “severe, widespread, and irreversible” (p. 17) global impacts of climate change by the end of the 21st century will require “substantial and sustained” (p. 8) mitigation and adaptation efforts. Thus, rather than asking whether Earth’s climate is changing, some scientists are now framing the question at hand as: “Can society manage unavoidable changes and avoid unmanageable changes?” (U.S. Global Change Research Program (USGCRP), 2014, p. 62).

In the midst of such complex questions, the public is increasingly likely to be asked to make decisions about scientific and technological issues with potentially serious ramifications (Hodson, 2003). Emerging climate literacy efforts in science education have the potential to help address this concern. The Next Generation Science Standards (NGSS Lead States, 2013), the first set of U.S. national science standards to explicitly include the topic of climate change, have drawn attention to the inclusion of climate change education in school science across the United States. In addition, the U.S. Global Change Research Program’s (2009) Climate Literacy Framework provides guidance to educators for cultivating learners’ abilities to assess scientifically credible information and communicate meaningfully about climate change, as well as to make informed, responsible decisions about actions potentially affecting climate.

With the growing attention to climate literacy in the science education community, science education researchers have become increasingly interested in examining science learners’ thinking related to climate change. A number of studies have explored how learners conceptualize phenomena related to climate change, including the greenhouse effect (e.g., Andersson & Wallin, 2000), global warming (e.g., Shepardson, Niyogi, Choi, & Charusombat, 2009), and carbon cycling (e.g., Mohan, Chen, & Anderson, 2009). Others have inquired about learners' beliefs regarding whether climate change is occurring (e.g., Leiserowitz, Smith, & Marlon, 2011), their attitudes related to the issue (e.g., Dijkstra & Goedhart, 2012), and their ideas regarding what should be done by whom (e.g., Lester, Ma, Lee, & Lambert, 2006; Sternäng & Lundholm, 2011). This body of research provides evidence of some common areas of confusion for learners regarding climate change. It also suggests much variability in learners' perspectives on the topic. Observing the variability in *what* learners think about climate change raises questions around *how* and *why* learners come to understand climate change in the ways that they do, and further, how (or whether) climate change *comes to matter* (Callison, 2014) to learners.

If an implicit goal of climate literacy efforts in science education is to enable learners to use scientific understandings to make real-world decisions, it may be important to consider a point raised by Feinstein (2015). He stated:

> We often express the desire for students, and for citizens, to think like scientists, but fail to consider that they are also, and already, thinking and acting as citizens, consumers, and members of various cultural groups. As we consider prior knowledge, we must also learn to think about prior mindset, and if we wish students to bring scientific practices to bear on their interpretation of science news… we should think carefully about the other sorts of practices that are already at work (p. 151).

In the case of climate change, an issue perceived and discussed quite variably across communities, cultures, and social groups, particularly in the United States (Leiserowitz, Maibach, Roser-Renouf, Feinberg, & Howe, 2013), socially and culturally formed mindsets may have important implications for how people learn about and relate to (or, identify with) climate change, as well as the extent to which their decisions and actions (or, agency) regarding climate change are ultimately motivated by scientific understandings. Questions around the ways in which the varied contexts in which learners are embedded may relate to their climate change perspectives, identities, and senses of agency prompted this study.

Statement of the Problem

The problem that I sought to address in this study is that while climate change education researchers have provided valuable insights into *what* learners understand about climate change, they have rarely explicitly examined *how* or *why* learners come to understand climate change in the ways that they do. In order to advance climate change education research and practice, there is a need for greater insight into the potential roles of learners' contexts—or conditions—in shaping their understandings of climate change, and conversely, into the potential implications of learners' climate change understandings for shaping their conditions. Secondary (teenage) science learners in the U.S. have expressed greater levels of uncertainty about their climate change understandings than adults (Leiserowitz et al., 2011), and may be particularly open to having their perspectives influenced by the diverse social and cultural worlds with which they interact. Therefore, this study examined the role of conditions in shaping learners' ideas about climate change, and ultimately, the potential role of learners' ideas in *re*-shaping their conditions—with the goal of providing insight into the processes by which learners develop and enact climate literacy.

Evidence from the realms of formal science education (e.g., Hansen, 2010; Herman, 2015), informal science education (e.g., Devine-Wright, Devine-Wright, & Fleming, 2004), climate change communication (e.g., Leiserowitz, Feinberg, Howe, & Rosenthal, 2013), and anthropology (e.g., Crate & Nuttall, 2009) all suggest that the social and cultural contexts in which people are embedded may play important roles in shaping their perspectives on climate change. For example, as is evident in the United States, discussions around climate change may vary across the cultural worlds of professional science, politics and media, and school science.

People's experiences of climate change may also vary with place (USGCRP, 2014). Thinking about place in Gruenewald's (2003) terms—as encompassing perceptual, sociological, ideological, political, and ecological realms—can provide a helpful way of imagining the importance of place in people's sense-making around climate change. People's experiences with physical climate change consequences (e.g., heat waves, ice melt, droughts) vary with place in the ecological sense. The meanings they make of these experiences may also vary with place in the perceptual sense. As an illustration, Howe and Leiserowitz (2013) examined U.S. adults' perceptions of the heat wave of summer 2010. They found that participants who already *believed in* climate change—possibly connected with place in the political and ideological sense—were more likely to perceive summer 2010 as hotter than normal. Conversely, those who did not believe in climate change were less likely to perceive summer 2010 as hotter than normal. Examples like these suggest the complex interactions of sociocultural forces that may shape people's perspectives on climate change.

Like adults, middle school learners are embedded in a variety of worlds, or places, or contexts, which may have the potential to shape how they come to understand climate change. These may include, among others, the contexts of media consumption and political discourse; of school and school science; of lived experiences in geographic regions affected by climate change in place-specific ways; of social relationships with family and peers; and of broader narratives around environment, science, and technology pervading American culture. If a goal of science education, including the standards related to climate change in the Next Generation Science Standards, is to foster learners' understanding of climate change from a scientifically-informed perspective in order to prompt scientifically-informed decision-making in the real world, there is value in examining how learners' diverse contexts shape their thinking about climate change. This may shed light on how learners' socioculturally-mediated understandings of climate change might align or conflict with scientific understandings, and may help to shape climate change education approaches with the potential to foster climate literacy.

Purpose

The purpose of this study was to investigate and report on the nature of the relationship between middle school science learners' conditions—or, their multifaceted contexts within and beyond the world of school—and their developing understandings of climate change. In applying the anthropological theoretical construct of figured worlds (Holland, Lachicotte, Skinner, & Cain, 1998) to investigate climate change learning, I posed the overarching question: How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded? I used qualitative case study methods to examine middle school learners' perspectives on climate change—including their developing perceptions, knowledge, values, and responses (Roncoli, Crane, & Orlove, 2009) related to climate change. I sought to describe the ways in which learners' interactions within the conditions in which they were embedded appeared to shape their perspectives on climate change. I examined how learners understood climate change as relevant to their own lives, and finally, how their responses to climate change had the potential to shape—by reinforcing or changing—the conditions in which they were embedded.

I collected multiple sources of empirical data to form insights regarding how learners come to understand climate change through learning experiences within and beyond the world of school. Data sources included: classroom observations, curriculum documents; focus group interviews with learners; individual interviews with learners, parents, and the 6th grade science teacher; and written assessments and artifacts, including learners' self-generated drawings related to climate change. I examined these qualitative data sources using the lens of figured worlds, central to which were notions of learners' developing identities and senses of agency in relation to climate change. In analyzing the collected data, I sought converging lines of evidence that provided insights with the potential to inform science education research and practice related to the teaching and learning of climate change.

Theoretical Perspective

In seeking insight into the relationship between middle school learners' understandings of climate change and the varied contexts in which learners were embedded, I held the perspective that learning is a socially and culturally mediated endeavor. Therefore, I used an application of sociocultural learning theory to guide my study. In this view, learners' interactions (e.g., with people, with cultural objects) in social environments are central to fostering meaning-making (Vygotsky, 1978). Further, I was particularly interested in examining learning about climate change through an anthropological lens, focusing on "the nexus of relations between the mind at work and the world in which it works" (Lave, 1988, p. 1). Toward this end, I adopted the theoretical perspective of figured worlds.

Anthropologists Holland, Lachicotte, Skinner, and Cain (1998) defined figured worlds as "historically contingent, socially enacted, and culturally constructed worlds" (p. 7), or "socially and culturally constructed realm[s] of interpretation" (p. 52). They described, for example, academia as a kind of figured world. In the world of academia, people adopt certain kinds of discourses, take on certain roles and social positions (e.g., professors, graduate students), and engage in certain kinds of tasks (e.g., teaching, writing, pursuing tenure) that are unique to the world of academia. As they enact such a world, participants themselves are changed. They develop identities, or "imaginings of self" (Holland et al., p. 5) in the world (e.g., of academia), and senses of agency: "Realized capacit[ies] to…act upon the world" (Inden, 1990, in Holland et al., p. 42), or "Control over their own behavior" (Holland et al., p. 40). As spaces in which participants' identities and agency are formed, and as spaces created and remade by participants' social interactions and activities, figured worlds may be considered "sites of possibility" (Urrieta, 2007a, p. 109). That is, the enactment of figured worlds has the potential to not only change participants themselves, but also to change their conditions.

Thus, the theoretical notion of figured worlds offers one particular conceptualization of the "nexus of relations between the mind at work and the world in which it works" (Lave, 1988, p. 1).

In my study, I took the perspective that coming to understand climate change—or, developing climate literacy—was a matter of learners forming, and being formed within, figured worlds of climate change. I suggested that beyond being an empirically supported phenomenon in science, [anthropogenic] climate change is a historical, social, and cultural phenomenon. Therefore, learners' meaning-making around climate change is likely to be mediated not only by their interpretations of empirical scientific evidence (itself potentially a socioculturally-dependent act), but also by varying social and cultural influences surrounding learners—or, their broader conditions.

I suggested that learners figure a world of climate change as they engage in socially and culturally mediated learning experiences inside and outside the world of school. I further suggested that learners' figured worlds of climate change come to encompass the perceptions, knowledge, values, and responses they develop in relation to climate change. Within figured worlds of climate change, I posited that learners develop identities (or, "imaginings of self" (Holland et al., 1998, p.5)) in relation to climate change. I envisioned learners' climate change identities as a matter of how learners come to see climate change in relation to their own lives. Concurrently, I also posited that learners develop agency, or "realized capacities to act" (Inden, 1990, in Holland et al., p. 42), in relation to climate change. Such climate change agency might take the form of learners' decisions, behaviors, and conversations with others around climate change. Such decisions, behaviors, and conversations might ultimately have the potential to shape—by reinforcing or remaking—learners' conditions, or the larger social and cultural contexts in which learners find themselves embedded. By adopting the theoretical lens of figured worlds, I explored its potential for providing new insights on middle school learners' climate change learning.

Significance

Global climate change is an urgent, scientifically and socially complex environmental problem that already affecting human and natural systems worldwide (IPCC, 2014; USGCRP, 2014). Because today's learners are likely to contend with climate change-related decisions throughout their lives, some in the science education community are beginning to recognize a need to reimagine science education for the "global climate change era" (Sharma, 2012, p. 33). At a moment in science education history when states are beginning to incorporate climate change into their curricula in response to the Next Generation Science Standards, there is a need for greater insight not only into *what* students know about climate change, but also *how* and *why* they come to know it, and ultimately, what difference this knowing might make in the world.

In taking a sociocultural perspective, by use of a figured worlds lens, to examine the ways in which learners' diverse contexts intersect with their climate change learning, this study contributes new knowledge to the science education research base on climate change learning. It also raises new questions for the science education research community to explore regarding the influence of learners' conditions on their perceptions, knowledge, values, and responses related to climate change. For science curriculum and instruction, particularly in the era of the Next Generation Science Standards, the study can also inform the design of pedagogical approaches that foster learners' identity and agency development in relation to climate change, while addressing key climate literacy goals.

Major Concepts and Terms

Discussions around the topic of climate change may be fraught with confusion over terminology and meaning. For example, people may confuse the terms *climate change* and *global warming* as interchangeable, may fail to distinguish between naturally occurring changes to the global climate and human-induced changes, or may fail to recognize the greenhouse effect as a naturally occurring process being enhanced by human activity. In an effort to prevent such confusion, I clarify my own use of such terms in this study.

Climate. Refers to an area's average weather conditions (e.g., temperature, precipitation, humidity) and their variability over long time intervals—typically over multiple decades (NASA, 2005; USGCRP, 2009). The *Essential Principles of Climate Literacy* (USGCRP, 2009) emphasize that climate is not the same as weather, which describes the local, minute-by-minute conditions of the atmosphere. To increase public understanding of the difference between climate and weather, some scientists have succinctly described climate as *what you expect*, and weather as *what you get* (NASA, 2005). Therefore, while singular extreme weather events in themselves cannot be appropriately attributed to climate change, increased occurrence or intensity of extreme weather events may be part of a trend that suggests a changing climate. That is, extreme weather incidents are expected to increase with climate change (USGCRP, 2009).

Climate change. Refers to changes to the Earth's climate (e.g., temperature, precipitation, humidity) and resulting impacts of these changes (e.g., sea level rise, polar ice melt) caused by the enhanced greenhouse effect. Earth's climate has changed throughout geological time as a result of natural processes (e.g., changes in incoming solar radiation, volcanic activity), but it has changed rapidly over the past century as a result of human activities (e.g., fossil fuel combustion, land use change) (IPCC, 2014). Currently observed changes are "unprecedented over decades to millennia" (IPCC, 2014 p. 1) and have had widespread impacts for natural and human systems. When I refer to climate change, I am referring to current (post-Industrial) climate change, which appears to be dominated by human activities (IPCC, 2014)—though the climate change term encompasses both naturally occurring and anthropogenic climate change. Beyond encompassing scientific evidence, research, and predictions, I frame climate change in line with anthropological perspectives that consider climate change to be not only a scientific research topic, but also a human *experience* (Callison, 2014). I note that while some researchers have suggested the use of the term *climate disruption* (Pimm, 2009) in reference to current climate change in order to limit confusion, I opt to use the more generalized climate change term because this is most commonly used in science education.

Greenhouse effect. The greenhouse effect is a naturally occurring phenomenon in which greenhouse gases in the atmosphere prevent some infrared radiation from being re-radiated from Earth to space, leading to a warming effect on Earth. The enhanced greenhouse effect refers to the amplification of this natural process as a result of greenhouse gas emissions (e.g., carbon dioxide) from human activities, including the use of fossil fuels (e.g., coal, oil, gas). When I use the term *greenhouse effect* as the mechanism behind current climate change, I am referring to the enhanced greenhouse effect.

Global warming. The term *global warming* refers to the heating of Earth's surface as a result of the greenhouse effect. As a result of the enhanced greenhouse effect, Earth's temperatures are increasing more rapidly than would be expected in the absence of human activity. I use the term *global warming* to refer to the increases in global temperature associated with the enhanced (human-exacerbated) greenhouse effect. I do not use the term interchangeably with climate change, which refers to the suite of changes associated with increasing global temperatures (e.g., changes in precipitation, sea level rise, ice melt). In reporting research around these topics, I used the terms employed by the researchers whose studies I discuss. For example, if a researcher investigated learner understanding of global warming, I took care to represent their work accurately.

Climate change education. In this study, climate change education refers to efforts in the fields of formal (school-based) and informal (out-of-school) science education to increase learners' understandings of climate change, or climate literacy. Because climate change is an inherently interdisciplinary topic, I acknowledge that climate change education efforts may also occur in other disciplines, such as social studies education. However, since the primary audience for this study is the science education community, my references to climate change education refer to those efforts in science education.

Climate literacy. The term climate literacy was popularized in science education with the release of the U.S. Global Change Research Program's (2009) Climate Literacy Framework, *Climate Literacy: The Essential Principles of Climate Science*. As has been the case with the term scientific literacy (see Roberts, 2007), I see climate literacy as having the potential to be conceptualized as encompassing: 1) learner understanding of canonical scientific knowledge about climate science and global climate change, or alternately, 2) the development of the learners' capacities to navigate "[climate] science-related situations" (Roberts, p. 730) they are likely to encounter as citizens. My view of scientific literacy, and therefore, climate literacy, is more in line with the latter perspective, in that I view becoming climate literate as encompassing more than familiarity with canonical scientific understandings about climate change.

Because I take a sociocultural perspective and examine climate literacy through the lens of figured worlds, I view developing climate literacy as a socioculturally-mediated process of developing identity and agency in relation to climate change. I align my view of how people become climate literate closely with Feinstein's (2011, 2015) ideas about how people become science literate: through "repeated exposure to [climate change] science in personally meaningful contexts" (Feinstein, 2015, p. 149), which helps them to "recognize the moments when [climate] science has some bearing on their needs and interests and to interact with sources of scientific expertise [regarding climate change] in ways that help them to achieve their own goals" (Feinstein, 2011, p. 180).

I draw from two key sources in conceptualizing climate literacy. The first are the four qualities of a climate literate person as described in the Climate Literacy Framework (USGCRP, 2009) (Figure 1). To add a cultural overlay, because of my interest in the roles of learners' social and cultural contexts, I also draw from four axioms for understanding the different ways cultures "engage their world through the prism of climate change" (p. 88), proposed by anthropologists Roncoli, Crane, and Orlove (2009).

These include learners' perceptions, knowledge, valuation, and responses regarding climate change. In Table 1, I show how I operationalize these axioms for examining the climate change perspectives of middle school science learners. In Figure 1, I show how these axioms overlap with the four qualities of a climate literate person as articulated in the Climate Literacy Framework (USGCRP).

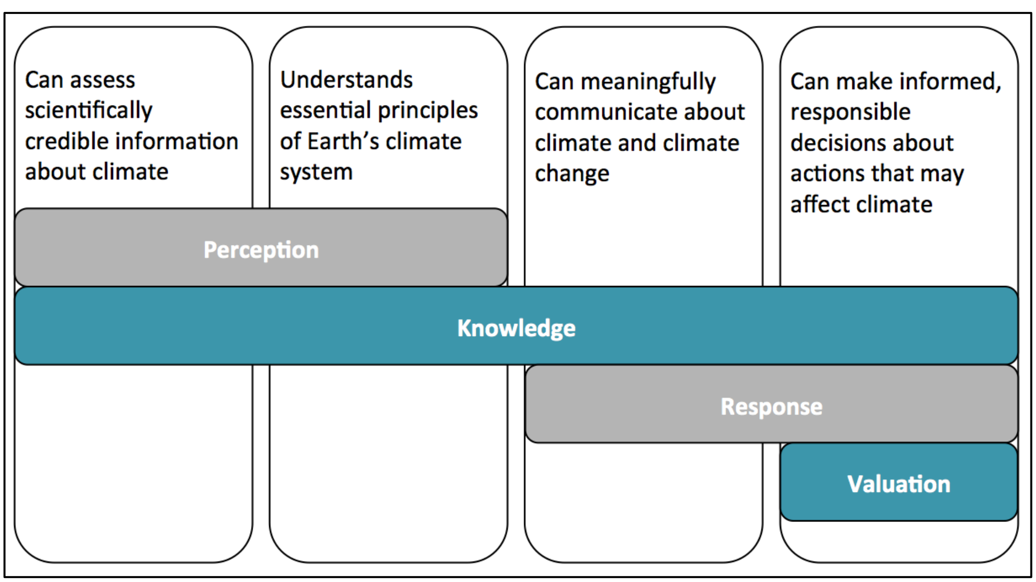
Table 1

Operationalization of Roncoli et al.'s (2009) Axioms for Examining Science Learners' Perspectives on Climate Change

Axiom	Operationalization
Perception	Learners' sensory information about climate change, as shaped by their experiences interacting within varied contexts
Knowledge	Learners' understandings of climate change causes, effects, and roles of human activity, as shaped by social and cultural experiences
Valuation	Learners' concerns regarding climate change, as shaped by social and cultural experiences
Response	Learners' actions (e.g., decisions, behaviors) in response to climate change, as shaped by social and cultural experiences

Figure 1

Mapping Roncoli et al.'s (2009) Axioms onto the Four Qualities of a Climate Literate Person (USGCRP, 2009)



Positionality

I embarked on this study acknowledging that my positionality and prior experiences had the potential to influence my research. First, I considered my background as an environmental educator. I was drawn to the field of environmental education because I believe that environmental learning experiences can benefit individuals personally—both cognitively and affectively, and because I believe that environmental education may be crucial for fostering a more ecologically sustainable future—an issue I see as an urgent concern. Acknowledging that certain beliefs and values shape my interest in environmental education and related research, I strove to attend to the ways in such beliefs and values might mediate my approaches to collecting and interpreting information as a researcher.

As an environmental educator, I have taught primarily in informal science education contexts (e.g., a nature center, an environmentally-focused children's museum, a community-based environmental organization). However, I have interacted often with teachers and learners in formal school science settings (e.g., visiting K-12 science classrooms to facilitate environmental education programs, teaching a university-based Elementary Science Methods course to undergraduate teacher candidates). I believe these experiences with the worlds of informal and formal science education have played a crucial role in shaping my view of learning as a phenomenon occurring through interactions across diverse contexts. This perspective on learning led me to select a sociocultural lens with which to examine my data, a choice that has implications for the case study insights I report.

Beyond my past experiences as an environmental educator, I believe my past and current roles as graduate student and graduate research assistant should also be acknowledged as potentially informing my thinking and my research approach. As a graduate student, I have conducted research in science teacher education, including on prospective teachers' understandings of climate change. I worked as a research assistant on Project NEXUS, an NSF-funded project examining a science teacher education model that blended formal and informal science education elements. As part of the project, I co-developed and researched the implementation of a climate change education module in an Elementary Science Methods course (Hestness, McGinnis, Riedinger, & Marbach-Ad, 2011; McGinnis, Hestness, & Riedinger, 2011). This work informed my prior understandings regarding how people—in this case, undergraduate students—think about climate change. It also informed my ideas about potentially fruitful research methods for gaining insight into people's thinking about climate change—particularly through the use of participant-generated drawings and accompanying interviews. In collaboration with my research colleagues, I have previously used these methods to examine both cognitive (i.e., mental models) and affective (i.e., moral and ethical) dimensions of prospective teachers' idea about climate change (Hestness et al., 2011; McGinnis & Hestness, in press). In this study, I built on my learning from these research experiences by using similar methods to examine learners' figured worlds of climate change, including their development of identity and agency in relation to the topic of climate change.

Since the beginning of my doctoral program, I have worked as a research assistant on an NSF-funded Climate Change Education Partnership (CCEP) project. Through the project, MADE CLEAR (Maryland and Delaware Climate Change Education, Assessment, and Research), I have studied climate change education extensively and have interacted with many science educators and researchers around the topic. One stated goal of the project is "to utilize learning principles and the sociocultural diversity of the [Maryland and Delaware] region to develop effective, scalable, and transferable modes of climate change education" (MADE CLEAR, 2012). This project goal prompted my inquiry about the fundamental relationship between sociocultural contexts and climate literacy development, and informed the articulation of my overarching research question: How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded?

While I conducted this study independently of my other work with the MADE CLEAR project, my role as a MADE CLEAR research assistant had implications for the study. For example, I entered my data collection phase already acquainted with study participants. I used my prior knowledge of participants to help inform the selection of focal participants for this study. I also cross-referenced my independently collected data with teacher-administered assessments that also served as data in the MADE CLEAR study in an effort to develop converging lines of evidence.

Limitations

There are a number of possible limitations to this case study. The first is that I examined the perspectives of one group of learners (6^{th} grade science students) in one setting (a suburban middle school). Yin (2014) advised that single-case designs run the risk of putting "all your eggs in one basket" (p. 64) and may result in less powerful analytic conclusions. However, considering the challenges related to time and logistics of gaining access to multiple schools to conduct research, I believed that my time in the field was best spent collecting very detailed qualitative information from a few purposefully-selected participants in one setting. I found that one setting was sufficient for gaining insights relevant to my research question. It also raised questions and provided a model to inform possible future investigations in other settings.

An additional potential limitation relates to my choice to conduct the research in a school setting. While I was interested in how school science experiences may shape learners' perspectives on climate change, these were not the only influences of interest in the study. It is possible that learners were more attuned to speaking about school-based learning experiences when being interviewed in a school setting, as opposed to other locations such as home, or in an informal learning setting. However, because my access to learners was limited to the time in which they were at school, I addressed this concern by explicitly encouraging participants to consider their learning experiences beyond school. I also interviewed the 6th grade science teacher and parents in order to gain insight into the ideas they saw learners developing through their in-school and out-of-school experiences.

Because participants were relatively young (ages 11-12), their familiarity and experiences with climate change may have been more limited than those of older potential participants. However, I had the advantage of collecting data after their participation in school-based climate change education, so could be fairly certain that they were familiar with the topic. In addition, I found that studying learners in early adolescence could also provide valuable insights for middle school science education. In particular, it provided a snapshot of the thinking of learners who, as a result of potentially fewer social and cultural experiences with climate change than their older counterparts, were at a point when they were still developing understandings of themselves in relation to climate change, and actively being influenced by diverse social and cultural forces.

I acknowledge that my chosen data collection methods may present certain limitations. For example, Yin (2014) described some weaknesses of interviews, including inaccuracies due to poor recall, and issues of reflexivity, or participants providing answers they believe the interviewer is seeking. I tried to limit these problems with specific and carefully designed questions (Kvale, 1996), and worked to establish a conversational rapport with participants that helped them to feel comfortable expressing their ideas (Yin). Other potential limitations may have included participant reflexivity during observations (i.e., the researcher's presence influencing participants' behavior) (Yin), and selectivity and accessibility of artifacts and documents, such as lesson plans and student work (Yin). Beyond the limitations of the data collection methods themselves, I acknowledge the potential for fatigue from participants' engagement in multiple studies and the temporal context of conducting the study in the final months of the school year. I addressed this concern by engaging in data collection activities that were not unnecessarily time consuming for participants, while also promoting their creativity (e.g., drawings) and social interaction (e.g., a focus group interviews).

Assumptions

I made several assumptions in my approach to this study. The first relates to my adoption of a sociocultural theoretical perspective. In taking a sociocultural view of learning, I made the assumption that learning occurs through learners' interactions within varied social and cultural worlds. Therefore, I assumed learners' interactions in varied in-school and out-of-school contexts were shaping their climate change learning. In adopting the specific sociocultural perspective of figured worlds, in which identity and agency are key dimensions, I made the assumption that learning is a process of developing identity and agency. Therefore, as learners came to understand climate change—or develop climate literacy—I also assumed that they developed identities and senses of agency in relation to the topic.

A second set of assumptions related to participants' engagement with the climate change topic itself. First, I assumed that participants had some familiarity with the issue of climate change, because they were participating in a science class in which the topic was taught. I also assumed that at least some of the learners would have had experiences learning about climate change outside of formal science education (e.g., engagement with media). Finally, I made the assumption that through engaging with the data collection methods I employed (e.g., interviews, observations, drawings), learners would be able to communicate their perspectives on climate change—that is, provide evidence of the nature of their figured worlds of climate change—and would also be able to provide some evidence of the social and cultural forces influencing these.

Chapter Summary

Climate change is a global challenge about which today's learners must be prepared to make scientifically-informed decisions. With the release of the Next Generation Science Standards (NGSS Lead States, 2013), climate change has become increasingly salient in the science education community. Prior research has provided insight primarily into *what* learners understand about climate change. This work has suggested some common areas of confusion for many learners, but also variability in learners' perceptions, knowledge, values, and responses related to climate change. Such variability raises questions around *how* and *why* learners come to understand climate change in the ways that they do—particularly the potential influences of the conditions in which learners are embedded. It also raises questions regarding how learners' understandings of climate change may have the potential to reflexively influence their conditions. In this chapter, I have described how applying a sociocultural perspective to learners' climate literacy development could provide valuable insights for science education research and practice for the "global climate change era" (Sharma, 2012, p. 33).

This case study applied the sociocultural theoretical perspective of figured worlds (Holland et al., 1998) to examine learners' climate literacy development. The purpose of this study was to investigate and report on the nature of the relationship between middle school science learners' conditions—or, their multifaceted contexts within and beyond the world of school—and their developing understandings of climate change. Thus, the study addressed the overarching question: How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded? I examined the climate change perspectives of purposefully selected focal participants from a group of 6th grade science learners at one school. Using a variety of data sources, including observations, interviews, documents, and written artifacts, including learners' self-generated drawings, I described the nature of learners' developing figured worlds of climate change, encompassing their perceptions, knowledge, values, and responses related to the topic. I sought insight into the conditional influences potentially shaping learners' ideas, how learners came to see climate change as relevant to their own lives, and how learners' developing identities and agency in relation to climate change had the potential to re-shape the conditions in which they were embedded.

In the next chapter, I elaborate the sociocultural theoretical perspective of figured worlds and discuss key insights from science education research examining learners' understandings of climate change. I then turn to a detailed description of the case study methodology I employed to empirically investigate climate change learning as a socioculturally-mediated process.

Chapter Two: Literature Review

In this study I investigate and report on the nature of the relationship between middle school science learners' conditions and their figured worlds of climate change. I foreground this work with a literature review organized into three sections. The first section provides an introduction to sociocultural perspectives on learning and some of their applications in science education research. I introduce the theoretical notion of figured worlds (Holland et al., 1998) as a fruitful lens through which to examine learners' climate literacy development. The second section provides a review of science education literature examining K-12 learners' perspectives on climate change. I describe key findings related to learners' perceptions, knowledge, values, and responses in relation to climate change. While few studies in this area have explicitly applied a sociocultural lens to examine to climate change learning, this body of literature provides potential insight into the ways in which learners' understandings may be shaped by the social and cultural contexts in which they are embedded. Therefore, in the third section, I examine the potential relationship between learners' conditions and their climate chance understandings. I briefly describe relevant insights from other social sciences domains (climate change communication and anthropology), and analyze existing science education literature on learners' understandings of climate change from a sociocultural perspective. I highlight several potential dimensions of learners' contextual embeddedness that may relate to their climate literacy development. In concluding the chapter, I discuss the ways I believe these bodies of literature may inform and raise new questions relevant to science education research on climate literacy development. Table 2 below provides an overview of the key ideas presented.

Table 2

Overview of Key Ideas from Literature Motivating the Study

In Section One, I will:		
• Introduce sociocultural perspectives on learning	→	*Key idea: Learning occurs through learners' interactions within social and cultural contexts. There exists a "nexus of relations between the mind at work and the world in which it works" (Lave, 1988, p. 1).*
• Describe applications of sociocultural learning theories in science education research	→	*Key idea: Science education researchers have applied sociocultural perspectives for various purposes, including to examine science learning as a process of identity and agency development occurring within and beyond the world of school*
• Provide a rationale for applying sociocultural perspectives to the study of climate literacy development	→	*Key idea: A sociocultural lens is useful for examining climate change learning (climate literacy development) as a process through which learners come to see themselves and their actions in relation to climate change (identity and agency)*
• Present the theoretical perspective of figured worlds (Holland et al., 1998) as a potentially fruitful sociocultural perspective to apply to the present study	→	*Key idea: Figured worlds are "historically contingent, socially enacted, culturally constructed worlds" (Holland et al., p. 7) in which identity ("imaginings of oneself in worlds of action" (Holland et al., p. 5)) and agency ("the realized capacity to…act upon the world" (Inden, 1990, in Holland et al., p. 42)) are formed.*
• Describe how figured worlds have been applied in science education research	→	*Key idea: Science education researchers have applied the theoretical perspective of figured worlds to examine intersecting and "multilevel influences" on learners' identities and senses of agency as they engage in science learning*

• Argue the appropriateness of figured worlds for the study of the relationship between learners' contexts and their climate literacy development	*Key idea: Learners may shape and be shaped by figured worlds of climate change, which are products of historical, social, and cultural context, and may have implications for how learners come to understand climate change and their relationship to it.*

In Section Two, I will:	
• Describe how science education researchers have examined K-12 science learners' perceptions, knowledge, action, and responses with regard to climate change and outline key insights from this body of work	*Key idea: Prior research suggests that learners vary in the extent to which they believe anthropogenic climate change is occurring; their knowledge of climate change causes, effects, and human connections; their concerns; and their actions in response to climate change.*

In Section Three, I will:	
• Provide an overview of social science literature that has examined the relationship between climate change understandings and context	*Key idea: Climate change communication and anthropology research provide insight into the diversity of perspectives on climate change and support for the notion that context has the potential to shape people's perspectives*
• Analyze science education literature on climate change learning, identifying potential ways in which learners' interactions within social and cultural contexts may have shaped their climate change perspectives as reported in the literature	*Key idea: Among other potential influences, learners' perspectives on climate change may be shaped by: public discourse (political, media); educational experience; place and personal experiences (felt consequences); social environment (family and peers); and cultural views of environment, science and technology. In other words, context appears to matter for learners' climate change understandings.*

In Section Three, I will:	
• Describe select studies in science education that have examined learners' identity and agency development as they engaged with environmental topics related to climate change	*Key idea: Learners' identity and agency development as they engage with the topic of climate change may have the potential to shape or re-shape the contexts (societies, cultures) in which learners are embedded (e.g., through learners' actions). In other words, learners' climate change understandings may matter for their contexts.*

Section One: Sociocultural Perspectives on Learning

From a sociocultural perspective, learning occurs through interaction with and within social environments. Vygotsky (1978) held that learners' interactions with other individuals, as well as with tools and cultural objects within their social environments, were essential for fostering meaning-making and higher mental functioning (National Research Council (NRC), 2000). In contrast to Piagetian perspectives concerned with the construction of mental structures within the individual mind, sociocultural perspectives on learning reoriented the focus to "the nexus of relations between the mind at work and the world in which it works" (Lave, 1988, p. 1). The unit of analysis, then, encompasses the individual *and* the social world, rather than the individual mind alone (Forman & Sink, 2006; Leach & Scott, 2003).

Applying sociocultural perspectives to educational research. In applying sociocultural perspectives to research in educational settings, a view of learning and learners as shaped by participation in diverse social and cultural worlds can help to explain the diversity of understandings that may emerge in classroom settings. Outside of school, learners may be shaped by cultural knowledge and social roles associated with differences in race, class, gender, and cultural or ethnic affiliations (NRC, 2007). Understandings developed through participation in varied social and cultural contexts may align or conflict with the kinds of understandings valued in the world of school.

Theorists have described the understandings developed through learners' participation in contexts outside of formal academic settings using terms such as *lifeworld knowledge* (Solomon, 1983); *everyday thought* (Lave, 1988); and *lifelong, life-wide, life-deep learning* (NRC, 2009). Lave criticized the sentiment that this everyday knowledge is inferior to scientific or academic thought. Rather than dichotomizing these realms, Lave suggested that *everyday* should encompass what people do in all contexts (or cultural worlds), including the classroom. Lave further stated that resistance to research focused on learning as participation in social contexts may stem from a perceived divide between cognitive processes and the settings in which they occur, as well as from a perception by some that that these types of studies lack methodological rigor. However, voices in the educational research community are increasingly acknowledging the importance of the social and cultural contexts of learning, and the need for research taking a sociocultural perspective on learning (NRC, 2000)

Sociocultural perspectives on science learning. Applying sociocultural perspectives to science education research departs from an individualized view of science learning and examines the development of scientific literacy among learners within participatory social, cultural, and institutional contexts. As Lemke (2001) stated, the introduction of sociocultural perspectives into science education research "challenged the view that science represents a uniquely valid approach to knowledge, disconnected from social institutions, their politics, and wider cultural beliefs and values" (p. 297). Instead, they frame science, science education, and science education research as shaping—and being shaped by—the institutional and cultural worlds in which they occur (Lemke). While research focused on individual cognition has provided insights on some aspects of science learning, as Leach and Scott (2003) suggested, it may overlook other important socially and culturally mediated dimensions of science learning.

Science education researchers have employed sociocultural perspectives for a variety of purposes. For example, some researchers have used sociocultural lenses to interrogate the institutional, social, and cultural values that shape science education and stated goals for science learning. Others have applied sociocultural perspectives to examine science education as a process of enculturation into science-related communities. Additionally, researchers have used sociocultural perspectives to describe science learning as a process of social participation occurring within and beyond the world of school. Finally, researchers have applied sociocultural perspectives to examine science learning as a process of learners developing identity and agency. Next, I describe each of these approaches and their potential implications for the study of climate literacy development.

Institutional, social, and cultural values shaping science education. Science education researchers have applied sociocultural perspectives at a macro-level to examine the ways in which institutional, social, and cultural values shape science education and its goals for learning. That is, they attend to the power of context in determining what is valued, emphasized, and communicated (implicitly or explicitly) in science education, and what is ultimately learned (intentionally or unintentionally). Since sociocultural perspectives view learning as shaped by cultural values (i.e., "what's worth knowing" (in

Forman & Sink, 2006, p. 10)) and the messages that institutional structures and interpersonal interactions convey to students, Apple (2004) underscored the need to interrogate what, as a society, we deem important to know.

One example of the ways in which institutional, social, and cultural values appear to shape science education may be found by examining how the goals of science education are defined and measured. For example, some researchers have pointed to the role of economic context in determining what is valued in science education in the United States. Lemke (2001) described how economic interests dictate the goals of science education, particularly emphasizing the goal of producing more scientists, engineers, and technicians to compete in the global economy. Apple (2004) and Tobin (2012) critiqued the commodification of education and the use of standardized testing as a way to compare the U.S. with its economic competitors.

Where certain institutional, social, or cultural values (e.g., advancement in the global economy) drive science education policy, curriculum, and practice, there may be implications for the ways in which scientific literacy becomes conceptualized. Roberts (2007) synthesized two general visions of scientific literacy in the science education community, each representing an extreme on a continuum, and each aligned with a different suite of values. At one end (Vision I), is a view that scientific literacy that entails becoming knowledgeable about “the products and processes of science itself” and “look[ing] inward” (Roberts, p. 730) at canonical scientific knowledge. At the opposite end (Vision II), is a view that becoming scientifically literate entails developing the capacity to navigate “science-related situations” (Roberts, p. 730) that learners encounter as citizens. From a sociocultural perspective, the extent to which either or both of these visions—or others—are forwarded in science education may relate to predominant institutional, social, and cultural values around what learners of science should know and become through their science education experiences. Lewenstein (2015) raised the issue, however, that these and most other framings of scientific literacy focus almost entirely on individual learners, rather than ascribing a more collectively-oriented meaning to scientific literacy. This, too, may be an indicator of dominant values in science education.

Science learning as a process of enculturation. Researchers have also employed sociocultural perspectives to examine science learning as a process of enculturation, or learning to participate in a culture or community (Lemke, 2001). Here, institutional goals and values, and ideas about what it means to be scientifically literate, may frame ideas about *which* communities science learners are to be enculturated, and for what purpose. For example: Should science education prepare learners to participate in the community of professional science, to participate as scientifically-informed citizens in their own communities, or to participate in some combination of these (or other) science-related communities?

Leach and Scott (2003) described how science educators act as "vicars of [a] culture" (Bruner, 1985, p. 32) in presenting scientific points of view to learners. Learners are asked to buy into (Wertsch, 1998) and adopt certain perspectives, practices, and forms of reasoning that characterize the scientific community (Leach & Scott). Some examples include norms for scientific argument and debate, developing a sense of trust and skepticism around scientific evidence, and a willingness to ask questions and seek help (NRC, 2007).

Because there are sets of values associated with such scientific practices, Lemke (2001) noted that a sociocultural approach "requires that we ask ourselves some tough questions about what kinds of personal identity and cultural values our science teaching accepts, respects, or is compatible with" (p. 300). Some learners may experience conflicts between the norms and practices from their own cultural backgrounds and the culture of science (NRC, 2007). However, students' own cultural perspectives also have the potential to enrich classroom discourse (NRC). Carlone, Johnson, and Eisenhart (2014) described how cultural perspectives in science education such as funds of knowledge (Vélez-Ibáñez & Greenberg, 1992) have helped to acknowledge as resources the complex understandings that learners bring from their home cultures to school.

Beyond considering science education as enculturation into the practices of the scientific community, researchers have also examined the science classroom as a space of enculturation, or the notion of school science itself as "embodied sociocultural practice" (Carter, 2008, p.171). For example, "school talk" (Heath, 1982) may be impersonal and expository, privileging learners from middle-class, mainstream backgrounds whose ways of knowing and communicating are more aligned with the norms of school science (Aikenhead, 1996; NRC, 2007). This privileging becomes a concern in diverse classroom communities that are culturally heterogenous (Lemke, 2001). It may also have implications for how learners see themselves in relation to science and how they are willing and able to participate (NRC).

Science learning as social participation within and beyond the world of school. Drawing on Vygotsky's (1978) ideas about the social nature of learning, sociocultural perspectives regard social interaction as essential to science learning (Lemke, 2001).

Vygotsky (1978) argued that learners' understandings are shaped by talk, activity, and interaction around meaningful problems (in NRC, 2000). These interactions may occur in school with teachers and peers, or outside of school with other members of learners' families and communities (Leach & Scott, 2003; NRC, 2007).

In a sociocultural view, understanding science learning requires attention to learners' social experiences and participation in communities both inside and outside of school (NRC, 2007). Research on science learning has begun to extend increasingly beyond the classroom to examine learning in informal education contexts, as well as learning that occurs through interactions with people (e.g., family members) or resources (e.g., books, television, Internet) outside of formal school settings (NRC, 2007, 2009). In this way, science education researchers acknowledge how learners' participation in varied organizations or institutions—for example, families, schools, corporations, economies, and online communities—helps to shape the development of their beliefs and values, languages and discourses, and specialized practices associated with science (Lemke, 2001). As Lemke stated, "the greatest promise of sociocultural approaches lies in looking both within and beyond the classroom" (p. 305). In doing so, he argues, researchers acknowledge the "sociocultural reality that students' beliefs, attitudes, values, and personal identities… are formed along trajectories that pass only briefly through our classes" (Lemke, p. 305).

Science learning as a process of developing identity and agency. From a sociocultural perspective, learners' development of identity and agency is central to science learning. Roth and Calabrese Barton (2001) described identity as the question of *who the agent is* in an activity. This notion of *who one is* can be shaped and reshaped through interactions within learning contexts, and therefore, is not static. According to Roth and Calabrese Barton, *who we are* is an outcome of action in the worlds that we create: “As we participate in the world, we expand what we can do... Expanded agency is the equivalent to saying that learning has occurred… In this sense, [learning] is a dialectic concept because it changes agency (limiting or expanding), [and] in the process, it produces and reproduces identity” (p. 17). They argued that science-related contexts—both in school and out-of-school—should foster positive formative experiences that allow learners to develop identities and agency as scientifically literate citizens. The National Research Council (2007) further suggested that identity plays a key role in determining learners’ views of science, their self-efficacy in science, and the extent to which they feel supported to participate in the scientific community of the classroom.

Sociocultural learning theorists have argued that possessing science-related identities may be a critical factor in individuals’ receptivity to learn in science education settings (Tobin, 2012). However, they also problematize the notion of a one-size-fits-all science identity (i.e., male-dominated; based in Western modern science), since learners are shaped by diverse social, cultural, and educational experiences (Lemke, 2001). For example, researchers examining science identity, especially amongst underrepresented groups in science, have pointed to these concerns (e.g., Brickhouse & Potter, 2001; Carlone & Johnson, 2007). Lemke (2001) articulated how changing students’ minds (i.e., science learning) is a process of inviting learners to adopt a system of beliefs and values and to join a particular subculture. Learners may experience this process as one in which they are asked to reject certain values and other aspects of their identities that link them to communities and cultures outside of the classroom (Lemke). Rather than imposing a specific kind of science identity on all students, Lemke argued for a vision of science literacy that "fit(s) with the lives and identities of a much larger fraction of the population" (p. 308).

Tobin (2012) described how learners may cultivate and sustain multiple identities (e.g., those linked to their everyday lives, those linked specifically to their roles as science learners) in a science class. Roth and Calabrese Barton (2001) considered methods for bridging learners in-school and out-of-school worlds, advocating in particular the value of science lessons examining contentious issues in the community as "ideal sites for identity producing interactions between participants" (p. 16) and thus, rich contexts for science learning. Researchers examining learning around socioscientific issues (SSIs), or societal dilemmas with linkages to science, have echoed this point and have highlighted the particular value of such issues for examining learners' moral and ethical development as they learn science (e.g., Zeidler, Sadler, Simmons, & Howes, 2005).

Rationale for applying a sociocultural perspective to climate literacy development. I have just broadly described some of the ways in which science education researchers have applied sociocultural perspectives to the study of science education and learning. I highlighted in particular the use of sociocultural perspectives to: 1) interrogate the institutional, social, and cultural values that shape science education and science learning; 2) examine science education as a process of enculturation into science-related communities; 3) describe science learning as a process of social participation occurring within and beyond the world of school; and 4) to examine science learning as a process of learners' development of identity and agency.

I now turn to considering the potential that lies in applying a sociocultural perspective to the study of learners' climate literacy development. It is possible that any of the previously described usages of sociocultural perspectives could provide unique insights on climate literacy development. For example, it is likely that institutional (e.g., state government, school district, and school-level) decision-making, based on what is valued within those institutions, would shape whether and how climate change is taught in school science. There is already evidence of this phenomenon in state-level debates around whether to adopt the Next Generation Science Standards, partially due to their inclusion of the climate change topic (Morello, 2013). Likewise, climate change learning could fruitfully be examined as a process of enculturation into the community of school science, of professional climate scientists, of climate change skepticism, or of climate change activism—depending on the teaching and learning context. Taking a learner-focused perspective, climate change learning could be examined as a process of a learner's social participation within and beyond the world of school-based climate change education, as well as a process through which learners develop identity and agency in relation to climate change. Further, as a socioscientific issue, climate change may also provide a fruitful context for examining learners' moral development as they come to understand and relate to the topic.

The present study is focused on the ways in which science learners' interactions in social and cultural contexts may relate to their development of climate literacy. Because I am interested in the learners themselves and the perspectives they are developing on climate change, I see the latter two usages of sociocultural perspectives in science education research—a focus on social participation and experiences within and beyond the world of school, and the examination of learners' identity and agency development through such experiences—as especially relevant to this study. Therefore, I adopt a specific sociocultural theoretical perspective, that of figured worlds (Holland et al., 1998), that I believe aligns well with these foci. Figured worlds, a perspective from the field of cultural anthropology, has recently begun to emerge in science education research (Carlone et al., 2014). As others researchers have suggested (Cobern & Aikenhead, 1998; Carlone et al.), I believe that cultural anthropology perspectives have the potential to provide valuable new insights into questions around science learning—particularly related to socially-relevant topics such as climate change. In the next section, I describe figured worlds and their potential applications to the study of climate literacy development.

Figured worlds. Sociocultural perspectives on learning take interest in "the nexus of relations between the mind at work and the world in which it works" (Lave, 1988, p. 1). To describe the *nexus of relations* between the individual learner and the social world, some sociocultural theorists have framed learning as a process by which learners develop identities, and sometimes agency, through participation in the practices of social communities (Wenger, 1998) or within social worlds (Holland et al., 1998). Holland et al. described identities as "imaginings of self in worlds of action" (p. 5), and therefore, as social products. For Holland et al., identity is bound up with agency—or "the realized capacity to…act upon the world" (Inden, 1990, in Holland et al., p. 42), and both are situated within "historically contingent, socially enacted, culturally constructed worlds" (p. 7), or figured worlds.

Holland et al. (1998) described figured worlds as contexts in which identity and agency are formed. They are socially and culturally constructed realms that people collectively form and are formed within (Holland et al.). They shape and take shape within a set of activities, discourses, performances, and artifacts carried out by their participants (agents) (Holland et al.). For example, cultural realms as diverse as academia, romance, environmental activism, crime, and games of *Dungeons and Dragons* can all be considered kinds of figured worlds (Holland et al.). Urrieta (2007a) described figured worlds as organized by narratives or storylines, or what Holland et al. called "standard plots" (p. 53).

The stories people tell can provide insight into how they understand themselves—and act in accordance with this self-understanding—within a particular figured world (Holland et al., 1998). For example, Holland et al. described how members of Alcoholics Anonymous (AA) located themselves within the figured world of AA through telling personal stories. Storytelling became a process that mediated self-understanding in relation to a problem—in this case, the self-recognized problem of alcoholism. As Holland et al. explained, "Simply learning the propositions about alcoholism and its nature is not enough. The drinker must apply them to his own life, and this application must be demonstrated" (p. 71). Framed this way, the *application to one's own life* represents *identity*, and the *demonstration of the application* represents *agency*. Identities—or, "stories about persons" (Sfard & Prusak, 2005, p. 14), and agency—or, the enactment of "decisive roles [that determine] the dynamics of social life and…[shape] individual activities" (Sfard & Prusak, 2005, p. 15) are thus formed within the particular figured world. Otherwise stated, stories can provide outsiders with "entrances" into the figured worlds of others (Kitchell, Hannan, & Kempton, 2000, p. 96).

As sites in which participants' agency is formed, figured worlds become sites of possibility (Urrieta, 2007a). As Carlone et al. (2014) described, while people may not be able to control their positioning within figured worlds, they must somehow respond or answer to it. Holland et al. referred to this response as a *space of authoring* that may include individual improvisations that come to be adopted by others (Carlone et al.). This may eventually create new "figured worlds of possibility" (Carlone et al., p. 661), potentially leading to social change. In this view, human life is shaped by social interaction among individuals whose activity creates and remakes their conditions (Holland et al.).

Applications of figured worlds in educational research. Urrieta (2007a) and Rubin (2007) reviewed some of the ways in which educational researchers have used sociocultural perspectives to examine learning as a participatory process of social interactions in cultural worlds. Urrieta (2007a) described how researchers have employed the lens of figured worlds for four key purposes: first, to examine the identity production of learners in educational contexts; second, to explore specific sociocultural constructs in education such as literacy and *smartness*; third, to examine specific educational contexts and the identities that emerge, or fail to emerge, from them; and finally, to "[make] worlds of possibility" (Urrieta, 2007a, p. 114) in various arenas. Rubin (2007) added to these the notion of educational researchers using figured worlds to examine the "wobble" (p. 222) between the multiple worlds in which learners participate.

Applications of figured worlds in science education research. The notion of figured worlds is related closely the issues of identity and agency that researchers have explored in examining science learning from a sociocultural perspective. However, the use of figured worlds as a theoretical construct has been limited in science education research, despite its "potential for illuminating the multilevel influences" on identity, and thus, learning in science (Carlone et al., 2014, p. 662). Carlone et al. described their own work in applying figured worlds to research on science learning. They described the science classroom as an interweaving of various figured worlds (e.g. the figured worlds of traditional schooling, family, childhood, and jock masculinity). For Carlone et al., figured worlds represented the cultural contexts in which students engaged in identity work (e.g., positioning and authoring (Holland et al., 1998)) as they participated in school science.

Taking a different approach, Tan and Calabrese Barton (2007) focused on the power dynamics inherent within figured worlds, and the ways in which learners develop agency in responding to them. In doing so, they described how learners created "new worlds of school science which had shared characteristics of both their lifeworlds and the world of school science" (Tan & Calabrese Barton, 2008, p. 64). Similarly, Calabrese Barton, Kang, Tan, O'Neill, Bautista-Guerra, and Brecklin (2013) highlighted how figured worlds may allow for the development of identity and agency (e.g., when learners leverage social and cultural resources in the science classroom), but may also be constrained by historical, cultural, and social norms and expectations (e.g., norms of traditional school science).

In reviewing such applications of figured worlds in science education research, Carlone et al. (2014) summarized their explanatory potential for understanding the development of identity and agency in diverse science learning contexts. Price and McNeill (2013) added that figured worlds may help to illuminate the *tangled up* (Nespor, 1997) nature of school and the science classroom, and the notion that learners do not leave the figured worlds of their homes, home cultures, and experiences behind when they enter the science classroom. In this sense, their view of figured worlds aligns with that of Carlone et al., attending to intersecting and multilevel influences on science learning. Such a view, they argued, could provide opportunities for the development of identity and agency in science, particularly when school science connects to learners' lives, communities, and experiences outside of school.

Rationale for applying figured worlds to the study of climate literacy. In my study, I will use the lens of figured worlds to examine the ways in which learners' interactions with their conditions relate to their climate literacy development. In doing so, I explore the possibility that learners develop figured worlds of climate change that shape and are shaped by their conditionally-mediated experiences with climate change. These figured worlds may support, or depart from, the kinds of knowledge and actions embedded in notions of climate literacy, such as those suggested in the *Essential Principles of Climate Literacy* (USGCRP, 2009). Unlike theoretical perspectives rooted in cognitive constructivism (e.g., mental models), a figured worlds perspective on learners' understandings of climate change would concern not how learners internally mentally construct the concept, but how their socially and culturally-mediated learning shapes how they come to see themselves and their roles in relation to the topic. Learners' figured worlds of climate change, then, would shape—and be shaped by—their developing identities and senses of agency in relation to climate change.

I argue that figured worlds provide a fruitful lens for the study of climate change learning, or climate literacy development, for several reasons. First, beyond being a natural science phenomenon, climate change may also be viewed as a "historically contingent, socially enacted, and culturally constructed" (Holland et al., 1998, p. 7) phenomenon. With this statement, I do not mean that climate change is a figment of human imagination, or is not actually happening in an empirical sense. I mean that from the anthropological perspective of figured worlds, enhanced climate change might be seen as a product of historical context (e.g., growing human dependence on fossil fuels from the Industrial Revolution to the present), social enactment (e.g., actions society takes, and fails to take, to mitigate or adapt to climate change), and cultural construction (e.g., climate change constructed as a controversy in U.S. political culture). To say that figured worlds are "historically contingent, socially enacted, and culturally constructed" (Holland et al., p. 7), then, is not to say that they are imaginary. On the contrary, Holland et al. emphasize that "figured worlds *happen*" (p. 55)—that is, people's actions in figured worlds matter and have real consequences. This would also be the case for people's actions in figured worlds of climate change.

Second, figured worlds provide a promising lens for examining climate literacy development by building on previous efforts to examine science learning—particularly around environmental topics—as a process of identity and agency development (e.g., Blatt, 2013, 2014; Calabrese Barton & Tan, 2010). Using this perspective, one might examine how learners come to view themselves in relation to the topic (e.g., its relevance to their lives and their communities), how they see their roles in relation to climate change (e.g., as having the potential, or not, to contribute to solutions), and how such identity and agency formation is contextually mediated.

Relatedly, the narrative or storytelling focus of figured worlds—for example, the examination of “standard plots” (Holland et al., 1998, p. 53), characters and their relations of power (Urrieta, 2007a), and “tensions between past histories and present discourses or images” (Holland et al., p. 4)—is potentially useful for portraying and interrogating learners’ development of climate change understandings. For example, it allows for the exploration of how learners see climate change playing out, who they see as the characters or actors in the unfolding story of climate change, and the tensions they may experience as they learn more about climate change (e.g., concerns arising from popular images of climate change impacts (polar bears on icebergs, hurricane-ravaged communities); concerns about how their own lives may be affected; concerns about how or whether they can intervene in the story). Using a narrative or storytelling frame, afforded by the lens of figured worlds, could provide a new and meaningful means of depicting the ways in which learners come to understand climate change, including their own positionalities in relation to the issue. In the past, my colleagues and I have found storytelling to be fruitful for examining teacher candidates’ developing understandings of climate change (McGinnis et al., 2011).

Finally, as “sites of possibility” (Urrieta, 2007a, p. 109), figured worlds may be particularly relevant to the study of climate literacy development. Hodson (2003) argued that science education is crucial for realizing an alternative, socially just, and environmentally sustainable future. If figured worlds of climate change are shaped by learning experiences inside and outside the classroom, and if these figured worlds have implications for the ways in which learners come to understand and respond to climate change, it follows that science education—and the figured worlds it contributes to shaping—has a potential (but not sole) influence on society's environmental decision-making and the subsequent consequences. As Urrieta (2007a) described, figured worlds can be employed as a lens in educational research to explore "worlds of possibility" (p. 114).

In this study, I explored the worlds of possibility that emerged from middle school learners' figured worlds of climate change. That is, I examined how learners responded to their positioning (Carlone et al., 2014) within the figured world of climate change (their "space of authoring" (Holland et al., 1998, p. 45)), and the potential of these responses ("improvisions" (Holland et al., p. 45)) to lead to new "figured worlds of possibility" (Carlone et al., p. 661) (e.g. social change) with regard to climate change. Holland et al. (1998) described a figured worlds perspective as a hopeful one, as exploring "possibilities for *becoming*" (p. 64). In this respect—the dimension of hope, I see figured worlds as particularly valuable for thinking about learners' developing understandings of climate change, a "defining challenge of our time" (United Nations, 2014, para. 4).

Section Two: Science Learners' Perspectives on Climate Change

Anthropologists Roncoli, Crane, and Orlove (2009) proposed four axioms for understanding human engagement with the topic of climate change: perception, knowledge, valuation, and response. In Chapter 1, I operationalized these axioms for examining *science learners'* perspectives on climate change (Table 1). I also proposed that they could provide a cultural overlay to the four qualities of a climate literate person as identified in the *Essential Principles of Climate Literacy* (USGCRP, 2009) (Figure 1). Following this perception-knowledge-valuation-response framework, I now discuss insights from literature examining K-12 science learners' engagement with the topic of climate change.

In the late 1980s and early 1990s, science education researchers began to examine learners' ideas about global warming and related phenomena. Since this point, research rooted primarily in a cognitive constructivist perspective on learning has described learners' cognitive frameworks (Francis, Boyes, Qualter, & Stanisstreet, 1993), conceptual models (Boyes & Stanisstreet, 1997), and alternative conceptions (Meadows & Wiesenmayer, 1999) of climate change causes, mechanisms, impacts, and solutions. Much initial work in this domain was based upon a view that learners possess alternative conceptions (or misconceptions) that should be diagnosed in order to inform pedagogy that could replace these ideas with scientifically-accepted views (Francis et al. 1993; Meadows & Wiesenmayer, 1999). More recently, researchers such as those taking a learning progressions theoretical stance have reframed alternative conceptions as starting points toward more sophisticated understandings (e.g., Mohan et al., 2009). Despite their theoretical differences, these perspectives share a view that gaining insight into learners' thinking is a necessary endeavor if science education research is to inform approaches to improving learners' climate literacy.

Science education researchers have also examined learners' values (or concerns) and responses (or willingness to act) regarding climate change. Researchers in these areas have articulated the need for educational approaches that enable learners to explore their environmental values and to consider the contribution of their own actions and decisions toward addressing environmental challenges (Boyes, Stanisstreet, & Yongling, 2008). Studies in this realm have examined in particular: K-12 learners' level of concern (or attitudes) about climate change; the specific dimensions of the problem that concern learners; the extent to which learners are taking (or are willing to take) action regarding climate change; and the relationship between climate change action and knowledge.

Research methods. Researchers examining learners' ideas about climate change have employed a variety of research methods with participants of diverse ages and backgrounds. Particularly dominant has been the use of closed-ended questionnaires to probe student thinking. For example, Boyes and Stannistreet (1993) developed a closed-ended questionnaire to examine British students' ideas about global warming causes, consequences, and solutions. They have also used the questionnaire (and adapted versions) to investigate learners' thinking across varied international settings (e.g., Boyes, Skamp, & Stanisstreet, 2009 (Australia); Boyes et al., 2008 (China); Kılınç, Stanisstreet, & Boyes, 2008 (Turkey)). Some researchers have contested the efficacy of questionnaire-based research for gaining insight into students' understandings, suggesting, for example, that the *misconceptions* such research claims to uncover may be artifacts of the instruments employed (Jakobsson, Mäkitalo, & Säljö, 2009). Other researchers have used discussions (e.g., Byrne, Ideland, Malmberg, & Grace, 2014), interviews (e.g., Reinfried & Tempelmann, 2014), open-ended writing prompts (e.g., Lester et al., 2006); drawing prompts (e.g., Shepardson et al., 2009) and other specially-designed written assessments (e.g., Bodzin & Fu, 2014), to collect information about learners' ideas related to climate change.

Insights from the literature: Learners' perceptions of climate change. A number of researchers have examined learners' perceptions regarding whether climate change (or global warming) is currently occurring. With learners in diverse international settings including Britain (Boyes & Stanisstreet, 2012), Australia (Boyes et al., 2009), and India (Chhokar, Dua, Taylor, Boyes, & Stanisstreet, 2012), researchers administered questionnaires investigating middle and high school learners' levels of certainty regarding whether global warming was happening. In all of these large-sample studies, results suggested that a majority of participants were either *sure* or *thought* that global warming was already occurring, with a minority of students stating they did not believe, or did not know, whether this was the case. In some studies, researchers found that certainty of beliefs increased with learners' age (Boyes et al., 2009). In the U.S., Leiserowitz et al. (2011) reported that just over half (54%) of the teens in their nationally representative sample believed that global warming was occurring, 16% believed it was *not* occurring, and 30% were unsure. Compared U.S. adults, teens were somewhat *less likely* to believe that global warming was occurring (63% compared with 54%), though teens were also less certain of their views. This latter finding may suggest that young people may be open to considering a variety of possibilities as they engage in learning about climate change.

Insights from the literature: Learners' knowledge of climate change. Beyond examining learners' ideas about whether climate change is occurring, researchers have examined learners' knowledge (often framed as conceptions) of climate change causes and mechanism, climate change effects, and the roles of human activity in relation to climate change.

Learners' knowledge of climate change causes and mechanism. Literature examining learners' understandings of climate change causes and mechanism reveals several typical areas of difficulty for learners, including the greenhouse effect and the role of the carbon cycle in global climate change. Researchers have documented a variety of explanations for the causes and functioning of the greenhouse effect amongst K-12 learners (e.g., Boyes & Stanisstreet, 1997; Shepardson et al., 2009). One of the most prevalent findings is learners' conflation of the greenhouse effect with ozone layer depletion. A frequent explanation that learners provided was the notion that a hole in the ozone layer, resulting from anthropogenic pollution, allows more heat energy from the sun to reach Earth, causing global temperatures to increase. Francis et al. (1993) suggested that such explanations might be the result of a "fusion" (p. 390) of ideas about environmental problems in learners' minds. Similarly, Boyes and Stanisstreet (1997) identified seven discrete *linking models*, or conceptual models that learners have employed to connect the two phenomena.

More recently, several researchers have suggested that learners' confusion between ozone depletion and the greenhouse effect may be declining (Punter, Ochando-Pardo & Garcia, 2011; Shepardson et al., 2009). However, Hansen (2010) reported an *increase* in greenhouse effect and ozone hole conflation among Norwegian high school students, from questionnaires administered in 1989, 1993, and 2005. Jakobsson et al. (2009) warned against privileging such questionnaire results as indicators of what people know. They found that when given an opportunity to engage in discourse, learners were generally able to come to scientifically-accepted understandings.

Researchers have documented a number of other explanations of the cause and functioning of the greenhouse effect amongst K-12 learners. These include the view that the greenhouse effect: occurs when a layer of gases builds up, acting like the glass of a greenhouse; occurs when sunrays are unable to escape from Earth; or is caused by pollution in general (e.g., Boyes & Stanisstreet, 1997; Shepardson et al., 2009). In addition, researchers have identified a variety of factors that learners may view as exacerbating the greenhouse effect (e.g., Boyes & Stanisstreet, 1993; Rye & Rubba, 1998). Most prevalent in the literature is the view that the greenhouse effect is exacerbated by the use of chlorofluorocarbons (CFCs)—a view that is likely to accompany the *ozone hole* explanation of global warming. Other studies have documented learners' ideas that unrelated factors such as ground-level ozone, litter, rotting waste, radioactive waste, acid rain, artificial fertilizers, and nuclear power stations play a role in enhancing the greenhouse effect (e.g., Boyes et al., 1993; Kılınç et al., 2008).

Researchers examining learners' understandings of climate change have found that learners may also have incomplete understandings of the carbon cycle and its role in climate change. For example, learners may be unaware of the ways in which human use of carbon-containing fossil fuels disrupts the natural carbon cycle, or which gases contribute to the greenhouse effect (Punter et al., 2011). Jakobsson et al. (2009) noted that few learners could identify carbon dioxide as a greenhouse gas or were able to explain its relationship to global temperatures in terms of the carbon cycle. Liarakou, Athanasiadis, and Gavrilakis (2011) found that just over half of the Greek secondary learners in their study were aware that fossil fuel combustion was the main source of greenhouse gases, but some held the view that burning natural gas would not contribute to the greenhouse effect. However, they noted that understanding of the roles of greenhouse gases and fossil fuels in climate change appeared to increase with learners' ages.

Taking a learning progressions theoretical perspective, Jin, Zhan, and Anderson (2013) and Mohan et al. (2009) examined learners' understandings of carbon-transforming processes relevant to climate change. They identified four levels that describe learners' progressively more sophisticated explanations. The fourth (highest) level represents the knowledge they believe learners require in order to effectively evaluate arguments around global climate change. They found that few learners achieved this level of understanding by the time they graduated high school, suggesting that current approaches to curriculum and instruction have been inadequate for fostering sophisticated understandings of carbon transforming processes (Jin et al.).

Learners' knowledge of climate change effects. Researchers examining learners' knowledge of climate change have suggested that they generally understand climate change effects better than causes and mechanisms (Liarakou et al., 2011; Punter et al., 2011). Findings have suggested that learners may be able to identify a variety of scientifically-supported climate change effects, including warmer global temperatures, ice melt, increased flooding, changes in weather, sea level rise, desertification, and loss of plants and animals (e.g., Boyes & Stanisstreet, 1993; Shepardson et al., 2009), though their explanations of these may vary. Likewise, learners may also identify effects of climate change that are not scientifically supported, including varying connections with human health, water quality, and unrelated natural disasters (e.g., Boyes & Stanisstreet; Rye & Rubba, 1998).

While learners may be aware of key consequences of climate change, they may have difficulty providing scientific explanations for why they are occurring. Shepardson et al. (2009) found that although many learners could identify sea level rise as an effect of global warming, and some accurately attributed the phenomenon to polar ice melt, others cited increased precipitation. They also found that learners often only considered changes in local temperature and precipitation, rather than thinking in terms of long-term global patterns. Such thinking suggests that learners may conflate the concepts of weather and climate when reasoning about climate change effects. Further, closer examinations of learners' ideas about climate change effects may reveal differences in learners' views in comparison with the scientific community. For example, Gowda, Fox, and Magelky (1997) noted that high school students' estimates of global temperature change were often more dramatic than scientists' estimates.

Science education researchers have suggested that learners may view some unrelated phenomena as examples of climate change effects (e.g., Kılınç et al., 2008; Punter et al., 2011). For example, a number of studies have provided evidence that learners may view increased prevalence of skin cancer, food poisoning, and heart attacks as effects of climate change. In addition, researchers have suggested that learners may view climate change as related to water issues. For example, various studies have documented the view that the enhanced greenhouse effect will make some tap water unsafe to drink, and that the greenhouse effect is associated with river pollution or the poisoning of fish in rivers (e.g., Kılınç et al., 2008; Punter et al., 2011). Finally, a few studies have reported learners' confusion about the connections between climate change and sea level change. For example, some learners may reason that ocean levels would fall, rather than rise, as a result of increasing temperatures (Boon, 2010).

Learners' knowledge of human activities and climate change. Science education researchers have examined learners' ideas about the ways in which humans activities may contribute to climate change causes and solutions. These studies suggest that learners may be aware of key scientifically-supported connections between human activities and climate change. In particular, learners frequently identify fossil fuel combustion, the use of alternative energy sources, car use, electricity use, deforestation, and industrial pollution as connected with climate change (e.g., Bodzin & Fu, 2014; Boyes et al., 2008). However, learners may vary in their explanations of the mechanisms behind these interactions. Researchers have also identified a number of erroneous connections that learners may draw between human activities and climate change, such as identifying irrelevant human activities as relevant to climate change, or identifying all pro-environmental behaviors as helpful for addressing climate change.

While learners may correctly identify human activities that contribute to the causes and mitigation of climate change, explanations regarding *how* they are connected may vary. For example, while many learners cite fossil fuel combustion and car use as contributing to the greenhouse effect, they may not be able to accurately describe the ways in which greenhouse gases from these sources function to enhance the greenhouse effect. Similarly, when learners connect deforestation and forest conservation with climate change, they may vary in their understandings of the role of the carbon cycle in this relationship. Shepardson et al. (2009) and Kılınç et al. (2008) indicated that some learners were able to describe how planting trees could offset carbon dioxide emissions. However, learners may not recognize the nuances of this process, including the time lag between emissions of greenhouse gases and absorption by forests (Shepardson et al.). Learners have also frequently cited recycling as an approach to addressing global climate change. In cases like these, Gowda et al. (1997) suggested that learners may be employing "fuzzy environmentalism" (p. 2237), lumping together any well-known environmental harms (e.g., trash production, failure to recycle) with climate change, without understanding the cause-effect relationships at hand.

Similarly, researchers have also documented the ways in which learners may inappropriately attribute actions they view as generally harmful as linked with climate change. For example, learners have connected the issues of aquatic pollution, cigarette smoking, the use of unleaded gasoline, and the use of nuclear weapons and nuclear power with climate change (e.g., Boyes & Stanisstreet, 1993; Boyes et al., 1997). However, studies that have investigated the beliefs of learners from multiple age groups have shown evidence that such views may decrease with older learners. For example, Boyes & Stanisstreet (1993) found older learners less likely to connect nuclear bombs, dumping trash in rivers, and beach pollution with climate change. Other studies have highlighted several additional areas of confusion for learners, including the association of nuclear power, CFCs and aerosols, and unrelated aspects food production and consumption with climate change.

Insights from the literature: Learners' valuation of climate change. Many questionnaire-based studies have inquired about K-12 learners' levels of concern or worry related to climate change. In most of these studies, researchers found that a majority of adolescent and teen participants were worried—at least to some degree—about climate change (e.g., Boyes & Stanisstreet, 2001; Chhokar et al., 2011). Researchers have also examined the potential connections between learners' levels of concern and their knowledge about climate change. Boyes and Stanisstreet (2001) found that there were no considerable differences between younger and older learners' concern about climate change, though older students typically demonstrated greater knowledge. Likewise, Dijkstra and Goedhart (2012) found that environment-related attitudes of learners in France, Norway, Italy, Netherlands, and Spain did not correlate with knowledge about climate change. However, they noted that younger students typically believed climate change was a more urgent problem than older students.

Other researchers have reported a relationship between climate change knowledge and concern. When Australian students in Taber and Taylor's (2009) study demonstrated greater knowledge of climate change following an instructional intervention, they also indicated higher levels of concern. Similarly, Leiserowitz et al. (2011) compared levels of climate change knowledge and concern among U.S. teens and adults, reporting that teens were somewhat less knowledgeable *and* less worried about climate change than adults. Counter to many other studies inquiring about teens' levels of concern about climate change, Leiserowitz et al. found that a majority of U.S. teen participants were *either not very worried* or *not at all worried* about climate change. As these studies suggest, concern about climate change has been variable among groups of K-12 learners examined, and the relationship between learners' conceptual knowledge and concern about climate change may be elusive.

A number of studies have provided insight into the particular dimensions of climate change about which learners express concern. These have included fossil fuel use as a contributor to climate change (Devine-Wright et al., 2004); potential economic and political consequences (Albe & Gombert, 2012); environmental degradation (Kılınç et al. 2013); human health concerns (Byrne et al. 2014); concern for the wellbeing of future generations (Albe & Gombert); and concern for justice (Byrne et al.).

In some cases, researchers have examined such nuances through classroom-based studies focused on students' argumentation. For example, Byrne et al. (2014) studied the *interpretive repertoires* utilized by Swedish and British students in classroom discussions regarding strategies for reducing carbon dioxide emissions. They found that students' arguments typically placed value on maintaining the status quo or one's normal lifestyle, maintaining personal health, and being fair or just. A key finding was that these learners frequently based their concerns—in this case, regarding climate change mitigation strategies—on potential impacts to people's (including their own) everyday lives. These types of discussion-based studies demonstrate the nuances that qualitative inquiry may provide toward understanding the ways learners think and learn about climate change.

Insights from the literature: Learners' responses to climate change. Researchers have examined action, or willingness to act, as a dimension of learners' thinking about climate change. Such studies have provided insight into learners' ideas about actions that should be taken (and by whom), actions learners are personally willing to take, and in some cases, actions learners do take to mitigate climate change.

Using qualitative and quantitative approaches, researchers have examined learners' ideas about actions that should be taken to address climate change. Lester et al.

(2006) engaged U.S. 5th grade students in developing their own radio announcements related to climate change, before and after an instructional intervention. In examining learners' ideas about reducing or stopping the production of greenhouse gases, they found that after instruction, learners were more likely to advocate actions grounded in accepted scientific thinking, such as decreasing fossil fuel use, reducing deforestation, and using renewable energy.

Researchers have also examined students' ideas about who should be responsible for these actions. Using a closed-form questionnaire, Boyes et al. (2008) examined Chinese high school students' ideas about who should be responsible for taking action against global warming. They found that many students saw climate action as a shared responsibility (e.g., between government, industries, and individuals), and that they favored certain approaches (e.g., education, legislation) over others (e.g., individual or corporate taxation). In a separate study with students in China, Sternäng and Lundholm (2011) noted the importance of students' interpretations of *individual*, and whether they conceptualized individuals as themselves or others. Typically, when students framed others as the individual actors in question, they felt more strongly that individuals should take environmental action. In general, students appeared to hold the view that "others should act in favor of the environment, but not me" (Sternäng & Lundholm, pp. 1145-1146).

Several studies have examined learners' personal willingness to take the kinds of actions they believe are necessary for addressing climate change. With colleagues in various international settings, including England (Boyes & Stanisstreet, 2012), India (Chhokar et al., 2012), Turkey (Kılınç et al., 2013), and Australia (Boyes et al., 2009), Boyes and Stanisstreet administered questionnaires that inquired about learners' willingness to engage in specific direct and indirect actions. Examples of direct actions included reducing electricity use, using public transportation or more fuel-efficient vehicles, and changing consumption habits. Indirect actions included voting for international climate agreements, environmental legislation, environmental taxation, or participating in environmental education. Chhokar et al. (2012) noted that, generally across studies, learners were more willing to engage in actions involving less personal effort (e.g., switching off electronics) than those involving greater costs or potential inconvenience (e.g., taking public transportation).

An additional dimension of studies examining learners' willingness to take action is the potential connection between learners' knowledge and willingness to act. Chhokar et al. (2012) described the phenomenon of the *knowledge-action gap*, or the notion that environmental knowledge alone does not necessarily lead to a willingness to change behaviors. This phenomenon was evident in several studies of learners' thinking about climate change. For example, at times, even when many students saw given actions as effective, such as taking public transportation, relatively few expressed willingness to do so (Boyes et al., 2009; Kılınç et al., 2013). Conversely, for other actions, such as switching off electrical devices and recycling, learners expressed a high willingness to act, despite a general view that the action would *not* be very effective in terms of global warming. For a limited number of actions, including planting trees, reducing meat consumption, and purchasing fewer goods, Boyes et al. (2009) found relatively close alignment between learners' willingness to act and their beliefs about the effectiveness of the actions. These studies suggest a complex relationship between learners' knowledge and willingness to respond climate change. While knowledge about climate change is likely a precondition for informed action, it is unlikely to be the only one.

Though most studies examining students' thinking about climate change action have inquired about students' hypothetical actions or stated willingness to act, a few have examined the extent to which students actually do engage in various actions. McNeill and Vaughn (2012) examined how students use knowledge to take action. Before and after a curricular intervention on climate change, they interviewed students about their personal environmental actions. They found that after the intervention, nearly all of the students reported taking action to limit their impact on global climate change (e.g., taking public transportation or carpooling, using compact fluorescent light bulbs, and conserving electricity), compared with half who were doing so before the intervention. However, students' views regarding whether climate change was occurring did not change, as most maintained an affirmative view. This led McNeill and Vaughn to suggest that belief in climate change was not enough to motivate action.

Other researchers have explored the connection between students' concerns and actions related to climate change. Ojala (2012a) found that action appeared to be a coping mechanism for some learners in dealing with feelings of worry, despair, anger, and guilt related to climate change. Students who used this method of *problem-focused coping* reported engaging in individual preparatory actions (e.g., reading and planning about climate change solutions) as well as direct actions (e.g., saving energy, driving less, eating less meat). Ojala noted that these strategies were more common in older than younger students. As these types of studies suggest, learners' responses to climate change may be linked to a variety of interacting dimensions of their thinking.

Section 3: Perspectives on Climate Change and Context

The body of research examining learners' perspectives on climate change provides much potential insight into *what* learners may think regarding the topic. It also raises questions around *how* and *why* learners come to understand climate change in the varied ways that they do, and ultimately, what difference this understanding might make in the world. Otherwise stated from a figured worlds perspective: How might learners' figured worlds of climate change develop and change as they interact in diverse contexts? How might learners' ideas about their own lives in relation to climate change (identity), and how they choose to respond to these (agency), come to change learners and the conditions in which learners find themselves embedded?

To begin to consider questions regarding the potential interrelatedness of people's climate change perspectives and their conditions, a variety of avenues might be explored. In this third and final section of the chapter, I begin with an overview of social sciences literature that has examined the potential influence of context on people's understandings of climate change. I then offer an analysis of the ways in which context appeared to shape learners' ideas about climate change in the science education literature reported above. Finally, I summarize initial insights from literature regarding to how learners' understandings of climate change—or, their climate literacy development—may have the potential to shape their identities and senses of agency in relation to climate change, and ultimately their conditions.

Contextual influences on human understanding of climate change. Social sciences literature, particularly in the areas of climate change communications and anthropology, provides insight into the diversity of perspectives on climate change. It also suggests a variety of ways in which context may play a role in shaping perspectives.

Insights from climate change communication. Climate change communication research has underscored the diversity of views on climate change, particularly within the U.S. Leiserowitz et al. (2013b) surveyed Americans on their beliefs, behaviors, and policy preferences regarding global warming. They identified *Six Americas*, or unique audiences that respond to the issue in different ways (*the Alarmed, the Concerned, the Cautious, the Disengaged, the Doubtful, and the Dismissive*), arguing that the climate change communication community would need to approach each audience with customized messages, messengers, and methods specific to the group's psychology, culture, and politics (Leiserowitz et al., 2013).

Researchers have also pointed to diverse contextual factors that may play a role in shaping people's climate change perspectives. Kahan, Braman, Slovic, Gastil, and Cohen (2007) described how cultural worldview (i.e., communitarian vs. individualist; egalitarian vs. hierarchical) was associated with people's beliefs about the reality of climate change. Others have noted people's tendency to seek out (e.g., via media outlets) and interpret climate change information in ways that reinforced their predispositions or worldviews (Feldman, Myers, Hmielowski, & Leiserowitz, 2014; Kahan, 2010). Researchers have also suggested that views of climate change may be linked the views predominating in one's social circles, including family (Mead, Rimal, Roser-Renouf, Flora, Maibach, & Leiserowitz, 2012) and religious community (Jones, Cox, & Navarro-Rivera, 2014). For instance, Mead et al. (2012) found that adolescents were likely to perceive climate change risk in the same way as their parents.

While these primarily survey-based studies provide insight into potential factors influencing people's views of climate change, they generally do not examine in depth the ways in which the climate-related views of specific communities and individuals are formed. Research in anthropology can help to address this issue by providing a more fine-grained analysis of climate change perspectives in specific communities. Anthropologists have focused less on whether people believe that climate change is occurring, and more on how people experience and interpret climate change in local contexts.

Insights from anthropology research. The study of climate change and culture is an emerging area in anthropology (Crate, 2011). In reviewing the existing anthropology literature in this domain, Crate (2011) underscored the "unprecedented sense of urgency" (p. 176) that distinguishes this research area at present. A key example in anthropology literature of the relationship between climate change perspectives and context relates to people's place-based experiences with climate change. Particularly in indigenous communities whose daily lives are closely tied to the natural environment, people have described their understandings of climate change in terms of observations such as thinning sea ice, arrival of unfamiliar insects, disappearance of familiar species, and changes in precipitation (Crate, 2009; Jacka, 2009; Marino & Schweitzer, 2009). People have also described climate change through the lens of changes in cultural activities, for example, being no longer able to predict the weather (Crate, 2009), or experiencing new difficulties in hunting and producing food (Crate, 2009; Jacka, 2009). As with other kinds of personally-felt effects, Nuttall (2009) cautioned that observations about unusual weather should not be automatically considered evidence of climate change. However, particularly when many generations have inhabited the same environment, social memory of past climate conditions and cultural practices may provide a basis for interpreting environmental change.

Research in anthropology has suggested a number of other contextual factors that may shape people's perspectives on climate change. For example, anthropologists have reported that people may interpret climate change in terms of cultural metaphors, symbols, or narratives. Crate (2009) found that Sakha elders in Siberia understood local climate change by integrating their observations with knowledge from ancient Sakha proverbs and legends (e.g., the departure of *The Bull of Winter*). Anthropologists have also examined the potential roles of cultural views of change. Crate's research in Siberia demonstrated how Sakha elders viewed their cultural survival as dependent on maintaining the icy climate of their ancestors. They perceived climate change as making conditions progressively worse. Conversely, Nuttall (2009) described how some Inuit communities in Greenland were less concerned about the effects of warming temperatures, viewing themselves as highly adaptable and viewing the natural environment—and themselves—as being in an ongoing process of *becoming*. Given such differences in cultural views of climate change, some anthropology researchers have highlighted the theoretical lens of *cultural models* (Holland & Quinn, 1987) – which are "conceptualizations of figured worlds" (Holland et al., 1998, p. 55) – as promising for the study of climate change and culture (Crate, 2011). As this body of literature suggests, research in disciplines such as anthropology may offer science education researchers new theoretical perspectives and insights into the ways in which context may shape people's thinking about climate change.

Contextual influences on learner understanding of climate change. Although only a small number of studies in the science education literature have explicitly examined social and cultural factors that may influence learners' ideas related to climate change (e.g., Devine-Wright et al., 2004; Herman, 2014), many studies point to potential contextual influences shaping learners' ideas. I next describe the ways in which science education researchers have discussed a number of these potential influences.

Potential influence of public discourse. Some science education researchers have highlighted the potential influence of public discussions around climate change on learners' thinking. In particular, researchers have elaborated on climate change discussions in the political arena, and the ways in which these and other conversations around climate change are conveyed in the media.

Climate change in the political arena. Researchers have suggested that political discussions of climate change have the potential to increase awareness and understanding, but also to mislead (Albe & Gombert, 2012; Boon, 2010). For example, Chhokar et al. (2011) suggested that campaigns and legislation could increase learners' awareness and inform their understandings of issues. However, Gowda et al. (1997) warned that incomplete information from such sources could also be problematic. In addition, the treatment of scientific information about climate change as more tentative in political communities than in scientific communities may also have the potential impacts on learners' understandings (Fensham, 2014). Boon (2010) argued that political rhetoric had called to question compelling scientific evidence, which may have had implications for the limited attention to climate change in science education. A few have contested such views, arguing for the treatment of all scientific information regarding climate change as tentative. For example, Legates, Soon, and Briggs (2013) argued that, "all sides must be covered in highly debatable and important topics such as climate change" (p. 2008). In response to such arguments, Fensham (2014) warned against presenting scientific evidence with a degree of uncertainty as completely unknown, and therefore, inconsequential.

Mixed messages and varied interpretations of scientific information in the political arena may influence learners' ideas about the trustworthiness of climate change information communicated by policymakers. For example, in a classroom-based mock debate on climate change, Albe and Gombert (2012) noted that French high school students raised questions about the trustworthiness of information presented in the film, *An Inconvenient Truth*, because Al Gore's political interests may have shaped its message. They also raised questions about the trustworthiness of government-funded scientific research, as certain scientists might receive funding for political reasons. Their ideas suggest that trustworthiness of climate change information was a salient concern, and that their perceptions of political culture had the potential to influence their reasoning about climate change. In Britain, Boyes and Stanisstreet (2012) reported that few students stated that, as voters, they would consider a politician's willingness to legislate on the environment. The authors posited that this could be related to learners' tendency to distrust politicians, and argued that it could have major implications if a population's generally pro-environmental stance did not influence its voting patterns. As a counterexample to this mistrust, however, Ojala (2012) reported that Swedish secondary students in her study *did* express trust in politicians and appeared generally hopeful about international political collaboration on climate change. This raises questions about the potential sociocultural influences on learners' trust or distrust of various sources of information, as well as the discrepant types of political discourses to which learners in varying contexts might be exposed.

Climate change in the media. Science education researchers have suggested that media is a primary information source for adolescent learners (Boyes et al. 2008; Hansen, 2010). In particular, learners have reported getting much of their information about global warming and climate change from television and the Internet, though some also report getting information from books, newspapers, radio, magazines, and movies (Boon, 2010; Leiserowitz et al. 2011). Because adolescent learners have reported getting much of their information about climate change from media sources, it may be important to consider whether media messages are perceived as trustworthy or "media hype" (Boon, 2010, p. 110), whose perspectives are being portrayed (Fensham, 2014), and whether these perspectives are scientifically accurate (Hansen, 2010).

Some researchers have suggested that information from informal sources can become a source of learners' misconceptions (Boyes & Stanisstreet, 2001; Gowda et al. 1997), or may confuse scientific terms such as using *climate change* and *global warming* interchangeably (Dijkstra & Goedhart, 2012). Others have argued that brief reports in the media may provide learners with incomplete information about the complexity of climate change (Boon, 2010; Varma & Linn, 2012). Further, they may have negative affective impacts, such as inciting feelings of fear (Kılınç et al., 2013). However, other researchers have suggested that it is also possible for media sources to contribute to improving learners' understandings of climate change (Andersson & Wallin, 2000; Hansen, 2010). It appears, then, that media sources may have the potential to influence learners' understandings of climate change in various ways, though researchers have not analyzed in depth the types of media messages adolescents consume, or how these messages might vary according to the media sources consumed by learners in diverse contexts (e.g., within different locations; within different political or social environments).

Potential influence of education. Researchers have described how curriculum and instruction, in both formal and informal educational settings, have appeared to influence learners' understandings of climate change. More broadly, some researchers have described the ways in which institutional or school culture may play a role in shaping students' thinking.

School culture. Researchers examining students' ideas about and engagement with issues such as climate change have suggested that a school's culture and institutional emphases have the potential to influence how students think and act in relation to issues. That is, even where curricula are similar, the culture of the school may play an important role in shaping students' experiences, and ultimately, their learning. For example, Bencze, Sperling, and Carter (2012) studied student-led, research-informed activism around socioscientific issues in three Canadian secondary schools. They found that school culture contributed significantly to students' perspectives, and that certain school environments were more conducive to taking action than others. In one of the three schools they studied, many students were already involved in highly visible action projects and campaigns (e.g. an EcoTeam). Students in this context showed a considerably greater commitment to action than students in the other two schools, which Bencze et al. characterized as having cultures more narrowly focused on academic and technical goals.

In India, Chhokar et al. (2011) likewise found that students in the schools they studied had a high level or concern and a strong willingness to act in response to global warming. Here, the authors posited a relationship between these views among learners and the high profile of environmental education (e.g. Eco clubs, Earth Day celebrations, school assemblies on global warming) afforded by the schools' cultures. Similarly, in China, students in a Green School that had an explicit focus on environmental education expressed high levels of concern about global warming, and were highly willing to engage in environmentally friendly actions (Boyes et al., 2008). In each of these cases, it is plausible that school culture may have played a role in shaping students' ideas. However, the extent to which families already inclined to environmentally-sensitive views were drawn to these school communities was not investigated; that is, there is a potential for overlap between school culture and learners' social (e.g., family) environments.

Curriculum and instruction. Beyond school culture, the enactment of curriculum and instruction around climate change appears, in many cases, to influence students' thinking about climate change. For example, some curriculum implementation studies have shown changes in learners' understandings of climate change from pre- to post-intervention (Bodzin & Fu, 2014; Varma & Linn, 2012), suggesting that learners' interactions in the classroom environment (i.e., with teachers, peers, artifacts) may shape their understandings. This was evident in Varma and Linn's description of how, after curriculum implementation, learners in their study moved from explanations based on prior incomplete ideas (often from the media) to more scientifically-informed understandings of global warming and the greenhouse effect. However, other researchers have suggested that, in many cases, science curriculum and instruction have not been sufficiently effective in shaping students' understanding of constructs relevant to climate change (e.g. Jin et al., 2013). In either case, these ideas suggest that learners' classroom-based engagement with climate change may have implications for the ways in which they come to understand the topic.

When asked about their sources of information on climate change, students have cited school science as a key source of their ideas (Boon, 2010; Kılınç et al., 2008), suggesting that learners are aware of the influence of science curriculum and instruction on their thinking. Less overt to learners may be the institutional and cultural forces shaping curriculum and instruction, including how climate change content is (or is not) presented. Hansen (2010) noted how political and public attention to climate change led to the introduction of the topic into the Norwegian national curriculum. Boon (2010) critiqued how the *inattention* to climate change by the Australian government may have been linked to inattention to the topic in school science. Both authors suggested that these institutional influences had potential implications for student learning. Beyond the matter of *whether* climate change is presented in the classroom, a number of researchers have suggested that *how* the topic is presented is crucial, and that pedagogy must take into account students' backgrounds and cultural experiences for meaningful learning to occur (Lester et al., 2006). As these studies suggest, approaches to curriculum and instruction—mediated by myriad social and cultural factors—may play a role in shaping the ways in which learners come to understand climate change.

Potential influence of place and personal experience. In a number of studies, learners' own place-based experiences, including experiences with atypical weather events and with environmental problems in general, appeared to play a role in shaping their perspectives on climate change. For example, in comparison with learners in other contexts, students in India who were experiencing record high temperatures at the time they were surveyed expressed a greater degree of certainty that global warming was occurring (Chhokar et al., 2011). Chhokar et al. suggested that these perceptions may have been shaped not only by the physical impact of the heat wave, but also by the ways in which it was reported in the media. McNeill and Pimentel (2010) likewise described how learners in the U.S. readily cited personal experiences with unseasonably warm weather as evidence of climate change, and were less inclined to cite scientific evidence unless explicitly asked to do so. In this way, it appears that students may perceive their own experiences as among the most reliable sources of information about climate change.

Researchers have also suggested that learners' personal experiences with environmental problems in general may play a role, particularly in shaping their values and responses to climate change. Lester et al. (2006) noted some place-specific concerns in students' writing samples, such as concern about flooding in coastal communities. Noting that learners in Hong Kong expressed high levels of concern about air pollution, having experienced the problem firsthand, Yeung et al. (2004) suggested that direct confrontation with environmental problems may encourage environmental responsibility. However, they noted that by the time problems become experientially obvious, action may be difficult, costly, or impossible.

Potential influence of social relationships and social norms. Learners' social environments may also have the potential to shape thinking about climate change, particularly with regard to decision-making and action (Boyes & Stannistreet, 2012;

Kılınç et al., 2011). For example, Boyes and Stannistreet described how social norms could act as a disincentive for environmental action (e.g., negative social images among adolescent students of the use of public transportation). Learners may rely on social relationships, including the perspectives of family members and peers, in order to inform their understandings of climate change and appropriate response. Several researchers have identified family and friends as key sources of information on climate change that influence learners' thinking (Kılınç et al., 2013; Leiserowitz et al., 2011). Devine-Wright et al. (2004) described how particular social environments—in this case, a cooperative learning environment created amongst adults and children in an informal science education setting—had a significant positive impact on children's understanding of climate change. They also noted that learners' attitudes regarding environmental issues were likely to depend on family background.

Beyond influencing learners' understandings, attitudes, and actions related to climate change, social environments may also serve as sources of support for coping with concerns and fears related to the topic. Ojala (2012) described how some learners sought social support from friends or relatives as a coping strategy to regulate worry about climate change. She emphasized that the regulation of emotions related to climate change was a social process shaped by the ways in which people talked and interacted with one another. As such examples suggest, learners' social interactions may have important implications for their perspectives on climate change.

Potential influence of cultural views on environment, science, and technology. Cultural views on environment, science, and technology may be another factor shaping the ways in which learners come to think about climate change. Researchers have highlighted this notion particularly in studies that make cross-cultural comparisons among learners. Chhokar et al. (2011) described how respect for the environment, based on the view that all species have a right to exist, was deeply embedded in Indian students' culture. They suggested that this might partially explain why students in India appeared more environmentally concerned and more open to environmental action than students in Europe and Australia. Kılınç et al. (2011) made a similar argument to connect Turkish students' widespread self-identification as *environmentally friendly* with aspects of Turkish culture. They described how ancient Turkish beliefs about the sacredness of the natural world, combined with Islamic teachings about humans as members of the community of nature, had the potential to shape Turkish students' environmental perspectives and values in culturally-specific ways. More generally, in analyzing students' arguments about climate change in classroom settings, Byrne et al. (2014) noted how certain cultural values instilled in children at a young age (e.g., *save the planet*, *stay healthy*, *be fair*) showed up as interpretive repertoires that students employed to support their arguments.

Cultural views of science and technology may also shape students' thinking about climate change, particularly with regard to responses or solutions to problems. Byrne et al. (2014) identified that learners used *science and technology* as an interpretive repertoire in their argumentation about climate change, particularly the notion that climate change could be resolved by technological fixes. Stanisstreet et al. (2008) also noted this view among learners in China, who, for example, relied on technological solutions such as filters on factories in suggesting climate change mitigation strategies. Some researchers have suggested that, in particular, youth in Western cultures may hold views of technology and progress that could impact their decision-making and actions related to climate change (Skamp, Boyes, & Stanisstreet, 2013). As these examples suggest, predominant views of the environment, science, and technology may vary cross-culturally, and may play a role in shaping learners' climate change perspectives.

Learners' identity and agency in relation to climate change. Beyond acknowledging the contextual forces potentially shaping learners' perspectives on climate change, applying a figured worlds lens to climate change learning must also attend to learners' identity and agency development in relation to the topic. In a figured worlds view, 1) learners' conditions may shape the perspectives they develop on climate change (as described in the previous section), and 2) the perspectives learners develop on climate change may in turn *re-shape* these conditions as learners act within them. As Forman and Sink (2006) stated, a sociocultural perspective "requires a reflexive relationship between the social forces (historical, cultural, and interpersonal) that shape identity and the agency of individuals who author their own identities" (p. 15). Urrieta (2007b) described how learners' participation in figured worlds leads them to reconceptualize how they understand themselves (identity) and "their ability to craft their future participation" (p. 120) (agency) in and across figured worlds. Examining existing literature on science learning through a figured worlds lens can provide some initial insight—and raise new questions—around the ways in which learners may develop identity and agency as they learn about climate change. Here, I describe several studies in science education that have attended specifically to learners' identity and agency development as they learned about environmental issues. Such studies may shed new light on the ways in which learners' perspectives on climate change may re-shape their contexts as learners act within them.

Calabrese Barton and Tan (2010) examined the relationship between science learning and agency development among urban youth in a community-based program on green energy technologies. During the program, participants investigated whether their community was experiencing the urban heat island effect, a potential consequence of climate change. To share their findings, participants created documentary films. Calabrese Barton and Tan (2010) used ethnographic data to discuss the ways in which the youth asserted themselves as community science experts through their participation in the project. They explain that:

> Agency *with* and *in* science implies that students use the knowledge, practice, and context of science to develop their identities, to advance their positions in the world, and/or to alter the world toward what they envision as being more just (Calabrese Barton & Tan, 2010, p. 195).

In the study, participating youth showed potential evidence of agency—and of reshaping the conditions in which they were embedded—as they directed their own scientific investigations relevant to their community, took on the roles of community science experts, and integrated science into their own familiar discourse and culture.

Using the theoretical perspective of critical science agency (Basu, Calabrese Barton, Clairmont, & Locke, 2009), McNeill and Vaughn (2010) investigated how an urban ecology curriculum supported high school students' climate literacy and critical science agency development. Insights from the study suggested that, alone, learners' belief in the reality of climate change was insufficient for critical science agency; conceptual understandings of climate science as well as understandings of the role of personal actions were also essential. After engagement with the curriculum, McNeill and

Vaughn found that a majority of students had developed a stronger sense of agency in relation to climate change, and were engaged in actions to limit their impact on climate change. In this way, the study suggested that learners had the potential to reshape their conditions through the actions they chose to take (evidence of agency) as they developed climate literacy.

In the same study context, Price and McNeill (2013) examined the relationship between identity and meaning as learners engaged with the urban ecology curriculum. Price and McNeill examined meaning in three layers. *Meanings in person* related to how learners were shaped by, and drew upon their histories to shape, their present and future situations. *Meanings in intent* related to the “ongoing reflexive and deliberative processes” (p. 505) in which learners engaged. Finally*, meanings in practices* related to “how individuals act—or see themselves acting—in the world” (p. 505). Insights included that learners’ meanings in person related mostly to their lives in the classroom (e.g., prior knowledge and understandings of science content)—rather than to their worlds outside of school. However, meanings in intent and practice suggested that learners hoped to make an impact on their broader contexts, as they expressed their desires to take actions that would improve ecological health. Most often, learners framed environmental actions in individualistic and consumerist-oriented terms (e.g., using CFL light bulbs), which the authors suggested was reflective of rhetoric within the contemporary environmental movement. This provides an example of how dimensions of learners’ conditions may shape their figured worlds, and how learners’ actions in response (agency) may serve to reinforce these dimensions of their conditions. Conversely, Price and McNeill also noted instances of learners *resisting* individualcentered meanings, and "push[ing] for a broader sense of accountability not reflected in the consumerist approach to environmentalism" (p. 521). This provides an example of how agency development within figured worlds may lead learners to seek to transform, rather than reinforce, aspects of their conditions.

Environmental identity and perspectives in adolescence. Also pertinent to this study is a broader body of research on adolescents' development of environmental identities and perspectives. As Blanchet-Cohen (2008) suggested, adolescents are "discovering themselves and carving a place in the world" (p. 258); thus, adolescence may be a "pivotal" (p. 259) period of life for environmental involvement.

Environmental identity. Environmental identity, or one's connectedness with the natural environment (Clayton, 2003), is an emerging area of research in the study of adolescent development. Kempton and Holland (2003) described environmental identity development as a process involving stages of: *salience* (becoming aware of environmental issues), *empowerment* (seeing possibilities for making a difference with regard to the environment), and *activism* (actively engaging in environmental practices). Stapleton (2015) described how high school students' social interactions with diverse groups of people (e.g., those affected by climate change; peers engaging in environmental action) variably fostered these different types of environmental identity development.

Blatt (2013) investigated environmental identity among U.S. high school students, and described a variety of possible views of one's own relation to the natural environment, including viewing oneself: as a part of nature; as damaging to nature; as superior to nature; as separate from but connected with nature; and as a protector of nature. Drawing on prior research in social psychology, Blatt (2014) suggested that during adolescence, young people may be engaged in a struggle to define their relationship to the natural world, and “may change [their] view situationally and over time, as [their] identities are subject to the influences of culture, the media, and [their] encounters and experiences with the environment” (Blatt, 2013, p. 469). Blatt (2013) also described how other types of identities in adolescence, such as student identities and consumer-materialist identities, might conflict with young people’s environmental identities, producing tensions and emotions that they must navigate and seek to resolve.

Environmental concern and hope. Adolescents may often exhibit high levels of concern about environmental issues, but may also express pessimism around whether environmental issues can be resolved (Hicks and Holden, 2007). Hicks and Holden compared the environmental concerns of British primary and secondary students. At both levels, they found similar environmental concerns. However, as students got older, they became increasingly pessimistic about the future, and – in contrast to younger children – less likely to think they could bring about change through their actions. Ojala (2012b) also reported that although young people have interest in global problems, it is common for them to feel hopeless, pessimistic, and helpless. For example, Tucci, Mitchell, and Goddard (2007) reported that more than a quarter of the Australian 10-14-year-olds in their study believed the world might end in their lifetimes.

Feelings of hopelessness may often be accompanied by inactivity (Ojala, 2012b). Thus, Ojala suggested that finding ways to instill hope amongst young people is critical. This may be especially true in the case of climate change, “an existential issue closely connected with uncertainty about the future survival or our planet… [and possibly] evoking feelings of existential anxiety and hopelessness” (Ojala, p. 626). To address these challenges, some researchers have suggested the need for educational approaches that adopt “a futures perspective” (Hicks and Holden, 2007). Hicks and Holden suggested that young people need opportunities to consider “Where we have come from, where we are now, where we are probably heading, and where [we would] prefer to go” (p. 510). Ojala posited that hope about a better alternative future could be crucial in motivating young people to engage in environmental action.

Youth agency and environmental action. Relatedly, Blanchet-Cohen (2008) examined youth agency in relation to environmental involvement. Rather than viewing young people as “objects of the dominant paradigm”, Blanchet-Cohen argued that focusing on child agency assumes that “children play an active role in determining their lives” (p. 259) and are “social actors who shape, and are shaped by their circumstances or social structure” (p. 261). She identified six dimensions of environmental agency, including connectedness, engaging with the environment, questioning, belief in capacity, taking a stance, and strategic action. The 10- to 13-year-old youth in Blanchet-Cohen’s study were able to believe in their capacities to act when they saw environmental issues positively and saw themselves as able to make a difference. Although they were aware of their limitations, young people valued the impact of small-scale actions and perceived success in “doing the most I can” (p. 268).

Toward the goal of providing insight on key conditions for encouraging environmental action among children and youth, Chawla and Cushing (2007) reviewed literature relevant to promoting *strategic environmental behavior* – that is, behaviors that would be most effective for addressing environmental problems. They described how many educational efforts relevant to environmental problems have focused on the "private sphere" (e.g. turning off lights, recycling) over the "public sphere" (e.g., collective public action) (Stern, 2000). They argued that although local small-scale actions are important for developing an individual sense of competence, particularly for young children, by middle and high school, learners should also be developing a collective sense of competence by focusing on the role of citizens in collective actions related to the environment. Chawla and Cushing argued that educational experiences should provide young people with opportunities to take personal ownership of issues, set goals that are personally significant, and integrate action for the common good into their sense of identity.

Chapter Summary

In this chapter, I have presented a review of the literature informing my study. In the first section of the chapter, I introduced the theoretical perspective grounding the study. I described sociocultural learning theories and their applications in science education research; provided a rationale for applying sociocultural perspectives to the study of climate literacy development; presented the theoretical perspective of figured worlds (Holland et al., 1998); described how figured worlds have been applied in educational research; and argued the potential value of figured worlds for the study of learners' climate literacy development.

In the second section of this chapter, I reviewed science education literature reporting on learners' perceptions, knowledge, valuation, and responses related to climate change. Studies examining learners' perceptions of climate change suggest that learners vary in the extent to which they believe anthropogenic climate change is occurring, as well as in their levels of certainty regarding their stances. Studies examining learners' knowledge of climate change suggest that while learners may recognize a relationship between gases, the atmosphere, human activities, and global temperatures, they may have incomplete understandings of the phenomena involved. In addition, while learners may be aware of a number of scientifically-supported effects of climate change, they may also cite effects unrelated to global warming or climate change phenomena. Further, learners may correctly and incorrectly identify human activities that connected with climate change causes and solutions.

Studies examining learners' values (concern) related to climate change have suggested that school-aged learners are generally worried or concerned about climate change. However, some researchers have reported lower levels of concern among young people in comparison with adults (Leiserowitz et al., 2011). Learners may prioritize actions in response to climate change that do not conflict with their everyday lives or impose high costs in terms of effort or convenience. They may also view others as more responsible for taking action than they view themselves. In the case of climate change, there appears to be a complex relationship between knowledge and action, with some studies reporting a relationship between the two and others contesting this claim. In terms of learners' enacted practices, researchers have suggested that knowledge may be insufficient to motivate action, though an understanding of how one's personal actions can make a difference may help encourage learners to act and alleviate potential fears associated with climate change.

In the third section of the chapter, I described initial insights from social sciences and science education literature regarding the interrelationship between context and climate change understandings. I began by describing some of the ways in which the climate change communication and anthropology communities have explored the influence of social and cultural context on people's perspectives on climate change. I then provided an analysis of key themes from the science education literature regarding potential contextual influences on learners' thinking about climate change. These included the potential influences of public discourse (in politics and the media), education (curriculum and instruction and school culture), place and personal experience, social relationships (family, peers), and cultural views of environment, science, and technology. After suggesting how learners' perspectives on climate change could be shaped by their contexts, I summarized initial insights from science education literature examining how learners' developing understandings of climate change—or, their climate literacy development—may have the potential to shape their identities and senses of agency in relation to climate change. I concluded by highlighting the potentially dialectic nature of the relationship between context and learners' climate change perspectives.

In the next chapter, I describe how the key ideas articulated here intersected to motivate my study. I then describe in detail the methods I used to empirically investigate the relationship between middle school science learners' conditions and their developing understandings of climate change through the use of a figured worlds lens.

Chapter Three: Methodology

The purpose of this case study was to investigate the nature of the relationship between middle school science learners' figured worlds of climate change and the conditions, or contexts, of their daily lives. Toward this end, my central research question was: *How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded?* Sub-questions related to this inquiry included:

1. What is the nature of learners' ideas (i.e., their perceptions, knowledge, values, and responses) in relation to climate change?
2. To what extent, if any, do learners' conditions appear to shape their climate change ideas?
3. To what extent, if any, do learners see climate change as relevant to their own lives?
4. How, if at all, might learners' ideas about climate change shape (reinforce or change) the conditions in which they are embedded?

In light of these questions, I used qualitative case study methods to gain insight into the figured worlds of climate change among eight 6th grade learners in one school site. This chapter provides a justification for the use of a case study approach, describes data collection and analysis procedures, and addresses issues of trustworthiness.

Justification for the Use of Qualitative Inquiry

Stake (2010) characterized qualitative inquiry as interpretive, experiential, situational, and personalistic. This study was *interpretive* in that it focused on human experience—in this case, the conditionally-mediated experience of climate change learning. Rather than seeking to control and explain climate change learning, or to identify cause-effect relationships, I sought deeper understanding of the climate change learning experience. As a researcher, this meant taking ongoing interpretive role throughout the study (Stake, 1995). The study was *experiential* in that it was field-based, taking place in a middle school setting, and in its focus on participants' observations and reflections in relation to climate change learning experiences. The study was *situational* in the sense that I sought to examine the importance of context in shaping learners' perspectives on a topic, which required learning much about the contexts, or conditions, in which learners were embedded. Finally, the study was *personalistic* in the sense that I was ultimately interested in what climate change came to mean for these particular learners, and how they saw themselves and their own lives in relation to climate change.

Qualitative research consists of practices that make worlds visible (Denzin & Lincoln, 2003). In collecting varied forms of data regarding climate change learning in a middle school setting, I sought to *make visible*—to the extent possible—learners' figured worlds of climate change. Through this process, qualitative researchers "interpret phenomena in terms of the meanings people bring to them" (Denzin & Lincoln, p. 5). Accordingly, my research question lent itself to interpreting the phenomenon of climate change learning in terms of how it *came to matter* (Callison, 2014) for the 6th grade participants. Finally, qualitative research takes place in historical moments. Denzin and Lincoln identified the present moment in qualitative research as being characterized by its attention to moral discourse. As a phenomenon Gardiner (2006) described as "a perfect moral storm" (p. 398), research regarding human engagement with climate change lends itself to inquiry around moral concerns. In seeking insight into learners' figured worlds of climate change, I sought to understand learners' moral commitments. I treated these as a valuable lens for interpreting learners' views of themselves (their *climate change identities*) and their capacities to act (their *climate change agency*) in relation to climate change. That is, I examined how learners thought the world ought to be, and how they saw themselves as agents in realizing that vision. In doing so, I sought to engage the challenge of connecting qualitative research with societal "hopes, needs, goals, and promises" (Denzin & Lincoln, p. 4).

Taken together, I argue that the characteristics and aims of qualitative research aligned well with the study I sought to conduct, and that the use of a qualitative inquiry approach was justified. Within the realm of qualitative inquiry, I next selected a qualitative research method that would lend itself to addressing my research questions.

Justification for the Use of Case Study

I chose to use case study to investigate my research questions. Among the strengths of case study method are its depth, its understanding of context and process, its ability to link causes of a phenomenon with outcomes, and its ability to foster new research questions (Flyvbjerg, 2011). However, Flyvbjerg warned that case study is often misunderstood as a research method, and clarified the points that: 1) concrete case knowledge is valuable in its own right (contrary to the view that predictive theories and universals are of greater value); 2) the "force of example" (p. 305) inherent in case study is valuable to scientific development (contrary to the view that formal generalization is the only source of scientific development); 3) case study can be valuable for theory-building (contrary to the view that case study may only serve as a first hypothesis-generating step of a larger research process); 4) case study is *not* unduly biased toward confirming the researcher's preconceived notions (contrary to the view that case study contains a greater verification bias than other research methods); and 5) case study is most valuably read as narrative in its entirety (contrary to the view that general propositions and theories are the only valuable outcomes of research). I approached my use of case study with these precautions in mind.

In designing my case study, I drew primarily from Stake's (1995) *The Art of Case Study Research*, with additional guidance from Yin's (2014) *Case Study Research: Design and Methods*. I drew from these two theorists each for specific reasons. Stake's approach to case study, with its focus on storytelling, was well-aligned with my theoretical perspective of figured worlds, which is likewise interested in participants' stories. Stake emphasizes that there is no singular way to conduct a case study, and describes a "palette of methods" (xii) from which the researcher must choose. This allowed for the use of creative approaches in my data collection (e.g., the use of art) and reporting (e.g., the use of a storytelling heuristic). However, in instances where I required additional guidance in my research process—particularly related to data collection procedures and issues of trustworthiness, I found the specificity of Yin's guidance to be useful.

Stake described case study as the study of "the particularity and complexity of a single case, coming to understand its activity within important circumstances" (xi). Similarly, Yin defined a case study as an in-depth empirical inquiry that investigates a *case*, or contemporary phenomenon, within its real-world context. Both definitions include a notion of a case, or phenomenon, and the circumstances, or context, in which it occurs. Because my study sought to understand climate change learning (the phenomenon, or case) amongst middle school science learners, and the intersections of this phenomenon with the circumstances in which learners were embedded (their context, or conditions), a case study approach was appropriate. According to Yin, the boundaries between the case and the context may not be sharp. Therefore, case study research can be especially useful in situations in which understanding a phenomenon is contingent upon understanding the context in which it occurs (Yin).

Case study research is unique in terms of its design and data collection procedures. Case study designs may be single-case or multiple-case designs, with single (holistic) or multiple (embedded) units of analysis (Yin, 2014). This study employed an embedded single-case design, which was *instrumental* (Stake, 1995) in nature. The purpose of instrumental case study is to seek understanding of a phenomenon that may extend beyond a particular case, but through the study of a selected case. In posing my research question, I was interested in the phenomenon of climate change learning; or, stated in light of my theoretical perspective, how learners *figure a world* of climate change. I believed that I could gain insight into the phenomenon by studying learners in one middle school setting, acknowledging that the phenomenon was also occurring in participants' lives that extended beyond that setting. The embedded units of analysis within the case were eight 6^{th} grade learners.

The collection of multiple sources of evidence is central to all case study research designs (Yin, 2014). In general, case study data sources may include, but are not limited to, documents, archival records, interviews, direct observation, participant-observation, physical artifacts, audiovisual materials (Yin). Following Stake (1995), I considered which available sources of case study data might provide insight into the questions:

“What needs to be known?” (p. 54) [the nature of learners’ figured worlds of climate change] and “What are some possible relationships that may be discovered?” (p. 54) [the relationship between learners’ conditions and their figured worlds of climate change]. I relied on multiple sources of data, including observations (teaching and learning of climate change content in a 6th grade science classroom), documents (student assignments, curriculum documents), artifacts (participants’ self-generated drawings), and interviews (individual (teacher, parents, learners) and focus group (learners)) as data sources.

Stake (1995) explained that data gathering in case study often takes the form of stories people tell, and that this storytelling form may be preserved in what researchers convey to their readers in reporting the case study. Therefore, in presenting the case, a case study researcher must make decisions about the extent to which they will use a story form (Stake). For guidance in this area, I referenced Leavy’s (2009) chapter on narrative in *Method Meets Art: Arts-Based Research Practice*. I did not characterize my research method as narrative inquiry, seeking to stay true to my chosen research method of case study. However, I saw insights from arts-based research (e.g., narrative inquiry) as potentially informative to case study research, particularly in articulating the means by which researchers extract themes from data and “[configure] stories making a range of disconnected research elements coherent” (Kim, 2006, p. 5, in Leavy, 2009). To provide a framework for such “restorying” (Leavy, p. 7), I referred to Truby’s (2007) *Anatomy of a Story: 22 Steps to Becoming a Master Storyteller*. I viewed Truby’s framework as providing helpful guidance on the story elements to which I, as a case study researcher, might attend within the collected data.

To summarize, I argue that the research question I posed, *How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded?*, was well-suited to investigation through the qualitative research method of case study. The question related to a phenomenon and its circumstances, which could be investigated with participants in a bounded setting where multiple data sources were available for investigation. Through the analysis of these diverse data sources, I was able to interpret and retell stories in ways that provided insights relevant to addressing the research question.

Case Selection

The phenomenon of interest in this study was climate change learning amongst middle school students. In line with my chosen anthropological theoretical perspective of figured worlds (Holland et al., 1998), I viewed the phenomenon of climate change learning in terms of learners' identity and agency in relation to climate change. To engage in the study of this phenomenon, an initial task was to select a case – in this situation, a middle school science-learning environment. Stake (1995) noted that that although case study researchers do not study cases primarily to understand other cases, "some cases would do a better job than others" (p. 4) in providing insights relevant to the question at hand. With this in mind, Stake argued that the principal goal in case selection should be to maximize what can be learned.

During my case selection process, I considered the affordances and limitations of selecting a school-based versus non-school-based learning environment in which to study the phenomenon of climate change learning. Prior research has suggested that U.S. teens may learn about climate change from mass media, their parents, and other out-of-school information sources (Leiserowitz et al., 2011). Therefore, I might have been able to study adolescents' climate change learning in their home environments, for example. Alternately, I could have examined climate change learning in the context of an informal science education setting such as a museum or afterschool program in which adolescent learners were engaged with climate change. However, during the timeframe in which I sought to collect data (Spring 2015), I did not have access to any such programs. Regarding the option of studying learners in their home environments, I could have no assurance that my phenomenon of interest – climate change learning – would be likely to occur.

With these limitations in mind, I opted to conduct my case study in a school-based setting, where climate change was included as part of the science curriculum. I regarded this option as maximizing my opportunity to learn (Stake, 1995) about the phenomenon, because I could be assured that the science teacher would seek to create an environment in which climate change learning could occur among middle school learners. However, so as not to miss the opportunity to gain insight into participants' out-of-school climate change learning, I inquired about this in my student interview protocol and opted to also interview participating middle school students' parents. In doing so, I believed I could gain a more holistic sense of the phenomenon of climate change learning amongst middle school learners, and its intersections with the varied conditions in which learners were embedded.

For logistical reasons, I opted to select a local school-based study site, rather than in another part of the country or world. I anticipated that my site-based data collection would span up to eight weeks, during which time I had other on-campus obligations as a doctoral student and graduate assistant. I acknowledge that conducting the study in another setting might have been equally, or perhaps more, fruitful. Nonetheless, I saw my local context as an appropriate setting for conducting research on climate change learning, because the state department of education had already adopted the Next Generation Science Standards (NGSS), which explicitly include the topic of climate change. However, the state was still in the midst of a five-year NGSS rollout process. This meant that at many schools, the NGSS—and climate change education—were not yet being formally implemented in science classrooms. This limited the school-based science learning environments from which I could select that would be conducive to the study of climate change learning.

As a member of the NSF-funded MADE CLEAR climate change education research project, I had served as a facilitator and researcher at a regionally-based summer teacher professional development academy on climate change education (Hestness et al., 2014; Hestness, McGinnis, Breslyn, McDonald, & Mouza, in preparation; Shea, Mouza, & Drewes, in press). Participants in the academy included practicing science teachers from the local region who were interested and engaged in climate change education. One of the participating teachers who agreed to participate in research during the academy, Ms. Asaan (pseudonym), taught 6^{th} grade science at Fairview Middle School (pseudonym), a blended learning charter school where climate change was already integrated as part of the school's science curriculum. Because Ms. Asaan was open to research participation, was already teaching middle school learners about climate change, and was locally-based, I saw her classroom as a strong potential site to conduct my case study.

I met with Ms. Asaan at the beginning of the following school year (2014-2015) to invite her and her students to participate in my case study. By that time, Ms. Asaan had moved into a new role at the school, and was no longer teaching 6th grade science. She introduced me to the new 6th grade science teacher, Ms. Kane (pseudonym), who was amenable to opening up her 6th grade science classroom as a study site – both for the case study I describe here, and for a separate study of climate change education conducted by our MADE CLEAR research team (McGinnis, Breslyn, & Hestness, 2016). Since Ms. Kane had not participated in the MADE CLEAR summer professional development academy on climate change education, our MADE CLEAR research team offered to provide her with additional instructional support and resources (described in the *Study Context* section) in line with what participants in the summer professional development academy had received.

Participant Selection

I designed my case study as an instrumental (Stake, 1995) embedded single-case design (Yin, 2014). The *case* itself was the phenomenon of climate change learning among middle school learners enrolled in Ms. Kane's 6th grade science course at Fairview Middle School. The embedded units were a small group of eight purposefully selected 6th grade learners. Qualitative methodologists vary in their guidance regarding the selection and number of within-case participants on whom to focus (Onwuegbuzie & Leech, 2007). Some examples of prior case studies that have applied a figured worlds lens to examine learners' perspectives have reported on the thinking of two (Tan & Calabrese Barton, 2008), four (Jurow, 2005), and six (Rubin, 2007) learners.

In designing my study, I planned to include six middle school learner participants and their parents. I believed that including six learners would be sufficient to obtain a variety of perspectives while maintaining a logistically feasible plan for data collection and analysis. In case of attrition or anticipated logistical complications (e.g., difficulties scheduling interviews with busy parents), I opted to invite eight 6^{th} grade learners and their parents (one parent each) to participate in the study. Seven of the invited learners and their parents consented to participate. The remaining 6^{th} grade learner agreed to participate, but his parents declined. I then invited one additional 6^{th} grade student and his parents, who agreed to participate. I did not encounter any attrition, and was able to complete interviews with all eight learners and their parents. Because all provided rich data that contributed to my learning about the phenomenon of study, I ultimately opted to include the data from all eight participants and their parents in my data analysis and case reporting. Thus, I increased the number of case study participants from six middle school learners (and their parents) to eight.

Stake (1994) emphasized that although case study researchers should seek variety, they should acknowledge they will not necessarily achieve representativeness. Instead, he advised, “the primary criterion is opportunity to learn” (Stake, 1994, p. 244). Because my data collection relied, in part, on participants’ ability to express their ideas verbally through individual interviews and focus groups, one of my goals was to select learners who had the ability to verbally articulate their perspectives. Second, I hoped to select learners who represented the racial and ethnic diversity of the school, as well as to include both male and female learners. Finally, I believed I could maximize my learning by selecting participants who represented a variety of perspectives on climate change.

Yin (2014) suggested that querying people knowledgeable about candidates can be a particularly valuable approach to screening. However, school district policy stated that researchers were not permitted to involve teachers in the participant selection process. Fortunately, because of my prior presence in Ms. Kane's classroom as a researcher during a separate study, which began several weeks prior to the present case study, I was able to get acquainted with the 6th grade students in advance of my study. During the previous study, I had the opportunity to interview some of the 6th grade students, examine their written and online work, and observe their classroom participation.

I selected eight 6th grade participants based on earlier observations and interactions in the 6th grade science class. First, I had some insight into these learners' abilities to express their ideas verbally. Second, I had some insight into these learners' ideas about climate change, as expressed in their written and online work. Finally, I had knowledge that these learners and their parents were open to research participation. In Table 3, I present a brief profile of the eight middle school learners who, along with their parents, consented to participate in my case study. I provide information about my rationale for inviting each learner to participate. I argue that in selecting these eight 6th grade participants, I achieved my aims of diverse representation and high opportunity for learning about my phenomenon of interest: climate change learning among middle school students.

Table 3

Profile of Case Study Participants and Rationale for Selection.

Participant pseudonym	***Sex***	***Race/ethnicity, parents' background***	***Evidence of verbal communication abilities***	***Evidence of climate change perspectives***
Aliyah	F	Black (African-American mother)	Demonstrated verbal communication abilities in interview	Relatively high level of background knowledge (83% on pre-assessment); vivid depiction of displacement from climate change in drawing
Autumn	F	Black (African-American mother, Nigerian father)	Demonstrated verbal communication abilities in interview; asked to participate in more interviews	Relatively high level of background knowledge (83% on pre-assessment); global awareness (father lives overseas), concern for health
Bobby	M	Biracial (European American mother, African American father)	Demonstrated verbal communication abilities in interview; eager to participate in interviews	Relatively low level of background knowledge (28% on pre-assessment); interest in geography and weather in relation to climate change
Isabelle	F	Biracial (Mexican American mother; European American father)	Demonstrated verbal communication abilities in interview and during observations	Moderate level of background knowledge (72% on pre-assessment); strong science identity (scientist grandfather); strong emotions about climate change risks
James	M	Black (Jamaican mother and father)	Demonstrated verbal communication abilities in interview; observed as inquisitive during class	Relatively low level of background knowledge (50% on pre-assessment); high level of concern for animals, natural disasters

Participant pseudonym	*Sex*	*Race/ethnicity, parents' background*	*Evidence of verbal communication abilities*	*Evidence of climate change perspectives*
Richie	M	Latino (Salvadoran mother, Mexican father)	Demonstrated verbal communication abilities in interview; observed as very inquisitive during class	Relatively low level of background knowledge (50% on pre-assessment); interested in renewable energy after family installed solar panels
Sarah	F	White (European American mother, Dutch father)	Demonstrated verbal communication abilities in interview	Relatively high level of background knowledge (89% on pre-assessment); cause-effect explanations; high environmental awareness
Sophia	F	Middle Eastern (Egyptian mother and father)	Demonstrated verbal communication abilities in interview	Relatively low level of background knowledge (50% on pre-assessment); concern for animals; global awareness (international travel)

Context of the Study

Because case study research is interested in understanding a case, or phenomenon, and the circumstances in which it is occurring (Stake, 1995; Yin, 2014), a case study researcher's attention to context is crucial. Stake (1995) suggested that case study researchers generally expect that "phenomena are intricately related though many coincidental actions and… understanding them requires looking at a wide sweep of contexts: temporal and spatial, historical, political, economic, cultural, social, and personal" (p. 43). With this in mind, I approached my case study with the assumption that the eight 6th grade learners were embedded within a "wide sweep of contexts" (Stake, p, 43) with potential implications for their climate change ideas. In line with my sociocultural perspective on learning, I recognized that learners' ideas could be shaped both through direct interaction with the *people and cultural objects* (Vygotsky, 1978) encountered in daily life (e.g., teachers, parents, curricula, media), but also that the people and cultural objects in participants' daily lives were embedded within a set of broader, potentially interacting circumstances (e.g., spatiotemporal, historical, political, economic, social, cultural, and personal). I further recognized that these broader circumstances could be examined at a variety of scales (e.g., globally, nationally, regionally, locally).

Taking this view, it becomes implausible to fully describe the context in which the phenomenon of climate change learning was occurring for the 6th grade learners participating in my study. Nonetheless, I needed to describe the study context to the extent possible, particularly with regard to the presence of varied forms of contextually-mediated climate change information and ideas surrounding the learners. Toward this end, I describe some key features of the shared multileveled contexts in which learners were embedded, as well as some key features of each learner's unique out-of-school context. In line with my theoretical perspective of figured worlds (Holland et al., 1998), I consider these multifaceted, multileveled contexts as collectively comprising learners' *conditions*.

To a considerable degree, the eight participating 6th grade learners shared a common set of climate change learning conditions. They attended the same school, and were all introduced to the same ideas about climate change by the same science teacher. The students all lived in the county and state where the school was located, which had specific sets of policies related to climate change and to science education. The students were embedded within the same geographic region of the United States, facing a particular set of regionally-specific climate change vulnerabilities (U.S. Global Change Research Program, 2014). They had all lived in the United States for their entire lives (from birth in 2003-2004 to the time of the study in 2015), where climate change has been a highly publicized and often polarizing topic (Leiserowitz et al., 2013). And finally, they were all growing up within the context of worldwide scientific research (IPCC, 2014) and international negotiations in relation to climate change (e.g., United Nations Framework Convention on Climate Change, 2015). During their lifetimes, climate change impacts were being observed across the nation (U.S. Global Change Research Program, 2014) and world (IPCC, 2014) amidst some of the hottest years in recorded history (World Meteorological Association, 2015).

At the same time, participants' climate change learning contexts varied in some ways. Their lives outside of school, while experienced largely in relatively close proximity, were unique. The individual 6th graders' family structures varied, and family members themselves varied in terms of the ideas and experiences they shared with participants regarding climate change. Participants also spent their out-of-school time interacting with different kinds of people and resources, guided by their unique individual interests or the interests of those around them. Participants' lives outside of school extended at times beyond their local communities, as some of the learners traveled to other parts of the state, country, and world, and engaged in experiences that shaped their ideas related to climate change and environment. They also all engaged with different kinds of information through media sources such as television and the Internet, expanding their contexts for learning beyond their immediate surroundings.

Participants' shared conditions. Participants' shared climate change learning conditions included their classroom, school, local, regional, national, and global contexts. Woven throughout each of these were unique dimensions of the precise times in which the students were experiencing these contexts, and in which the study was taking place.

Global level. At the time of the study, climate change was a subject of international scientific research efforts. The year prior, the Intergovernmental Panel on Climate Change (IPCC) – the leading international body for the assessment of climate change - had released its Fifth Assessment Report (AR5) (IPCC, 2014). The report reiterated that human activities were "extremely likely" (IPCC, 2014, p. 4) to have been the dominant cause of Earth's observed warming, and that the evidence for human influence on the climate system had grown since the IPCC's Fourth Assessment Report (AR4) in 2007. It also stated that "substantially more" (IPCC, 2014, p. 7) of the changes to Earth's physical, biological, and human systems were attributable to climate change than previously reported. Media coverage (broadcast, print, and social media) and framing of the report's findings varied internationally. For example, O'Neill, Williams, Kurz, Weirsma, and Boykoff (2015) reported that the AR5 report garnered five times more media coverage in the U.K. than in the U.S.

In addition to being a topic of international scientific research, climate change was also a topic of focus for the international development community. The 2015 Millennium Development Goals Report stated that climate change was undermining the development progress achieved in other areas, and that "addressing the unabated rise in greenhouse gas emissions and the resulting likely impacts of climate change… remains an urgent, critical challenge for the global community" (United Nations Development

Programme, 2015a, p. 8). Toward this end, the U.N.'s 2030 Agenda for Sustainable Development outlined seventeen Sustainable Development Goals (SDGs), including taking "urgent action to combat climate change and its impacts" (United Nations Development Programme, 2015b, p. 25). Pope Francis (2015) echoed this message in his papal encyclical on the environment, *On Care for Our Common Home*, released during this study. It emphasized that climate change is an urgent global concern disproportionately affecting the poor, and argued that the world has a moral imperative to act (Pope Francis, 2015).

In the geopolitical sphere, world leaders were preparing for the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) in Paris, which occurred several months after this study took place. The goal of the much anticipated conference was to achieve the first legally-binding and universal international agreement on climate. Leading up to the conference, climate activists rallied in cities worldwide (BBC, 2015). Ultimately, 195 nations developed the historic Paris Agreement in December 2015, with a stated goal of keeping "global temperature rise this century well below 2 degrees Celsius and… driv[ing] efforts to limit the temperature increase even further to 1.5 degrees Celsius above pre-industrial levels" (UNFCCC, 2015, para 3).

National level. In the United States, the Federal government-led National Climate Assessment (U.S. Global Change Research Program, 2014) reported that climate change impacts were already underway nationwide. The report outlined the intersections between climate change and various U.S. sectors (e.g., water, energy, agriculture) and communities (e.g., urban, rural, Indigenous). It also described climate change impacts by geographic regions, with the intention that the American public might gain insight into the impacts of climate change for their localities. Meanwhile, U.S. state departments of education were deliberating the adoption or moving forward with the implementation of the Next Generation Science Standards (NGSS Lead States, 2013), the first set of U.S. national science standards to explicitly include the topic of climate change. In some states, such as Wyoming and West Virginia, lawmakers viewed the inclusion of the climate change topic as a reason *not* to adopt the standards – at least without altering the way in which climate change would be presented to students (Schrank, 2015). In other states, such as Maryland, the inclusion of the climate change topic in the NGSS supported existing statewide efforts around improving learners' environmental literacy.

Across the U.S., the diversity of views on the inclusion of climate change in the science curriculum reflected the diversity of views about climate change that existed amongst the American public. In 2014, estimates of public opinion suggested that 63% of Americans believed global warming was happening, and just less than half of Americans (48%) agreed with the scientific-consensus view that global warming is caused mostly by human activities (Howe, Mildenberger, Marlon, & Leiserowitz, 2014). In 2015, climate change continued to be a divisive topic amongst U.S. presidential candidates running for election in 2016, with some candidates denying that climate change is a real phenomenon and others outlining specific plans of action to combat climate change (Kelly, 2015).

Regional and state level. At the regional and state level, learners were situated in a geographic area, a coastal state in the Northeastern U.S., where certain impacts of climate change were presenting growing challenges (U.S. Global Change Research Program, 2014). The National Climate Assessment highlighted heat waves; coastal flooding; infrastructure damage; sea level rise; intense precipitation events; compromised agriculture, fisheries, and ecosystems; and hurricane vulnerability as concerns for the Northeastern Coastal region where participants lived (U.S. Global Change Research Program, 2014). In recent years, the region had experienced several major hurricanes, including Hurricane Irene in 2011 and Hurricane Sandy in 2012. Located in a hotspot of accelerated sea level rise (Sallenger et al., 2012), the state's sea level rise projections anticipated a 2.1-foot rise in the state's coastal waters by the year 2050, and a 3.7-foot rise or more by 2100 (Boesch et al., 2013). Survey research suggested that a majority of the state's residents (55%) believed that protecting the coasts from sea level rise should be an important priority of the state government, though more than a third of the respondents (36%) stated that they were unsure whether human activities or natural processes were causing sea level rise (Akerlof & Maibach, 2014).

The State Department of Education mandated environmental education in the public schools, and the state was the first to pass an environmental literacy graduation requirement for its graduating high school students. Public school teachers were expected to integrate the state's environmental literacy standards into their curricula, though students were not specifically assessed in relation to these standards. The state's environmental literacy standards did not specifically mention climate change. However, the state was one of the first to adopt the Next Generation Science Standards, which include performance standards related to climate change at the middle and high school levels. At the time of the study, the rollout of the Next Generation Science Standards was underway statewide. In general, the NGSS were not yet being implemented at the classroom level, though they were already integrated into the science curriculum at Fairview Middle School.

Local and community level. The suburban county in which the study took place, Douglass County, was located just outside of a major East Coast city. It is the second-largest county in the state, and home to the state's largest public university. Douglass County is predominantly Black/African American (64.5%), with 19.2% of residents identifying as White, 14.9 % Hispanic/Latino, 8.5% some other race, 4.1% Asian, 3.2% two or more races, 0.5% Native American, and 0.1% Native Hawaiian or Pacific Islander (U.S. Census Bureau, 2010). The county is the most affluent majority African American county in the U.S., with a median household income of $71,696 (U.S. Census Bureau, 2010). Of the county's total population, 7.4% live below the poverty line (U.S. Census Bureau, 2010). The Douglass County School District is one of the 25 largest in the U.S., operating 208 schools and centers. In recent years, the charter school movement had grown in the county. At the time of the study, the Douglass County was home to 10 public charter schools, including Fairview Middle School.

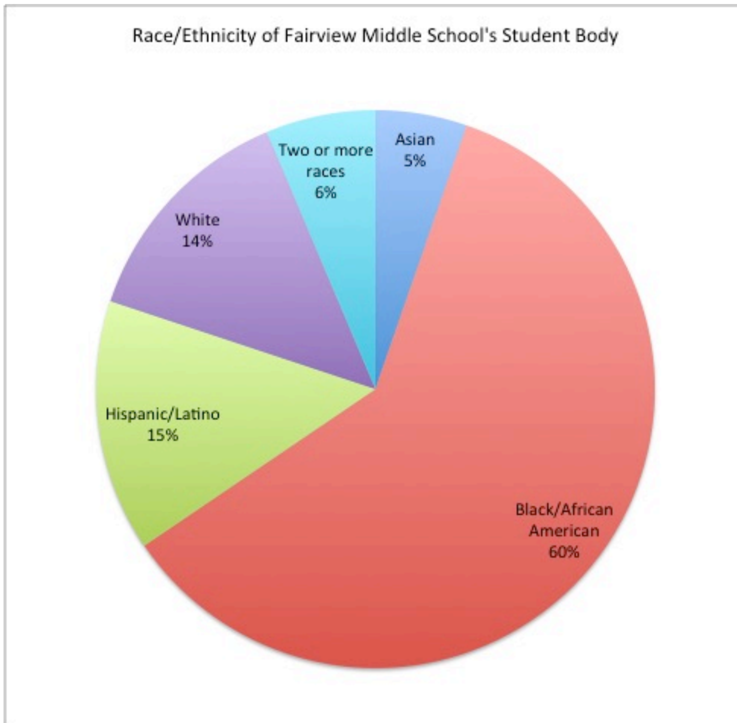
In Douglass County, climate opinion surveys among adults estimated that residents were more likely than U.S. residents at large to believe global warming was happening (72% in Douglass County vs. 63% nationwide) and to be worried about global warming (60% in Douglass County vs. 52% nationwide) (Yale Project on Climate Change Communication, 2014). However, just under half (49%) believed that climate change was caused by human activities and that most scientists believe that climate change is happening (48%) (Yale Project on Climate Change Communication, 2014). These data suggest that while Douglass County's adult residents were generally convinced and concerned about climate change, they may have had incomplete understandings about some dimensions of the issue.

During the weeks in which I interviewed participants (June 8-23, 2015), Douglass County was experiencing hotter than average temperatures and greater than average precipitation. On average, it was 7.6 °F warmer than normal on the days I conducted interviews, and there was about three times more precipitation than average (Weather Underground, 2015). This information may be important for the interpretation of the interviews, since people's personal experiences of the weather may influence their ideas about climate change (Kempton, 1997).

School level. Embedded within these larger global, national, regional, and local contexts was the shared context of school, where the eight 6th grade case study participants interacted with a common set of people (e.g., teachers, classmates) and cultural objects (e.g., curriculum, educational media) with potential implications for their climate change learning. Fairview Middle School was a public charter school that employed a blended learning approach. All of the participants were completing their first year at Fairview Middle School, having matriculated from various elementary schools across Douglass County. Fairview Middle School was in its second year of operation, having opened its doors the previous school year (Fall 2013). At the time of the study, Fairview served 6th, 7th, and 8th grade students, but had plans to expand to high school grades in subsequent years. The 378 students at the school were racially and ethnically diverse (Figure 2), and 17.2% of students were eligible for free and reduced-price meals. The school had an active community of parents.

Figure 2

Race/Ethnicity of Fairview Middle School's Student Body



As a new charter school, Fairview Middle School was operating in a temporary location, utilizing classroom space in a building owned by a Catholic church. The building was located near a large public research university. The principal, Ms. Diaz, supported the creation of partnerships between Fairview Middle School and the university. She collaborated with Dr. Johnson, who served in a liaison role between Fairview and the university, to cultivate partnerships with university researchers, the university's Student Government Organization, and the university's teacher education program. One outcome of these efforts was the school-wide implementation of project-based learning around sustainability. In the spring, all Fairview students engaged in collaborative projects with the help of project coaches from the university. The students' task was to develop proposals for improving the sustainability of Fairview Middle School with regard to energy (6th grade), water (7th grade), and waste management (8th grade). The culminating event was a Sustainability Fair, in which students presented their proposals to a panel of judges from the university. This collaboration illustrated one way in which the school's proximity to a university – and in particular, a university putting energy into its own sustainability efforts – potentially shaped the ideas to which Fairview Middle School students were introduced in relation to climate change.

Classroom level. All participants were students in one of Ms. Kane's five sections of 6th grade science. Ms. Kane was in her first year teaching at Fairview Middle School. Previously, she had taught six years of high school science, including AP Environmental Science, in another state. She had also worked as an informal science educator at a nonprofit organization, where she led outdoor education experiences for middle school groups. She had relocated to an area near Fairview Middle School during its inaugural year, and began to look for teaching jobs. Principal Diaz hired her as a long-term substitute that year, and then as the full-time 6th grade science teacher the following year. Ms. Kane had a strong science content and pedagogy background, with a Bachelor's degree in Botany and a Master's degree in Science Education. She had a good rapport with her students, and was viewed by participants' parents as a strong teacher. In her instruction, Ms. Kane often illustrated science ideas using examples familiar to students' everyday lives. She sometimes shared stories from her own life, particularly from her experiences living in Hawaii – which were of particular interest to students.

Ms. Kane's classroom was in the basement of the building. At the front of the classroom, there was a traditional science lab bench with a sink. Students sat in desks, which Ms. Kane sometimes arranged in rows, sometimes in pairs, and sometimes in groups, depending on the day's activities. On the classroom walls, Ms. Kane displayed student work, such as student-created posters about natural resource conservation practices completed as part of a previous science unit. At the beginning of each class period, Ms. Kane typically led a whole-class demonstration or discussion, and then oriented students to activities they could complete independently or with their peers. Though Ms. Kane was highly interested in engaging her students in hands-on science learning, she had a limited amount of science equipment available to her, but used simple everyday materials to create hands-on lessons when she could.

Curriculum. As Fairview Middle School was a blended learning school, the curriculum was taught partially online. All students carried laptops or tablets with them throughout the school day. The school used *Innovate*, an online Education Management System and curriculum developed by a large education and assessment publishing company. In Ms. Kane's classroom, learners usually spent part of the class period working at their own pace through the *Innovate* curriculum online, and part of the class period working on demonstrations or activities that Ms. Kane introduced to supplement the online curriculum. Though students completed most of their online work independently, sometimes wearing headphones while they worked, Ms. Kane often seated them with other students who were at approximately the same place in the *Innovate* curriculum unit so that they could assist one another as needed. The adoption of *Innovate*, an NGSS-aligned curriculum, expedited Fairview students' and teachers' engagement with the Next Generation Science Standards. Although the state had adopted the Next Generation Science Standards, they were not yet being implemented most schools.

My interactions with participants occurred as they engaged in the final unit of the *Innovate* 6th grade science curriculum, *Weather and Climate*. During this unit, the learners completed online lessons supplemented with learning activities led by the 6th grade science teacher, Ms. Kane. Table 4 outlines the topics included in the *Weather and Climate* unit, and included content relevant to climate change.

Table 4

Lesson Topics Included in the Innovate Curriculum Unit (Weather and Climate) and Included Content Relevant to Climate Change

Lesson Topics	**Content Relevant to Climate Change**
Lesson 1. The Water Cycle	• Atmosphere • Precipitation
Lesson 2. Clouds	N/A
Lesson 3. Precipitation	• Precipitation, drought, floods • Hurricanes (referencing Hurricane Sandy on the U.S. East Coast in 2012; Hurricane Katrina in New Orleans in 2005) • Storm surge • Disaster preparedness
Lesson 4. Severe Weather	• Hurricanes • Storms • Severe weather safety
Lesson 5. Predicting the Weather	N/A
Lesson 6. What Causes Climate?	• Temperature • Precipitation
Lesson 7. Climate Regions	• Adaptations of organisms to specific climate conditions (e.g., polar bears, cacti) • Regional differences in climate conditions
Lesson 8. Greenhouse Gases and Habitability*	• Greenhouse effect • Greenhouse gases (e.g., carbon dioxide) • Carbon footprint • Global warming • Climate change • Roles of human activities in contributing to global warming

*Lesson 8 is the only lesson explicitly mentioning global warming and climate change

In alignment with the Next Generation Science Standards, Lesson 8: *Greenhouse Gases and Habitability*, a two-day lesson, included explicit instruction related to climate change. Learning objectives for this lesson were: "1. Describe greenhouse gases and explain their effects on the environment and on organisms" and "2. Explain measures for reducing global warming" (*Innovate* curriculum unit). The online text that learners read as they worked through the lesson specifically stated that because of the build up of greenhouse gases in the atmosphere, climate change was already underway. The lesson introduced students to the greenhouse effect, and included an image of Earth inside a greenhouse to illustrate how some atmospheric gases "act like the glass panes in a greenhouse" (*Innovate* curriculum unit). Under the image, the caption stated: "Human activities contribute to climate change" (*Innovate* curriculum unit).

In explaining how human activities affect climate, the curriculum emphasized fossil fuel use and deforestation as contributing to the increase of atmospheric carbon dioxide leading to global warming. It stated that global warming can have "devastating effects" (*Innovate* curriculum unit), and gave the examples of drought, melting glaciers, rising sea levels, changes in the biosphere, and regional temperature changes. In this section of the online curriculum, learners saw an image of a single polar bear on a glacier with water at its edge, with the caption "Global warming causes glaciers to melt" (*Innovate* curriculum unit).

The lesson introduced the concept of an individual's *carbon footprint*, or the amount of carbon dioxide emissions attributable to an individual person's daily activities. This part of the lesson stated that "Knowing your carbon footprint helps you make changes to improve your life and the environment" (*Innovate* curriculum unit). It emphasized individual actions that learners and their families could undertake to limit their greenhouse gas emissions and help reduce global warming, such as switching to renewable energy sources (e.g., wind, solar power). The lesson also suggested that using energy more efficiently could help reduce global warming, suggesting actions such as fixing a leaky faucet and recycling. It also stated that planting trees could be beneficial for reducing greenhouse gas emissions. The lesson linked to an online video entitled "*How You Can Help Slow Global Warming"*. The video re-emphasized actions such as turning out lights, recycling, and reducing the use of cars as beneficial.

Curriculum enhancement with MADE CLEAR researchers. My MADE CLEAR climate change education research colleagues (McGinnis and Breslyn) and I co-taught additional climate change activities with Ms. Kane. In consultation with Ms. Kane, our research team developed lesson plans for two 6th grade science class periods. The lesson plans included activities introduced to teachers who participated in the MADE CLEAR summer professional development academy on climate change education. These activities came largely from the Lawrence Hall of Science's *Ocean Sciences Sequence Curriculum* for grades six through eight. The purpose of this curriculum sequence was to provide middle school science teachers and learners a means of examining climate change through an ocean sciences lens. The professional development leaders of the larger MADE CLEAR project had chosen this curriculum sequence as one that might be of particular relevance to teachers and learners in our coastal state.

In total, each 6th grade student participated in two class periods (75 minutes each) of online learning specifically related to the greenhouse effect using the *Innovate* online curriculum, plus two additional in-person class periods (75 minutes each) designed to supplement the climate change information included in the *Innovate* online curriculum. In the first of the co-taught in-person class sessions, we led students in activities focused on climate change evidence. The class session began with a demonstration that modeled glacial melt and its relationship to sea level rise. Learners made predictions about what would happen to the level of water in a plastic cup containing only ice and water (representing sea ice and the ocean), compared with a plastic cup containing ice situated on top of a rock surrounded by water (representing a melting glacier). The purpose of the activity was to show how melting glaciers contribute to sea level rise.

Next, students rotated through three stations in which they examined evidence of climate change. In the first station, the 6th graders examined maps and graphs of sea ice change between 1979-2007. Students learned about how melting sea ice reduces the amount of solar energy that can be reflected off the white surface of Earth's ice (the albedo effect), further heating Earth's land and oceans. In the second station, students examined photographs of changes in glaciers over time in Montana, Peru, and Tanzania. In the third station, students examined maps and graphs of global sea level change between 1870-2006. They also discussed a map labeled with locations on Earth vulnerable to sea level change (e.g., New York, Maldives, Buenos Aires, Singapore, Sydney, and Lagos). The map included a table with information about the populations of each location, prompting students to consider the effects for human populations.

During the second co-taught class session, students engaged in learning activities related to the greenhouse effect and the role of human activities in climate change. We began the class session with a demonstration of an inflatable Earth beach ball in a transparent plastic bag, representing the Earth and its atmosphere. Students reviewed how the atmosphere helps to regulate temperatures on Earth through the greenhouse effect. On a large projection screen, they viewed an animation from a PhET interactive simulation modeling the greenhouse effect (https://phet.colorado.edu/en/simulation/greenhouse). The animation demonstrated how heat-trapping gases in the atmosphere allowed some heat to escape into space, and some to be reradiated back toward the Earth's surface. As the animation played, learners could observe a thermometer showing small fluctuations, but overall stability, of Earth's temperature. Next, we replaced the plastic bag (atmosphere) around the Earth ball, and blew additional carbon dioxide into the bag. Students made predictions about what would happen. We ran the PhET greenhouse effect simulation again, changing the greenhouse gas concentration to "LOTS". Learners observed the increase in Earth's temperatures, and discussed what life would be like on Earth under these conditions.

After engaging with these greenhouse effect models, students viewed two short online videos entitled *Too Much Carbon Dioxide (2:45)* (http://planetnutshell.com /project/episode-4-too-much-carbon-dioxide/) and *Where Does Carbon Dioxide Come From?* (2:49) (http://planetnutshell.com/project/episode-5-where-does-carbon-dioxide-come-from/). The first video provided another metaphor for describing the enhanced greenhouse effect, comparing Earth's atmosphere to a thickening blanket. It explained that the Earth has "more carbon dioxide than it can handle", which cannot all be absorbed by plants and oceans. Finally, it showed carbon dioxide concentration and global temperature graphs, explicitly stating that their increases are directly connected. The second video described how the fossil fuel use has increased from the 18th century (e.g., coal-powered steam engines) to the present (e.g., fossil fuel-powered buildings, cars, planes, factories, computers, TVs, air conditioners). It stated that carbon dioxide emissions from energy consumption are having unintended consequences, and emphasized to students that they could be part of the solution.

Finally, students explored ways to address the problem of human activities increasing greenhouse gas concentrations in the atmosphere. Students engaged in an activity from the *Ocean Sciences Sequence Curriculum* that introduced three types of mitigation and adaptation activities: 1) putting fewer heat trapping gases in the atmosphere; 2) taking back some heat trapping gases that are already in the atmosphere; and 3) lessening the effects of climate change. Students rotated through stations to discuss possible mitigation and adaptation actions (see *Role of Human Activities* in Table 5 for examples).

To review the key ideas presented, the class session ended with a game in which students could agree or disagree with various statements about climate change. These included statements related to the role of the ozone layer, the function of the Earth's atmosphere, how the greenhouse effect is enhanced by human activities, the role of nuclear power, and the view that the greenhouse effect is harmful. Students' understanding of these and other concepts related to climate change was also assessed through an online 18-item multiple-choice assessment that students completed before and after receiving instruction related to climate change. Table 5 below summarizes the key ideas communicated to students about climate change in school.

Table 5

Key Climate Change Science Content Presented to Learners in their School Context

Climate change dimension	Key ideas from *Innovate* curriculum	Key ideas from the MADE CLEAR co-facilitated class sessions
Mechanism	• When solar energy reaches Earth, some heat is radiated back toward space and some is trapped in the atmosphere • Greenhouse gases in the atmosphere act like the panes of glass in a greenhouse, keeping heat in • Build-up of greenhouse gases, especially carbon dioxide, in the atmosphere is already causing global warming	• Increased concentration of greenhouse gases in atmosphere leads to an increase in temperatures on Earth • Heat becomes trapped in the atmosphere (like a bag around Earth, like a blanket over Earth)
Effects	• Global warming can have "devastating effects" • Possible effects include: o Drought o Melting glaciers o Rising sea levels o Changes in the biosphere o Regional temperature changes	• Global warming will have varying effects in different parts of the world • Possible effects include: o Glacial melting o Sea ice melting o Sea level rise o Albedo effect

Climate change dimension	Key ideas from *Innovate* curriculum	Key ideas from the MADE CLEAR co-facilitated class sessions

Role of human activities	• Human activities add greenhouse gases to the atmosphere, making Earth warmer
	• Activities contributing to global warming include:
	  o Burning fossil fuels
	  o Deforestation
	  o Energy use
	  o Car use
	• Individuals can help reduce global warming by changing their actions; if millions individuals change their actions, it could go a long way in reducing climate change
	• Activities reducing global warming include:
	  o Conserving electricity
	  o Recycling glass, cans, and papers
	  o Reducing car use
	  o Switching to renewable energy source
	  o Fixing leaky faucets
	  o Planting trees
		• Human activities add greenhouse gases to the atmosphere, making Earth warmer
		• Activities contributing to global warming include the use of:
		  o Cars
		  o Planes
		  o Factories
		  o Computers and TVs
		  o Air conditioners
		  o Refrigerators
		• People can help mitigate and adapt to climate change, both on the individual level and group level
		• Activities to mitigate or adapt to climate change include:
		  o Adjusting the thermostat
		  o Walking or biking to school,
		  o Eating less meat,
		  o Buying used instead of new
		  o Preserving forests,
		  o Recycling and using less paper,
		  o Planting a tree or garden
		  o Making an action plan for sea level rise,
		  o Improving fuel efficiency,
		  o Improving public transportation,
		  o Using wind or solar power

To summarize, the eight 6th grade case study participants all experienced the same climate change education activities in their science classroom, interacting with the same educational media, learning activities, and science educators. More broadly, they were embedded in a common school, community, regional, national, and global context, all within the same historical time. Thus, in many ways, learners' contexts for climate change learning were shared. Yet learners' lives varied outside of school. They interacted with different people and media, and had experiences in different places outside of school. Therefore, in order to more fully describe the conditions in which my phenomenon of interest – middle school students' climate change learning – was taking place, it is also necessary to acknowledge the unique contexts in which individual participants were embedded in their out-of-school lives.

Participants' unique conditions. All of the learners in this study lived in Douglass County with their families. Their family structures varied, as did their family members' cultural and professional backgrounds. Though participants all lived in the same area, they each had exposure to unique parts of the region and world through their parents' stories and experiences, through travel with their families, and through communication with family members in other geographic areas. All of the participants engaged with media outside of school, particularly the Internet and TV, but varied in the types of media they consumed and with whom. They also engaged in different kinds of recreational activities and varied in their interests, which may have made a difference in what was most salient to them when considering the topic of climate change. Next, I describe each participant's unique out-of-school contexts.

Aliyah's out-of-school conditions. Aliyah was an African American student who lived with her mother, a lifelong resident of Douglass County, who worked as an administrative assistant. Aliyah also spent a great deal of time with her maternal grandparents, who lived nearby. She was known as a talented artist among her family, teachers, and peers; drawing was one of her favorite activities. At the end of the school year, she received the award for "Most Creative" student in the 6th grade. Aliyah had been involved in Girl Scouts since Kindergarten, and had engaged in environmental learning experiences with her troop. According to Aliyah's mother, it was a visit to a recycling plant with her Girl Scout troop that sparked Aliyah's commitment to recycling – a practice that Aliyah enforced at home. At home, Aliyah also took note of her mother's environmental actions, such as the fact that she took public transportation to work, and preferred that they open the windows on hot days rather than use the air conditioning.

Outside of school, Aliyah had heard about climate change from a variety of sources. She recalled news reports she had seen about island residents having to leave their homes as sea level rise began to affect their communities. She also knew from media reports about the relocation of New Orleans residents during Hurricane Katrina. Aliyah had once flown over Louisiana to visit family in Texas, and thought about residents' displacement as she looked down at the landscape. Aliyah's mother recalled having conversations with Aliyah about the weather, which sometimes led to the topic of climate change. For example, they talked about how it was becoming hot in the summers earlier than it had before, and about how recent winters had been unusually cold as a result of the polar vortex (referring to the 2014 North American cold wave, an extreme weather event that affected the East Coast of the U.S. and Canada). Aliyah and her mother also watched *The Weather Channel* together, particularly during hurricane season, to monitor hurricanes that might be heading toward the East Coast. Aliyah's mother believed that learning about climate change was important for Aliyah. She said, "I think it's important for her to learn, because you never know, one day she may be able do to something to change it. Or to influence others to change" (Aliyah's mother, interview).

Autumn's out-of-school conditions. Autumn was an African American student who lived with her mother, a long-time resident of the Douglass County area. Her father was from Nigeria, and now lived in Australia for work. Autumn talked with him on the phone regularly. Autumn's mother worked in a hospital as a respiratory therapist and was also in school. Autumn's grandmother was also actively involved in her care. Outside of school, Autumn enjoyed spending time on the Internet, reading anime books, writing her own stories, growing plants in her apartment, and spending time with her grandmother. Autumn was interested in art, particularly digital arts, and hoped to become an animator someday. She and her grandmother often took walks around the neighborhood after school, taking cell phone pictures of beautiful things they saw.

Autumn's perceptions of climate change were informed primarily by what she learned in school, by her own outdoor experiences, and by her conversations with family. When she talked to her father on the phone, she was surprised to learn that it was 107 degrees in the Australian desert where he was working. Autumn talked with her mother about climate change in relation to seasonal changes, such as the lack of snow on Christmas in recent years. They also both noticed many sources of air pollution around them, such as from traffic and construction projects, which they saw as contributing to climate change and posing threats to human health. Autumn's mother believed that

Autumn's ideas about climate change were "probably more precise" (Autumn's mother, interview) than hers, and saw it as important for Autumn to continue to learn. She said,

> We're not taking responsibility anymore, you know? And we're not teaching the new generation. I was told, from wise people who have passed on, who have taught me lessons… they'd say that "Each generation is better than the other". You know? They're smaller than us, and we should teach them. And they're a little bit wiser than us. Autumn, I consider, like ten times smarter than me. (Autumn's mother, interview)

Autumn's mother talked about her family's involvement with the Pentecostal Church, and how her spirituality related to her ideas about "Nature in general. The beautiful sky. We believe in… the Creator and God" (Autumn's mother, interview).

Bobby's out-of-school conditions. Bobby was a biracial student (African American and European American) who lived with his mother, father, and college-aged brother. Bobby's mother worked at the university in an administrative role, and his father was a teacher. They were long-time residents of the area, and Bobby's grandparents still lived nearby and were actively involved in his life. Bobby was an athlete, and loved playing basketball, football, and baseball outside of school. In the summer, Bobby's family enjoyed traveling to the eastern part of the state to go to the beach, a tradition carried on from his mother's childhood.

Bobby spent time after school at his grandparents' house, and obtained much of his information about current events from watching and discussing TV with them. He particularly enjoyed watching *The Weather Channel* and *The History Channel*. In describing Bobby's ideas about climate change, his mother explained. "He'll talk about different weather, and then… with the geography. He'll say, 'Well, do you know…' in whatever country. And he'll tell us about a drought, or the rain, or different things like that… I think he really gets it" (Bobby's mother, interview). Bobby also described learning about climate change from his mother – for example, when she would tell him about articles that her friends shared on Facebook. Bobby's mother thought that Bobby would probably have more ideas about climate change solutions than she did, and that an interest in taking care of the environment would "probably be something that will stick with him as he gets older" (Bobby's mother, interview).

Isabelle's out-of-school conditions. Isabelle lived with her Irish-American father, her Mexican-American mother, and her 6-year-old sister. Both of Isabelle's parents had spent their entire lives in Douglass County, though they also had family in in the coastal region of the state and in California. Isabelle was close with her paternal grandparents, who lived nearby and helped care for her after school. Before retiring, Isabelle's grandparents both worked for NASA. They discussed science topics with Isabelle, and helped her with her homework most days after school. In her free time, Isabelle enjoyed horseback riding, dancing, visiting the beach in the summer, and spending time with friends.

Isabelle had heard about climate change from a variety of sources. She had seen climate change information and images online and on TV. She recalled watching a documentary on YouTube about climate change, and a *Discovery Channel* show about how indigenous people's ways of life were changing in Alaska as temperatures increased. She had talked with her grandfather about climate change. She also talked with her mother – who worked in the field of emergency management - about disaster preparedness, and what they would do in the event of a dangerous extreme weather event. Isabelle's mother believed that Isabelle generally shared her perspective on climate change, but that Isabelle felt more strongly. She said, "It's the generation… They're the ones that are gonna have to make the changes. We've totally screwed that up. I mean nobody can agree on whether or not it's a fact at this point. I think right now it's gonna be up to them" (Isabelle's mother, interview). Isabelle's mother was not sure there was much that her family could do about climate change. However, she believed that multiple families and multiple generations could make an impact.

> I'm not even gonna lie and say "Oh, there's so much we could do"… I mean, it's not the kind of thing where my family of four is going to make the world look different. But my family of four plus my neighbors and their neighbors and their neighbors… I guess my feeling on it is it's kind of like voting. What's my one vote gonna do? …But you know, with us practicing it, and then [my daughters] getting older and then they're practicing it. That's the spread of it. (Isabelle's mother, interview)

James's out-of-school conditions. James lived with his parents, who had moved to the area from Jamaica as young adults, his high school-aged brother, and his eight-year-old sister. James drove with his father about 45 minutes every morning to get to Fairview Middle School. The family had been drawn to the school particularly because of its racial and cultural diversity, in contrast to his previous school. James was an avid soccer player, and spent most of his time out of school with his soccer teammates. He also enjoyed spending time on the Internet. James loved animals, and was interested in becoming a veterinarian when he grew up.

Outside of school, James had heard about climate change on the news, *The Weather Channel*, the Internet, and through conversations with his older brother. James had also been noticing that temperatures had been warmer earlier in the spring than in the past, a change that he associated with global warming. At home, James said that he tried to enforce environmentally friendly practices. James often reminded the family to recycle and conserve electricity at home. James's father explained that he felt strongly about climate change. He said, "Oh yeah, I believe the hype!" (James's father, interview). He spoke about his concern regarding the destruction from Hurricane Sandy on the U.S. East Coast in 2012, and the increases in extreme weather events worldwide. James's father believed it was important for his children to learn about climate change because,

> Climate change is gonna affect their lives more than it affects mine. And I think, you know, they can actually take more steps to reduce climate change… I think it's important and we should do more to educate people. Because the evidence is clear that if we don't do something, it will just become more extreme. And whatever we can do to offset that, we should do (James's father, interview).

James's father hoped that James would continue his environmentally-friendly practices like recycling, and also become an environmentally-conscious consumer as he got older. He believed that James would have more ideas than he did about how to address climate change.

Richie's out-of-school context. Richie was a Latino student who lived with his mother – who was from El Salvador, his father – who was from Mexico, his two older siblings, and his twin brother. Richie had lived in Douglass County his entire life. In his free time, Richie enjoyed playing soccer and video games, and spending time outdoors.

His family would go camping at parks in the summer, or would sometimes camp in tents in their backyard. Richie was good with computers and the Internet, and his family considered him the "technician" of the house.

Richie said that he had gotten most of his information about climate change at school. However, his family was in the process of installing solar panels at home, so the whole family was learning more about renewable energy. After seeing a number of families in their neighborhood switch to solar panels, Richie's mother was convinced to do the same by a colleague at the supermarket where she worked. In speaking about the decision, she said, "If you can do something, even for saving money, you can save the planet" (Richie's mother, interview). She joked that Richie thought he could now play unlimited video games since they were using renewable energy. For the most part, however, Richie's mother said that her children were the ones encouraging environmental stewardship at home: "Actually, they're the ones talking to me! [laughs] Yeah, I learn from them" (Richie's mother, interview). Growing up in a different culture, she noted how rushed American culture felt, and attributed people's lack of time to their environmental carelessness. She said,

> There's a lot of things we can do, but it's really bad because we don't do it. And it's not because we can't… it's we don't want to or we don't have the time to do it. You know… life here is rushing for everything (Richie's mother, interview).

She worried that even when a few people cared and took action on climate change, it would likely be insufficient. She said, "In 100 people, maybe 20 or 10 think in that way. The other 80 or 90, they're doing their way" (Richie's mother, interview).

Sarah's out-of-school conditions. Sarah was a European American student, whose father had moved to the U.S. from Holland and whose mother had grown up in Latin America as a child of U.S. government workers stationed there. Sarah and her eight-year-old brother had spent their entire lives living in Douglass County, where their parents had lived for fifteen years. In her free time, Sarah spent time playing lacrosse, skating, and swimming. At home, she also enjoyed playing video games, watching TV with her friends – especially *Dr. Who* and *Sherlock* – and teaching herself programming through the *Code Academy* website.

Sarah had learned about climate change from a variety of sources outside of school. Sarah had noticed changes in the weather, which she believed could relate to climate change. For example, she recalled a heat wave she experienced while participating in an all-day summer lacrosse camp. On a road trip with her family to Yosemite National Park, she had picked up a book in the gift shop that had information about climate change. She had also seen images of climate change effects on the Internet. Sarah's mother said they would sometimes talk about climate change, but not in depth: "If there's a story that I read about, then sometimes I'll share it with Sarah. And sometimes she'll share things with me…But you know, we try to be careful because we don't want to scare the kids, so we try to walk a fine line" (Sarah's mother, interview). Sarah had watched a documentary with her parents about Walmart, which raised her awareness about the environmental impacts of people's consumption habits. At home, the family recycled and composted, and Sarah's mother believed that her children "should try to do what they can [and]… do their part" (Sarah's mother, interview). By learning about climate change, Sarah's mother hoped that Sarah would be more careful and conscientious about consumption, and would “come up with some really brilliant ideas” (Sarah’s mother, interview) about how to resolve climate change.

Sophia’s out-of-school conditions. Sophia was an Egyptian-American student who lived with her parents, two siblings, maternal grandparents, aunt, uncle, and cousins. Her parents moved to the U.S. from Egypt as young adults, and Sophia had visited Egypt several times in her life. These visits appeared to make an impression on Sophia’s environmental outlook. She was critical of the amount of litter she noticed in Egypt, and interpreted that people seemed not to care about it. Living in a large household, Sophia’s family tried to conserve energy and water at home, especially to reduce their bills. For example, Sophia described her family’s energy conservation practice of turning on the air conditioner in only one room of the house, where all of the kids would do their homework. In her free time, Sophia enjoyed spending time on the computer and was learning computer programming on her own through online tutorials from the Khan Academy website.

Sophia and her family spent recreational time at home on the Internet, and Sophia had seen information online about climate change before. As Sophia’s mother described it, “Mr. Google is our best friend” (Sophia’s mother, interview). Sophia also enjoyed spending time outside and was interested in weather. She regularly monitored the outdoor temperature using a thermometer she taped to the side of the house. When Sophia asked her mother about why the thermometer readings in the winter were so warm, it sparked a conversation between them about global warming. Sophia’s mother believed it was important for her children to engage in environmentally-friendly practices, and made sure her family recycled and conserved energy at home. She hoped that Sophia and her siblings would think about the future, and try to improve conditions for those who came after them. Sophia's mother stated:

> I would like it if my kids would see something - for example, if the school doesn't recycle, they would take an effort to do something about it. Because this is your world… Do something to make an impact, leave something good for the people after you. They're gonna leave this school. Does this school recycle? Does every classroom have a recycle bin? You know, these are things they should be aware of. They should be aware not only of them here, but also everywhere else. What's happening in the world? That's important (Sophia's mother, interview).

Context summary. Because case study research is concerned not only with the case itself, or phenomenon of interest, but also with the circumstances in which that phenomenon occurs, I have taken care to describe – to the extent possible - the "wide sweep of contexts" (Stake, 1995, p. 43) in which the eight 6th grade participants were embedded. I described the global, national, regional, local, school, and classroom conditions that participants shared, including the instruction they received at school specifically related to climate change. I also described participants' unique conditions. I sought to illustrate the diversity of participants' out-of-school lives in relation to climate change learning (e.g., varied recreational activities, media consumption, family relationships), as well as some common threads across their out-of-school lives (e.g., parents concerned about climate change, use of technology for out-of-school learning, home-based environmental stewardship practices).

I regard participants' school-based and out-of-school (i.e., daily life) conditions as the spaces in which they interact directly with people and cultural objects (Vygotsky,

1978) with the potential to shape their ideas about climate change. I regard their broader local, regional, national, and global conditions – including their temporal and spatial, historical, political, economic, cultural, social (Stake) dimensions – as having more indirect implications for their climate change learning. That is, these broader conditions may dictate *with whom* or *with what* participants engage in their daily lives as they come to learn about climate change. Having described the case study context – that is, the multifaceted, multilayered conditions in which the phenomenon of interest was occurring – I turn now to the research procedures in which I engaged while immersed in this context.

Case Study Protocol

Case study researchers must develop a plan, rooted in their research questions, for carrying out their studies (Stake, 1995). In this section, I present an overview of the plan that I carried out in conducting my case study, which was rooted in the research question: *How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded?*

Overview of the case study. The purpose of this case study was to understand the nature of the relationship between middle school science learners' figured worlds of climate change and the conditions, or contexts, of their daily lives. I collected data in one middle school in which science learners were engaged in climate change education, however, the *context* under consideration in this study encompasses students' conditions both within and beyond the world of school. The case, or phenomenon of interest, was climate change learning among middle school learners. In light of my theoretical perspective of figured worlds (Holland et al., 1998), climate change learning is thought to include learners' developing identity and agency in relation to climate change; or *figuring a world* of climate change in which they see themselves as actors.

I examined this phenomenon among eight 6th grade learners in one middle school context, selected due to their diversity of perspectives on climate change, their parents' willingness to participate, their diversity of gender and racial/ethnic backgrounds, their science teacher's inclusion of climate change in their school-based science curriculum, and the convenience of their school site for data collection.

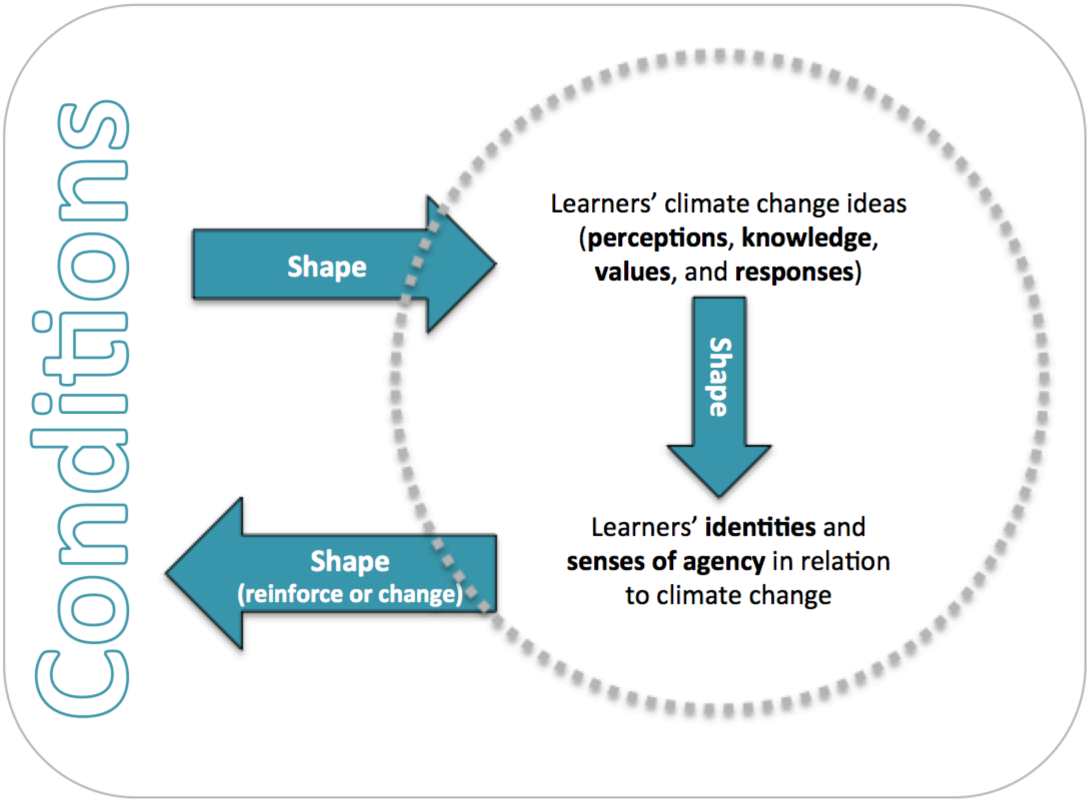
Following Yin (2014), I articulated four key theoretical propositions to examine:

- As learners engage in climate change learning, they develop perceptions, knowledge, values, and modes of responding to climate change.
- Learners' ideas about climate change are formed through social interaction and are thus shaped by aspects of their conditions.
- Climate change learning entails developing identity and agency with regard to climate change.
- Learners' identity and agency development may reinforce or change the conditions in which they are embedded.

Through empirical examination of these propositions, I sought to describe the nature of the relationship between learners' conditions and their figured worlds of climate change. In Figure 3, I provide a model of how I conceptualized this relationship. The model provided a useful tool for conceptualizing and organizing the theoretical propositions I sought to investigate.

Figure 3

Theoretical Model of Climate Change Learning as a Process of Identity and Agency Formation in Figured Worlds of Climate Change

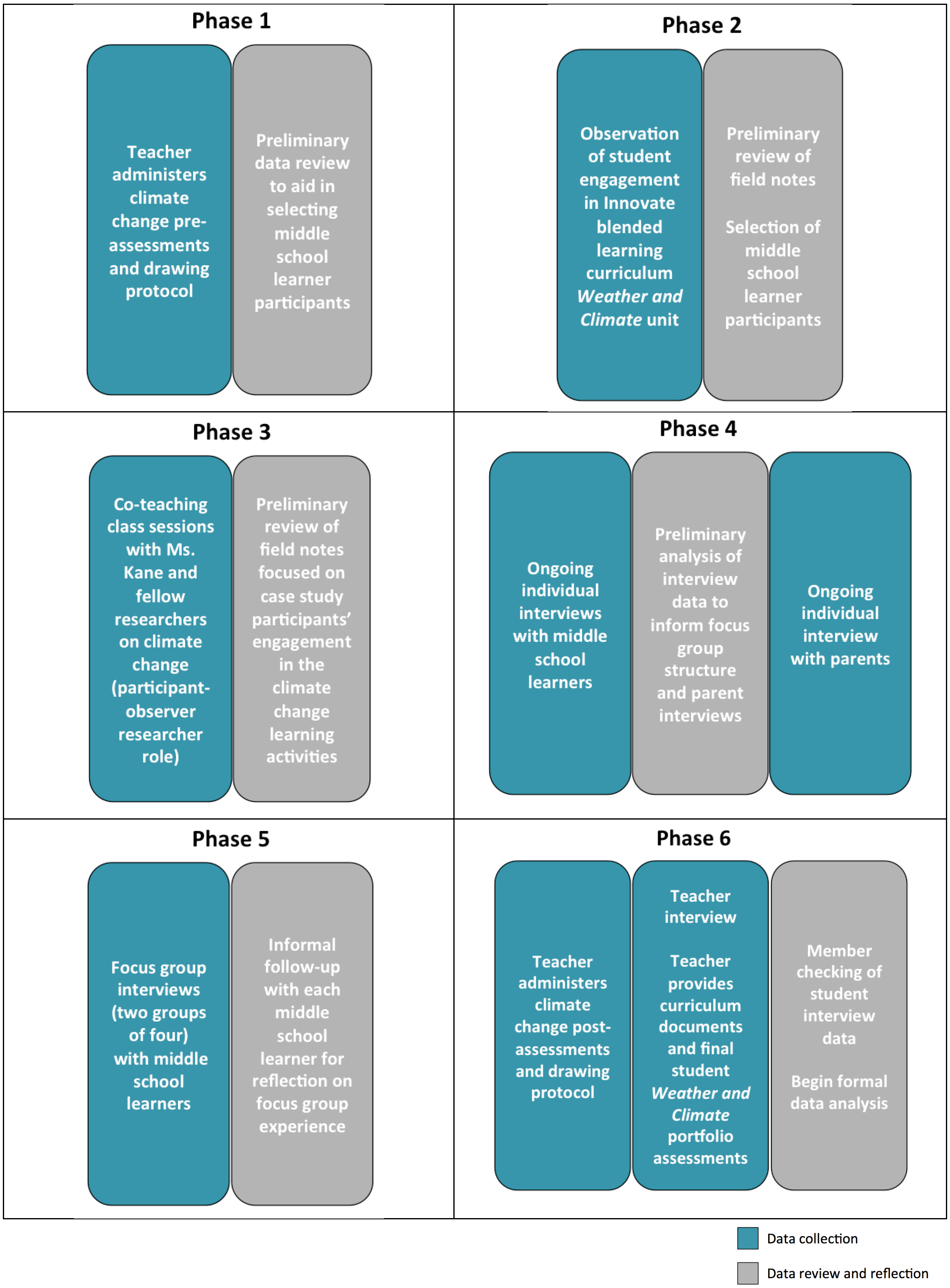


Data collection procedures. In this section, I present an overview of my procedures for collecting data from multiple sources, organizing and storing data, and for protecting human subjects who participated in the research.

Data sources. A central dimension of case study research is the use of multiple sources of data (Yin, 2014). In this study, I collected four broad types of data: observations, documents, participant-generated drawings, and interviews (see Figure 4).

Figure 4

Process for Data Collection and Ongoing Analysis



Observations. I was present in the classroom engaged in observation and collecting field notes during Ms. Kane's teaching of the *Weather and Climate* unit, and later, as a participant-observer (Angrosino, 2008) as I co-taught two additional class sessions on climate change with Ms. Kane and other colleagues. In total, I spent 6.5 weeks in the classroom. The observations and field notes I collected during this time were intended to serve several purposes. First, they provided insight into the ways in which climate change-related topics were presented to learners in school. Along with collected instructional materials (see *Documents* below), observations provided information about how learners' interactions within their school context may have had the potential to shape their perspectives on climate change.

Another intended purpose of the observations was to gain insight into how learners interacted with one another around the topic of climate change. During classroom-based learning activities, I planned to take field notes to capture the kinds of conversations in which learners were engaged with one another related to climate change. However, during their engagement with the *Innovate* online curriculum lessons, learners moved at their own pace and were often working on different aspects of the unit individually. Therefore, I did not observe learners engaged in conversation about climate change during that time. Instead, my experience observing in the classroom served to provide valuable information about the school context in which learners were embedded. I took open-ended notes in a notebook to record my observations of the classroom environment. During the additional class sessions on climate change that I helped co-teach with Ms. Kane, I was able to collect field notes on learners' discussions related to the topic of climate change, since all were engaged in the same activities together.

I opted not to audiotape or videotape classroom activities in order reduce potential obtrusiveness and reflexivity, and to avoid concerns associated with the use of such recording devices that may dissuade potential participants from taking part in the study. Stake (2010) warned that new researchers have a tendency to "worry too much about making an accurate record of what is happening… [and] look for safety in audio or video recordings" (p. 94). In doing so, they may run the risk of losing sight of what is really happening in the setting. Because I did not believe that such recordings in the classroom were essential for meeting my data collection objectives, avoiding their use may have helped me to avoid this potential risk.

Documents. I collected two forms of documents. First, I collected curriculum artifacts in the form of PDF documents of climate change-related lesson plans that Ms. Kane facilitated as part of the Innovate curriculum's *Weather and Climate* unit. The purpose of collecting these materials was to gain insight into the messages about climate change communicated to students through school curriculum and instruction. This information is potentially important to document, as some researchers have suggested that school is an important contextual influence shaping learners' perspectives on climate change (e.g., Boon, 2010; Gowda et al., 1997; Kılınç et al., 2008).

The second group of written artifacts I collected were student products from climate change related lessons taught in the course. These included learners' responses to pre- and post-assessments of their content knowledge (collected online) (Appendix A), portfolio assessment documents completed as part of the Innovate online curriculum's *Weather and Climate* unit, and their final online unit test. Of these documents, the climate change content knowledge assessment[1] provided information about learners' reasoning about climate change content, and some of the alternative conceptions they may have held. The portfolio assessment documents provided information about the focus of the curriculum, but little information about learners' thinking specific to climate change. The final *Weather and Climate* unit test included four items related to the greenhouse effect and global warming, including one open-ended item in which learners were required to explain global warming and what people could do to reduce global warming (Appendix B). These student products were valuable for providing insight into some aspects of participants' knowledge of climate change science content, but less so for providing insight into their developing personal stances with regard to climate change.

Participant-generated drawings. I had planned to administer a draw and explain (White & Gunstone, 1992) protocol (Appendix C) to the selected participants to elicit their perspectives on climate change after the completion of climate change related instruction. However, Ms. Kane believed it would be useful as a diagnostic assessment, and opted to distribute it to all students prior to instruction. Therefore, I was able to use learners' pre-instruction drawings to help me select participants with diverse perspectives on climate change. I administered the drawing protocol again to selected participants after instruction and after their first individual interview. Here, I did not make the assumption that the drawings provided evidence of change in learners' climate change content understandings. Rather, I was interested to see if new aspects of climate change

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[1] I note that two of the participants (James and Bobby) did not complete the post-instruction climate change content assessment, so my data set for these two participants was incomplete. However, I believed that the other data sources provided sufficient information about their ideas that I could still include them in the

became salient to learners after instruction and reflection during the interview, or if they represented themselves in new ways in relation to climate change.

Learners responded to the prompt: *Draw what comes to mind when you think about climate change. Please include some details about how climate change relates to your life or your community (if at all). On the back of this page, write what you were seeking to communicate through your drawing* (see Appendix C for the draw and explain protocol). By asking specifically about the relevance of the topic to participants' lives and community, I believed the drawings could provide insight into participants' developing senses of agency and identity with regard to climate change. I had previously piloted the *Draw what comes to mind when you think about climate change* portion of the prompt. However, because participants in these pilot studies did not typically consider the personal relevance of the topic in their written and drawn responses, and because I was interested in how participants in this study saw themselves in relation to climate change, I opted to add the second aspect of the prompt: *Please include some details about how climate change relates to your life or your community (if at all).* In doing so, I drew on Alerby's (2000) use of an open-ended drawing prompt to elicit environmental perspectives, as well as Bonnett and Williams' (1998) use of personally-relevant drawing prompts.

I opted to use drawings as a data source for several reasons. First, they had the potential to provide participants with a unique form of self-expression. Second, there was precedent in the literature for using drawings to examine both learners' ideas about climate change (Hestness et al., 2011; McGinnis & Hestness, in press; Shepardson et al., 2009) and identity (Katz, McGinnis, Hestness, Riedinger, Marbach-Ad, Dai, & Pease, 2011)—a central dimension of the theoretical notion of figured worlds. Therefore, I viewed drawings as a data source that could provide valuable insight into learners' figured worlds of climate change.

Interviews. My final data sources were semi-structured, individual interviews with the teacher (Ms. Kane), the eight participating learners, and one parent of each participating learner. I also conducted semi-structured focus group interviews with learners in two groups of four learners each. Interviews were audio-recorded and transcribed using Express Scribe for Mac software. Yin (2014) described case study interviews as fluid and less structured than interviews conducted in other research traditions (e.g., survey research). During interviews, case study researchers must follow their own lines of inquiry and work to ask questions in a conversational and unbiased manner (Yin). I followed these recommendations, as well as Kvale's (1996) tenets of qualitative research interviews (e.g., specificity, descriptive, deliberate naivete, sensitivity).

My interview with Ms. Kane was approximately 50 minutes in duration (see Appendix D). The interview took place in Ms. Kane's classroom after school at the end of the school year, once she had completed all science instruction. The purpose of the teacher interview was to further examine curriculum and instruction regarding climate change in the 6th grade science course (complementing the written artifact data); gain insight into Ms. Kane's rationale for her approach to the *Weather and Climate* unit (e.g., key ideas she intended to communicate); and inquire about her perspectives on student learning, including perceptions of the conditional influences shaping learners' ideas.

My interviews with the 6th grade learners ranged from 20-40 minutes in duration (see Appendix E). During the individual interviews, I used learners' drawings as a starting point for the conversation in order to elicit information about their perspectives, knowledge, values, and responses to climate change. I also sought to elicit more specific details regarding how they saw themselves in relation to climate change. I conducted most of the interviews in corner of a large multipurpose room at the school, also occupied by 7th and 8th grade teachers and students during their independent reading block. I conducted a few of the interviews on a bench in a public hallway, when the multipurpose room was too noisy, or when 6th graders' available time to interview was limited. Most interviews were completed during learners' homeroom period. A few learners who had finished all of their science work in Ms, Kane's class were available to talk with me during the latter portion of their science class period (as arranged with Ms. Kane). Ms. Kane was highly collaborative in helping me arrange interviews with students at times that did not interfere with instruction.

Finally, I interviewed one parent of each participating learner (see Appendix F). These interviews lasted from 15-30 minutes. I offered parents the option to be interviewed at the school, at home, or by phone. Most parents (the parents of Aliyah, Bobby, Isabelle, James, Richie, and Sophia) opted to be interviewed at school, around drop-off or pick-up times, or when they were at the school for other activities. One parent (Sarah's mother) opted to be interviewed at her home on a Saturday. Finally, one parent (Autumn's mother) requested to be interviewed by phone. One purpose of the parent interviews was to seek insight into how learners' out-of-school contexts may shape their thinking about the topic of climate change. Another purpose was to inquire about how the parents saw their children responding to climate change, particularly in terms of how they see climate change relating to their lives and how (or whether) they see their children developing agency in relation to the topic of climate change.

After conducting the individual interviews, I engaged the participating learners in focus group conversations (see Appendix G). I conducted two focus groups with four learners each. Focus group interviews were between 40-50 minutes each, and took place at the end of the school year after participants had turned in all of their work. I facilitated the focus group conversations in another teacher's classroom during participants' homeroom time and into a portion of independent work time. Beyond the advantage of being a potentially efficient means of collecting data from multiple participants, well-facilitated focus groups have the potential to create a social environment in which participants to feel comfortable sharing information and reacting to others' ideas (Onwuegbuzie, Dickinson, Leech, & Zoran, 2009). My goal was to moderate the focus group in such a manner that created a safe environment for participants to share ideas, while deliberately probing the views of each group member regarding particular aspects of the case study (Krueger & Casey, 2009).

The purposes of the focus groups were to engage participants in conversation around the influences shaping their own perspectives on climate change, as well as to gain additional insight into their climate change ideas. Because my observations of learner interaction around the topic of climate change were limited, I also believed that the focus group conversation could provide insight into how participants interacted with their peers in discussing climate change. As with the individual interviews, I incorporated drawings – this time, drawings created by participants' peers (with their peers' names removed) – as an entryway into the discussion.

Data storage. As recommended by Yin (2014), I created a case study database to organize and store collected data. I scanned hard-copy data sources (participant-generated drawings), and stored electronic copies (PDFs) in password protected computer folders dedicated to each data source. I kept the original hard copies of these data sources filed in folders stored in a locked metal file cabinet. I transferred audio data sources (recordings from individual and focus group interviews) into computer folders within the case study database. I transcribed the audio content into Microsoft Word documents (one per interview) stored electronically in the case study database. I then deleted the audiorecorded interviews from the recorders.

Human subjects protections. Throughout the data collection process, I protected participants using the guidance of the National Research Council (2003). This included gaining informed consent from all participants (teacher consent, parent consent, and student assent); protecting participants from harm, including avoiding the use of deception; protecting vulnerable groups, including children (e.g., seeking both parental consent and learner assent for participants under age 18; conducting learner interviews in spaces where school personnel were also present); and selecting participants equitably (e.g., purposeful selection of interview participants to represent the diversity of the group in terms of backgrounds and perspectives). I protected participants' privacy and confidentiality by using pseudonyms for all participants and institutions (NRC, 2003).

Data collection questions. Data collection questions are questions posed to the researcher to guide data collection efforts and are often accompanied by a list of likely data sources (Yin, 2014). In Table 6, I present each data collection question, the relevant data sources, and the purpose of each source in relation to the question.

Table 6

Data Collection Questions and Accompanying Data Sources

<table>
<tr><th>Data collection questions</th><th>Data sources and purposes</th></tr>
<tr><td>1. What is the nature of learners' ideas (i.e., their perceptions, knowledge, values, and responses) in relation to climate change?

<u>Note</u>: Data collected regarding this question were intended to contribute to describing the nature of learners' figured worlds of climate change.</td><td>Participant-generated drawings and accompanying written reflections
Purpose: To provide insight into learners' knowledge of climate change causes, impacts, and the roles of human activity; concerns them about climate change; and views of appropriate climate change responses
Interviews
Purpose: To further probe ideas about climate change perceptions, knowledge, values, and responses as represented in learners' self-generated drawings
Written artifacts (student work)
Purpose: To provide information about learners' knowledge of climate change causes, impacts, and the roles of human activity</td></tr>
</table>

Data collection questions	Data sources and purposes
2. *To what extent, if any, do learners' conditions appear to shape their ideas about climate change?* Note: Specific contextual factors of interest include: • Educational context, • Social relationships (family/peers), • Public discourse, • Felt impacts of climate change and ascribed meanings, • Cultural views of environment, science, and technology	• Observations o Purpose: To provide potential insight into the roles of educational context in shaping learners' ideas • Written artifacts (lesson plans, student work) o Purpose: To provide potential insight into the roles of educational context in shaping learners' ideas • Individual interview (learners, teacher, and parents) o Purpose: To probe learners' ideas about climate change and potential contextual factors that have shaped these ideas; to probe teachers' impressions of the influences on learners' ideas about climate change as observed during classroom instruction; to probe parents' ideas about climate change and the ways in which learners out-of-school experiences may shape their thinking • Focus group interview o Purpose: To provide potential insight into the roles of peer interaction (social relationships); to obtain additional information about the extent to which contextual factors of interest—and others—play a role in shaping learners' ideas about climate change

Data collection questions	Data sources and purposes

3. *To what extent, if any, do learners see climate change as relevant to their own lives?*
 	
Note: Data collected regarding this question were intended to provide information about learners' *climate change identities*, contributing to the eventual goal of describing the nature of learners' figured worlds of climate change.
	• Individual interviews
	  o Purpose: To inquire about whether and how learners see themselves and their communities as connected with climate change (e.g., causes, effects, solutions); to inquire about learners' own responses to climate change (e.g., decisions, behaviors)
	• Participant-generated drawings
	  o Purpose: To examine participants' representations of themselves in relation to climate change
	• Focus group interviews
	  o Purpose: To examine how learners' views of the relevance of climate change to their own lives are potentially shaped by their conditions

4. *How, if at all, might learners' ideas about climate change shape (reinforce or change) the conditions in which they are embedded?*
 	
Note: This question relates to the theoretical notion of figured worlds and the idea that learners both *shape* and *are shaped by* their social and cultural contexts.
	• Individual interviews
	  o Purpose: To provide insight into learners' responses to climate change; to gain insight into teachers' impressions of learners' reactions to learning about climate change
	• Participant-generated drawings
	  o Purpose: To examine written descriptions in particular for evidence of learners' current or desired responses to climate change
	• Focus group interviews
	  o Purpose: To inquire about how learners respond to (e.g., internalize, resist) ideas about climate change communicated to them

Data Analysis

In this section, I describe the analytic strategies and techniques employed in analyzing the collected data, as well as the specific coding procedures that facilitated my data interpretation.

Examining theoretical propositions. Yin (2014) recommended developing theoretical propositions prior to beginning a case study as a means of guiding data collection and analysis. Above, I presented a hypothetical model of climate change learning as a process of identity and agency formation in figured worlds of climate change (see Figure 3). I used this model to suggest four key theoretical propositions to examine within this study.

One theoretical proposition I explored was the notion that*: As learners engage in climate change learning, they develop perceptions, knowledge, values, and modes of responding to climate change*. This framework is based upon the work of anthropologists Roncoli, Crane, and Orlove (2009). I reinterpreted it for use in this case study as encompassing learners': 1) sources of perceptual information that made them aware of climate change [perception]; 2) understandings of the mechanism and causes of climate change, impacts, and roles of human activities [knowledge]; 3) concern or care related to the issue of climate change [values]; and 4) ideas regarding what they or others should do about climate change [response]. This translation of Roncoli et al.'s framework guided my examination of diverse and specific dimensions of learners' climate change ideas.

A second theoretical proposition I examined was: *Learners' ideas about climate change are formed through social interaction and are thus shaped by aspects of their conditions.* This theoretical proposition is based upon sociocultural perspectives that regard learning as a matter of the "nexus of relations between the mind at work and the world in which it works" (Lave, 1988, p.1). With regard to socioculturally-oriented research on science learning, it is based upon a view that understanding science learning requires examining learners' social experiences and participation within and beyond the world of school (NRC, 2007). I specifically focused my study on examining the potential roles of key sociocultural influences suggested in science education literature, including:

public discourse, educational experiences, place and personal experiences with climate change, social relationships (peers, family), and cultural views of environment, science, and technology. I also remained open to the possibility that other influences could play a role in shaping learners' thinking.

A third theoretical proposition I examined was that: *Climate change learning entails developing identity and agency with regard to climate change.* This theoretical proposition is based upon Holland et al.'s (1998) theory of figured worlds as spaces in which agency and identity are formed. I posited that as they learn about climate change, learners' figured worlds of climate change would be formed, and learners would develop a sense of themselves (identity) and their actions (agency) in relation to climate change. For identity, or "imaginings of oneself in worlds of action" (Holland et al., p. 5), my theoretical proposition was that learners would develop a sense of how climate change relates to, and comes to mean something for, their lives and the communities they inhabit. That is, learners develop *imaginings* of themselves in the world of climate change. For agency, or learners' "realized capacity to act upon the world" (Inden, 1990, in Holland et al., p. 42), my theoretical proposition was that learners would gain new perspectives on how their actions (personal and collective) have potential import in the world of climate change.

The final theoretical proposition I examined was that: *Learners' identity and agency development may reinforce or change the conditions in which they are embedded.* This proposition relates to the notion of figured worlds as sites of possibility (Urrieta, 2007a). In applying these ideas to climate change learning and the notion of figured worlds of climate change, I considered the possibility that learners' agency and identity development in figured worlds of climate change would have the potential to shape—by changing or reinforcing—aspects of their conditions. For learners in this study, I saw this phenomenon as potentially manifesting in learners' decision-making, behaviors, or discourse about climate change within the diverse contexts they inhabited (e.g., their homes, schools, local communities). In addition to potentially changing these larger contexts (e.g., Bencze et al., 2012), I also considered the possibility that learners' decisions, behaviors, and discourse could also reflect a desire to maintain current conditions (e.g., Byrne et al., 2014)

Examining rival explanations. Along with examining theoretical propositions, Yin (2014) noted that examining plausible rival explanations could allow case study researchers to place more confidence in their findings. One rival explanation I examined was that: Interacting aspects of learners' conditions <u>do not</u> shape their ideas about climate change. I considered the possibility that learners' ideas about climate change—as they showed up in the data—might be strongly reflective of classroom-based curriculum and instruction. I assumed this might have been the case if learners have never heard of climate change prior to instruction. If learners had not cited other sources of information, and simply restated messages about climate change that were explicitly stated in the classroom, it may not have been appropriate to make claims about how learners' conditions within *and beyond* the school environment shaped their figured worlds of climate change. However, as I will describe in the next chapter, I found that even when participants had limited prior exposure to climate change, all had some information from outside of school. In addition, learners' ideas and values about environmental issues in general – formed through prior experiences and interactions both within and beyond the world of school – played an important role in their climate change ideas.

Relatedly, it was possible that: The focal aspects of learners' conditions that I chose to examine specifically (e.g., public discourse; educational experiences; place and personal experiences with climate change; social relationships (peers, family); and cultural views of environment, science, and technology) were not among the influences on their climate change learning. If no evidence had appeared to support the explanation that such forces previously identified in the literature were shaping learners' ideas in this case study, I would have needed to further probe participants' thinking to gain insight into the forces that did appear did shape their perspectives. As I will describe in later chapters, I found that many of the influences previously reported in the literature appeared to shape participants' climate change ideas, however, some did not appear to have direct influence, or were not dimensions of learners' conditions that were salient to them in their everyday lives.

Another plausible rival explanation I considered was that: *Learners did not develop perceptions, knowledge, values, or responses related to climate change*. It may have been the case, for example, that learners would express great uncertainty about whether climate change is happening [perceptions], whether they should be concerned or not [values], and whether they should act or not act in certain ways [response] given the meanings of climate change they were developing. If the data had suggested that this were the case, it may have indicated that Roncoli et al's (2009) perception-knowledge-valuation-response axioms were not appropriate for describing figured worlds of climate change for these learners. However, as my data will show, learners did not express these kinds of uncertainties related to climate change.

Finally, it was also possible that the data could suggest that: *Learners did not develop identities or agency with regard to climate change.* For example, I might have encountered learners who did not think about climate change as specifically relevant or irrelevant to themselves (i.e., their lives and communities)—simply as a topic they learned about in school. Likewise, learners might not have thought about climate change as something to which they (or others) would specifically respond in the real world. This might have suggested that the theoretical perspective of figured worlds—which includes identity and agency development as central features—may not have been the most fruitful for describing the ways in which learners form ideas about climate change. As I will describe later, learners did express evidence of climate change identities and agency. Individual learners saw multiple – sometimes conflicting climate change identities – for themselves, and envisioned themselves acting in accordance with these varied identities.

Use of a model. The use of a model is a data analysis technique that may be particularly appropriate for analyzing case study data related to a process of change. In Figure 3, I presented a theoretical model of climate change learning as a dialectic process by which learners' figured worlds of climate change are shaped by their social and cultural contexts, and by which the identities and agencies that learners develop in figured worlds of climate change may shape (reinforce or change) the conditions in which they are embedded. Like a logic model, this theoretical model of climate change learning represents a chain of occurrences over time (Yin). Thus, I used the theoretical model of climate change learning to match empirical evidence with theoretically predicted events. Alternately, I might have found that empirical evidence disconfirms theoretically predicted events (e.g., certain contextual influences *may not* appear to shape learners' perspectives on climate change). Though my empirical evidence did not disconfirm theoretically predicted events, as I will describe in the chapters that follow, I noted complexities in the data that were not always sufficiently represented by the model. In Chapter Five, I deconstruct the model into its component parts and present new representations in light of my analysis of empirical evidence.

Coding Procedures

As a way to use the data I collected to examine theoretical propositions, I began by distilling the evidence collected from each data source. To guide this process, I referred to Saldaña's (2012) *Coding Manual for Qualitative Researchers* and Miles, Huberman, & Saldaña's (2014) *Qualitative Data Analysis: A Methods Sourcebook*. I followed Saldaña's general codes-to-theory model. Saldaña defined a code as "a researcher-generated construct that symbolizes and thus attributes interpretive meaning to each individual datum for later purposes of pattern detection, categorization, theory-building, and other analytic processes" (p. 4) and as "a datum's primary content and essence" (p. 4). Applying codes facilitates the grouping and linking of qualitative data in order to make meaning from it; that is, to use collected evidence to develop empirically-based assertions or theory (Saldaña).

I began the analysis process while still engaged in collecting, transcribing, and organizing the case study data. During this phase, I wrote "preliminary jottings" (Saldaña, 2012, p. 20), or ideas for analytic consideration that come to mind during my initial interactions with the data. These included ideas for codes or noticeable patterns (Saldaña). When I began first cycle coding, I referred back to these preliminary jottings.

During first cycle coding, I used structural coding (Saldaña, 2012). Structural coding entails the use of research questions to help initially categorize data so that similarly coded segments can be grouped for more detailed analysis, including analysis of commonalities, differences, and relationships. Here, I used my data collection questions as guides. Table 7 below shows how I translated the data collection questions into structural coding questions. In total, I had six unique structural coding questions, which served as six unique analytic lenses that I used to code the relevant data sources (a. Climate change information sources; b. Climate change perceptions; c. Climate change knowledge; d. Climate change identity; e. Climate change values; f. Climate change responses/agency). I coded all of the data sources relevant to each data collection question using the corresponding structural coding questions. Otherwise stated, I coded the data in six different ways during first cycle coding.

Table 7

Analytic Lenses Aligned with Data Collection Questions, Structural Coding Questions, and Relevant Data Sources

Analytic lens and data collection question(s) *(rooted in research subquestions)*	**Structural coding questions** *(questions guiding my coding process for the relevant analytic lens)*	**Data sources coded**
a) Climate change information sources [Relevant data collection question: *To what extent, if any, do learners' conditions appear to shape their ideas about climate change?*]	*What were the apparent sources of learners' climate change information?* Parent codes: ▪ In-school ▪ Out-of-school	• Observations • Written artifacts (lesson plans, student work) • Individual interviews (learners, teacher, and parents) • Focus group interview
b) Climate change perceptions [Relevant data collection question: *What is the nature of learners' ideas (i.e., their* ***perceptions****…) in relation to climate change?*]	*How did participants show evidence of their perceptions of the world in relation to climate change?* Parent codes: ▪ Visual information ▪ Verbal information ▪ Physical (felt) information	• Learner-generated drawings and accompanying written reflections • Individual interviews (learners) • Focus group interview
c) Climate change (science content) knowledge [Relevant data collection question: *What is the nature of learners' ideas (i.e., their…* ***knowledge****…) in relation to climate change?*]	*How did participants provide evidence of their sense-making of information about climate change (i.e., communicate knowledge about climate change as a sequence of causally-connected events)?* Parent codes: ▪ Ideas about climate change *causes and mechanism* ▪ Ideas about climate change *effects* ▪ Ideas about *human activities*	• Written artifacts (student work) • Participant-generated drawings and accompanying written reflections • Individual interviews (learners) • Focus group interview

Analytic lens and data collection question(s) *(rooted in research subquestions)*	**Structural coding questions** *(questions guiding my coding process for the relevant analytic lens)*	**Data sources coded**
d) Climate change identities [Relevant data collection question: *To what extent, if any, do learners see climate change as relevant to their own lives?*]	*What characters emerged in participants' stories of climate change, and in what roles did participants cast themselves and others?* Parent codes: ▪ Roles of others ▪ Roles of self (individual) ▪ Roles of self (as group member)	• Individual interviews • Participant-generated drawings • Focus group interviews
e) Climate change values [Relevant data collection question: *What is the nature of learners' ideas (i.e., their **values**…) in relation to climate change?*]	*What did participants appear to uphold as the good (or right) and the bad (or wrong) as they communicated about climate change?* Parent codes: ▪ Good or right ▪ Bad or wrong	• Participant-generated drawings and accompanying written reflections • Individual interviews (learners) • Focus group interview
f) Climate change agency, or responses [Relevant data collection questions: *What is the nature of learners' ideas (i.e., their… **responses**) in relation to climate change?* *How might learners' ideas about climate change shape (reinforce or change) the conditions in which they are embedded?*]	*How do participants respond to climate change?* Parent codes: ▪ *Emotional responses* ▪ *Behavioral responses (imagined)* ▪ *Behavioral responses (enacted)*	• Individual interviews • Participant-generated drawings • Focus group interviews

Because of the multifaceted nature of my approach to data analysis, and the organizational challenges inherent in using multiple lenses to examine the data, I opted to use a CAQDAS (Computer Assisted Qualitative Data Analysis Software) program to aid in database organization and data analysis. Miles et al. (2014) noted that CAQDAS programs provide helpful features to support data analysis, but may entail a steep learning curve. I experimented with trial versions of several CAQDAS programs. Ultimately, I selected the CAQDAS program, NVivo (QSR International), because it was compatible with my research needs and I was able to learn to use it relatively quickly. I created six separate NVivo projects, one for each of the six analytic lenses (i.e., structural coding questions). For each new NVivo project created, I uploaded all of the relevant data sources (see Table 7). I coded inductively by creating codes (or "nodes" in NVivo) relevant to the guiding structural coding question.

During first cycle coding, I also used subcodes (Miles & Huberman, 1994), or second-order tags to add specificity when needed. As with the parent (Gibbs, 2007) structural codes (or "parent nodes" in NVivo), I inductively determined the subcodes. As I engaged in this process, I wrote analytic memos to keep a record of the insights I was developing with regard to the data collection questions. Before transitioning to Second Cycle coding, I reviewed my codes and analytic memos to create initial "network displays" (Miles, Huberman, & Saldaña, 2014) or operational model diagrams (Saldaña, 2012) to depict emerging ideas relevant to my data collection questions.

Second Cycle coding entailed the reorganization and reanalysis of First Cycle codes, "condensing the vast array of initial analytic details into a 'main dish'… a key assertion or theory" (Saldaña, 2013, pp. 208-209). As a Second Cycle coding method, I use focused coding (Charmaz, 2006) to guide the process of clustering together first cycle codes into categories (Saldaña). In following Glaser's (1978) recommendation that data should not be forced to fit into pre-conceived categories during this process, I developed the categories emergently as I reorganize the data.

I then synthesized my interpretations of the interconnections between my discretely coded data. That is, I reexamined the analyzed data holistically for insight into my overarching research question, which inquired about the relationship between climate change learning <u>conditions</u> (operationalized as *information sources* in my coding) and learners' <u>figured worlds</u> of climate change (operationalized as *climate change identity* and *climate change agency* in my coding, which I viewed as contingent upon learners' climate change understandings (operationalized as their *perceptions*, *knowledge*, *values*, and *responses* to climate change).

I considered varying possibilities for arranging and rearranging these salient ideas as I prepared to write up my case study report. In doing so, developed a tentative analytic storyline (Charmaz, 2008) that guided my written description of "what [was] happening to participants" (Saldaña, p. 257) as they engaged in climate change learning. As I will further describe in Chapter 4, to organize my reporting, I adopted elements of Truby's (2007) *The Anatomy of a Story* framework for storytelling.

Establishing Trustworthiness

The trustworthiness of a qualitative study depends on the extent to which the researcher establishes credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). In this section, I describe the approaches I used to increase the trustworthiness of my case study, including seeking crystallization of evidence, using peer debriefing, and using member checking procedures.

Crystallization of evidence. Yin (2014) noted that a major strength of case study research is the opportunity to use many sources of evidence to develop *converging lines of inquiry*—a practice known as triangulation. Toward this end, I sought to use multiple sources of evidence to corroborate specific case study findings. In Table 7 above, I show how I grouped the diverse data sources to provide insight into various dimensions of my study (e.g., using drawings, interviews, and written work to examine learners' climate change knowledge). I opted to refer to this practice as crystallization, rather than triangulation, as I was drawn to Richardson's (2000) idea that qualitative inquiry is more aptly characterized by "an infinite variety of shapes, substances, transmutations, multidimensionalities, and angles of approach" (p. 934).

Peer debriefing. Lincoln and Guba (1985) described peer debriefing as the practice of engaging disinterested peers in exploring portions of a study that might otherwise remain only implicit to the researcher. To do so, I sought feedback from other researchers regarding the insights I was developing throughout the research process.

Member checking. Member checking entails presenting draft copies of research materials to informants for correction and comment (Stake, 2010). This practice may help to increase the accuracy of evidence, decrease possible insensitivity, and open up new interpretations or meanings (Stake). To ensure that the eight 6th grade case study participants felt that their voices were accurately represented in the data, I met with participants and asked them to review written transcripts of their interviews. Most participants made minor corrections to phrasing, and some filled in missing content in the interview transcripts that was inaudible to me on the audio recordings. After making these minor corrections, all of the 6th grade participants indicated that the transcripts accurately represented their voices and ideas.

Maintaining a chain of evidence. Yin (2014) emphasized the value of showing how findings come from the data collected, as described in the case study protocol and motivated by the original research questions. Toward this end, I strove to carefully document my procedures, attend to all available evidence, and document the steps leading to the development of my findings.

Confronting researcher bias. All researchers carry their own biases. Stake (2010) emphasized that "we need to help the reader see the biases we are trying to deal with" (p. 166). Toward this end, I made an effort to clarify and articulate my own positionality and assumptions, and strove to remain open-minded to the multiplicity of stories to be interpreted from the collected data.

Chapter Summary

In this chapter, I have described my approach to investigating the research question: *How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded?* I provided a rationale for the use of qualitative inquiry, specifically case study, for addressing my research question. I described the *case*, or phenomenon, under investigation: climate change learning amongst eight 6th grade learners in one middle school setting, and provided an explanation of my case and participant selection processes. Because context, or conditions, are a critical dimension of my study, I described at length the nested contexts in which my phenomenon of interest was occurring. This included detailed descriptions of participants' school-based and out-of-school climate change learning contexts, and acknowledgement of the broader multilayered (local, regional, national, and global) and multifaceted (e.g., spatiotemporal, political, economic, social, cultural) conditions in which participants' daily lives were embedded.

I presented my case study protocol, including my data collection and analysis procedures. I demonstrated how I rooted my analytical approach in the research questions, through the use of discrete analytic lenses that came from my data collection questions. Finally, I described my processes for maintaining trustworthiness as I developed assertions from the data in light of my overarching research question. In the next chapter, I turn to an in-depth description of the research findings that emerged from the process I have described here.

Chapter Four: Findings

In this chapter, I report on the insights the data provided with regard to the question: *How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded?* In taking a figured worlds perspective on climate change learning, which foregrounds identity and agency in relation to climate change, I describe how I interpreted the 6^{th} grade participants' views of themselves and others as enacting certain roles in the *story* of climate change. In doing so, I necessarily describe what these learners' understandings, or stories, of climate change entailed. Through my analysis of the data sources described in Chapter 3, I interpret and synthesize participants' conditionally-mediated perspectives on climate change, weaving together the collective climate change story communicated through the data.

Unlike more fully-immersive ethnographic studies, I was limited in my case study to relatively short-term interactions with participants. As a result, rather than interpreting stories communicated by participants as cohesive wholes, I was required to piece together and interpret participants' stories retrospectively from discrete data sources, engaging in what Leavy (2009) referred to as "restorying" (p. 7). This placed me in the role of meta-narrator of participants' stories, and at times required making inferences about participants' intended meanings, as I will describe. To address such challenges, while still benefitting from the use of a lens proven valuable in prior figured worlds research, I adopted elements from an existing storytelling framework: Truby's (2007) *The Anatomy of a Story*. Though the framework is intended for use by screenwriters, it has provided me with helpful guidance as a qualitative researcher in past studies of climate change learning (see McGinnis, Hestness, & Riedinger, 2012). Further, as I will demonstrate, I found it to align well with my chosen analytic lenses.

Use of Storytelling

Truby (2007) describes a story as "a 'living' system in which the parts work together to make an integrated whole" (p. 109). In my data analysis, I examine how the *parts* of the climate change stories that participants were telling through the data could form "an integrated whole" (Truby, p. 109) with the potential to shed light on participants' figured worlds of climate change. These story elements included: *story world*, *plot*, *characters,* and *moral argument* (Truby, 2007). I use the notion of story world to describe participants' perceptions (Roncoli et al., 2009) of the world in which climate change was taking place, and in which they were embedded. I draw on the notion of plot to describe participants' knowledge (Roncoli et al.) of climate change as a sequence of events related to human activities and their consequences. I use the notion of character to describe the people or entities that participants saw as enacting this sequence of events, and who they cast in these roles, including themselves and others. From a figured worlds perspective, I interpret the roles in which participants cast themselves as evidence of their *climate change identities*. Finally, I use the notion of moral argument to describe the values (Roncoli et al.) that I interpreted through participants' stories of climate change.

In synthesizing these aspects of participants' climate change storytelling, I reflect on the ways in which participants' conditions (or contexts) may have contributed to shaping the ideas they expressed, including the roles in which they cast themselves and others. This represents one dimension of the conditions-to-figured worlds connection that

I seek to examine with my overarching research question: *How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded?*

For the inverse dimension of the relationship, or how participants' figured worlds of climate change had the potential to *reshape or reinforce* the conditions in which participants were embedded, I add a dimension to Truby's (2007) *The Anatomy of a Story* framework. Here, I describe preliminary evidence of what I consider participants' *critical responses* to their stories of climate change. *Responses* (Roncoli et al., 2009) reflect on the ways participants themselves changed, inwardly and outwardly, as they learned about, discussed, and reacted to climate change. I interpret participants' responses to climate change as providing evidence of their senses of *agency* – or, their views of their own capacities to act (Holland et al., 1998) - in relation to climate change. In figured worlds terms, these responses represent participants' *spaces of authoring* (Holland et al.), or the ways in which participants' enactment of their figured worlds may serve to reinforce or change their conditions. Table 8 shows how I used Truby's (2007) *Anatomy of a Story*, with my added framework dimension of *critical response*, as a heuristic to guide my data analysis and reporting. I present how I aligned the storytelling framework elements with my analytic lenses and their related data collection questions; my structural coding questions; and my case study data sources. I structure the next sections of this chapter using this framework.

Table 8

Alignment of Storytelling Framework Elements with Their Relevant Analytic Lenses, Data Collection Questions, Structural Coding Questions, and Data Sources

Storytelling framework element	**Analytic lens and related data collection question(s)** *(rooted in research subquestions)*	**Structural coding questions** *(questions guiding my coding process)*	**Data sources coded**
Story world (Truby, 2007)	a) Climate change information sources [Relevant data collection question: *To what extent, if any, do learners' conditions appear to shape their ideas about climate change?*]	*What were the apparent sources of participants' climate change information?* Parent codes: ▪ In-school ▪ Out-of-school	• Observations • Written artifacts (lesson plans, student work) • Individual interviews (learners, teacher, and parents) • Focus group interview
Story world continued (Truby, 2007)	b) Climate change perceptions [Relevant data collection question: *What is the nature of learners' ideas (i.e., their* ***perceptions****...) in relation to climate change?*]	*How did participants show evidence of their perceptions of the world in relation to climate change?* Parent codes: ▪ Visual information ▪ Verbal information ▪ Physical (felt) information	• Learner-generated drawings and accompanying written reflections • Individual interviews (learners) • Focus group interview

Storytelling framework element	**Analytic lens and related data collection question(s)** *(rooted in research subquestions)*	**Structural coding questions** *(questions guiding my coding process)*	**Data sources coded**
Plot (Truby, 2007)	c) Climate change (science content) knowledge [Relevant data collection question: *What is the nature of learners' ideas (i.e., their… **knowledge**…) in relation to climate change?*]	*How did participants provide evidence of their sense-making of information about climate change (i.e., communicate knowledge about climate change as a sequence of causally-connected events)?* Parent codes: ▪ Ideas about climate change *causes and mechanism* ▪ Ideas about climate change *effects* ▪ Ideas about *human activities*	• Written artifacts (student work) • Participant-generated drawings and accompanying written reflections • Individual interviews (learners) • Focus group interview
Character (Truby, 2007)	d) Climate change identities [Relevant data collection question: *To what extent, if any, do learners see climate change as relevant to their own lives?*]	*What characters emerged in participants' stories of climate change, and in what roles did participants cast themselves and others?* Parent codes: ▪ Roles of others ▪ Roles of self (individual) ▪ Roles of self (as group member)	• Individual interviews • Participant-generated drawings • Focus group interviews

Storytelling framework element	**Analytic lens and related data collection question(s)** *(rooted in research subquestions)*	**Structural coding questions** *(questions guiding my coding process)*	**Data sources coded**
Moral argument (Truby, 2007)	e) Climate change values [Relevant data collection question: *What is the nature of learners' ideas (i.e., their* ***values****…) in relation to climate change?*]	*What did participants appear to uphold as the good (or right) and the bad (or wrong) as they communicated about climate change?* Parent codes: ▪ Good or right ▪ Bad or wrong	• Participant-generated drawings and accompanying written reflections • Individual interviews (learners) • Focus group interview
Critical response (my framework addition)	f) Climate change agency, or responses [Relevant data collection questions: *What is the nature of learners' ideas (i.e., their…* ***responses****) in relation to climate change?* *To what extent, if any, might learners' ideas about climate change shape (reinforce or change) the conditions in which they are embedded?*]	*How do participants respond to climate change?* Parent codes: ▪ *Emotional responses* ▪ *Behavioral responses (imagined)* ▪ *Behavioral responses (enacted)*	• Individual interviews • Participant-generated drawings • Focus group interviews

Story World: Figured Worlds of Climate Change as Created in Contexts

In Chapter 3, I provided a detailed description of the study context, which outlined the multifaceted, multileveled conditions in which the 6th grade participants were embedded. In this chapter, I focus on how participants perceived climate change information through interactions within their contexts, and subsequently drew upon these interpretations to describe the *story world* in which they understood climate change to be taking place. To be clear, the study context I described in Chapter 3 represents *my interpretation* of the conditions in which participants were embedded. The *story world* I describe in this chapter represents my understanding of *participants' interpretations* of the world in which they were embedded—and in which they interpreted climate change to be taking place.

Truby describes *story world* as "everything surrounding the characters all at once" (p. 147). Elements of Truby's story world include: 1) the natural setting; 2) human-made (social) spaces; 3) technology (tools); and 4) time. In applying the notion of story world to this study, I interpreted the ways in which participants, embedded within nested contexts (e.g., global, national, regional, local, in-school, out-of-school), perceived information about climate change through their interactions and experiences. I begin by synthesizing my findings related to participants' contextually-mediated perceptions of climate change. This entails describing what participants saw, heard, and felt that informed their ideas about climate change[2], and the sources of that information. I then describe the *story world* that I saw emerging through participants' discussions of their contextually-mediated climate change perceptions – that is, how I understood participants' interpretations of their conditions as a *world* in which the story of climate change was unfolding.

Participants' perceptual modes and sources of information on climate change. I consider participants' climate change perceptions to be the awareness about climate change that participants gained through the use of the senses (i.e., by seeing,

[2] I reserve discussion of participants' sense-making of this perceptual information for a later section, in which I turn to participants' *knowledge* (the plot) of climate change.

feeling, hearing). This aspect of my data analysis represents my application of the *sources of information* analytic lens (Table 9).

Table 9

Alignment of the Story World Framework Element with the Sources of Information Analytic Lens

Storytelling framework element	Analytic lens and related data collection question(s)	Structural coding questions	Data sources coded
Story world (Truby, 2007)	a) Climate change information sources [Relevant data collection question: *To what extent, if any, do learners' conditions appear to shape their ideas about climate change?*]	*What were the apparent sources of participants' climate change information?* Parent codes: ▪ In-school ▪ Out-of-school	• Observations • Written artifacts (lesson plans, student work) • Individual interviews (learners, teacher, and parents) • Focus group interview

I identified three modes by which participants perceived climate change information from the contexts in which they were embedded: 1) by attending to information communicated by others (verbally, visually, or in writing); 2) by observing human behaviors they interpreted as exacerbating or mitigating climate change; and 3) by observing changes in their physical environments they interpreted as evidence of climate change. It is important to note that the latter two modes of perceiving information about climate change presume some level of pre-existing climate change knowledge and awareness. For example, I do not make the claim that participants felt warmer temperatures (perceptual mode #3, above) and – from this sensory information alone –

first became aware of global climate change. I do suggest, however, that after having had climate change information communicated to them by others (e.g., teachers, family, the media), participants perceived new kinds of information (e.g., observations of the natural world, human activity) as relevant to climate change. Therefore, I consider the first perceptual mode (attending to information communicated by others) to be a prerequisite for the other two modes.

In the section that follows, I explain each of the three perceptual modes and provide examples of the how participants perceived information in each mode through interactions within their contexts. Within each perceptual mode, I used inductive coding to identify participants' sources of information on climate change.

Perceptual mode: Attending to information communicated by others. I begin with an examination of the main sources of communicated messages (verbal, visual, written) that appeared to shape participants' perceptions of climate change. I discuss *interpersonal interactions* and *media* that participants cited as information about climate change both in school and out of school. Taking a sociocultural view of learning, these information sources represent the *people and cultural objects* (Vygotsky, 1978) with which participants interacted that shaped their ideas about climate change.

School context. In school, participants appeared to perceive information about climate change through their interactions with other people (classmates, teachers, researchers), their online curriculum, and other educational media.

Interactions with science educators during instruction: "They say flat out 'This is what's happening'". In the science classroom, interacting with the 6th grade science teacher, Ms. Kane, my research colleagues, and myself appeared to influence participants' perceptions of climate change. During their interviews, all participants described messages they had heard during the 6th grade science class sessions devoted to the topic of climate change. All viewed information presented in class as reliable. As Isabelle stated during the focus group, "It's not like [our teachers] bring the topic up like, 'This is what some people believe, it may be happening it may not'. They say flat out 'This is what's happening'" (Isabelle, focus group). This statement suggests that participants interpreted communication from science educators in their classroom as trustworthy and direct. In most cases, participants reported the 6th grade science class sessions on climate change were their first experience hearing about climate change in a formal classroom setting. Though most had not previously encountered climate change in school, participants were familiar with the term and had some ideas about what it meant.

In my interviews with parents, some reported that their children told them about the science class sessions on climate change, typically describing visual information or demonstrations presented. For example, Autumn's mother explained, "[Autumn] talked to me about the ice… I recall her talking to me about the ice melting in the Antarctic, so a lot of flooding happens in the Antarctic if the ice would melt" (Autumn's mother, interview). Here I interpreted Autumn's mother as referencing the model glacier demonstrations that were presented in class. Such examples of participants bringing ideas home provide evidence that interactions with science educators during classroom instruction influenced participants' climate change ideas.

Participants themselves also showed evidence that in-class activities made an impression. In some cases, information communicated though these activities appeared to provide participants with new metaphors for understanding climate change phenomena.

For example, Richie described the atmosphere as being “like a bag” (Richie, interview), which I interpreted to be a reference to the “Earth in a bag” demonstration. In other cases, messages communicated through classroom activities appeared to create confusion for participants. For example, the demonstrations that modeled glacial and sea ice melt left Sophia with the impression that melting ice *would not* contribute to sea level rise. She expressed her confusion during one of the focus groups, saying, “Wait, but I don’t understand… When we did an experiment in the classroom about glaciers and the water, when you put the water inside the cup, the water level stayed the same. So if the ice is melting, it will stay the same…” (Sophia, focus group). Here, Sophia conflated the sea ice model, in which melting *did not* lead to sea level rise, with the glacier model, in which melting *did* lead to sea level rise. This suggests that in addition to perceiving information that helped participants make sense of climate change, classroom interactions may have left some participants with areas of confusion. I interpreted either case as evidence that interactions with educators during classroom instruction did appear to shape their climate change ideas.

Interactions with educational media in the classroom: “When we watched a video, I learned that the carbon dioxide is making a big cloudish thing”. Participants interacted with a variety of online media, both individually and as a class, as they learned science in their blended learning middle school. In my analysis of the data, I noted that participants rarely referenced the lessons they completed individually on the computer as part of their *Innovate* online curriculum, which explicitly included the topics of global warming and the greenhouse effect. Where I did interpret participants making reference to the *Innovate* online curriculum, they generally described it as giving them greater awareness of the topic and of personal climate change mitigation strategies. For example, as Autumn described:

> It's promoted awareness, like, it's given more detail and information of how global warming has started and how humans are affecting it to grow larger and larger. And also giving sources of how… even if you can't ride a bicycle you can do at least something else to stop carbon dioxide. (Autumn, interview)

This statement suggests that greater climate change awareness, gained through interaction with the *Innovate* online curriculum, included greater awareness of what individuals could do to reduce their impacts on climate

I also noted how elements of the *Innovate* online unit on *Weather and Climate* appeared salient to participants as they spoke about climate change. For example, I noticed that a number of participants used the water cycle – an important element in the *Weather and Climate* unit - in their explanations of climate change-related phenomena. As Sophia described climate change consequences, she explained: "So like in rivers and stuff, the hotter it is the more it gets evaporated, so like the water will get evaporated and it might rain more" (Sophia, interview). Such statements suggested that ideas communicated to participants through the *Innovate* online curriculum had an influence on their climate change ideas.

Beyond their use of the *Innovate* online curriculum, participants engaged with a variety of other digital media during group and individual science learning activities. For example, during the interactive class sessions on climate change, Ms. Kane and the MADE CLEAR research team incorporated videos, digital images, and online simulations as educational resources. In particular, visual information appeared to make an impression on participants. As Richie explained, “When we watched a video, I learned that the carbon dioxide is making a big cloudish thing” (Richie, interview). I interpreted Richie to be referencing an online video shown in class. During the focus group, Richie also referenced a computer simulation presented in class that allowed users to alter greenhouse gas concentrations in the Earth’s atmosphere. During one of the focus groups, participants were discussing the relationship between greenhouse gases and temperature. Richie turned to me and said, “The video you showed us, about if there was no atmosphere…” (referring to the simulation) (Richie, focus group) as he described how colder temperatures could relate to amounts of atmospheric gases.

In addition to educational media presented by educators at school, participants engaged independently with online media during their school day in order to complete assigned tasks. Sarah spoke about happening upon websites with climate change information while she worked on a school project. She explained, “Sometimes I have to look up stock images for a project, like trees and such, I needed to cite my sources. So that’s where I found these websites and I would read a little more into them… And they would tell a lot about climate change” (Sarah, interview).

Both Sophia and Isabelle spoke about using Google Image Search on their laptops in order to help them complete the pre-assessment climate change drawing task (*Draw what comes to your mind when you think about climate change*). Both represented in their drawings the online images they encountered. For example, Sophia drew images of Arctic animals dying (Figure 5) that were similar to images she had seen online. She explained, “I Googled this and saw some of the animals, so, that’s how I tried to draw a few of them" (Sophia, interview). Such examples suggest that visual information presented through online media appeared to be highly influential for some participants.

Figure 5

Sophia's Drawing Informed by a Google Image Search

Interactions with classmates: "We all had similar ideas". I interpreted classmates or peers at school as having a minor role in shaping participants' climate change perceptions. During my observations in the science classroom, I rarely observed discussion amongst students regarding climate change. Students primarily interacted with their computers (the *Innovate* online curriculum) and their teacher, but rarely with one another around the curriculum content. When they did interact with one another, it was typically social interaction or for the purpose of discussing assigned tasks. When our research team visited the classroom to collaborate with Ms. Kane in facilitating climate change learning activities, I observed that discussion of climate change was typically a back-and-forth between the facilitators and individual students volunteering ideas. In some cases, participants explicitly stated that they had not talked to classmates about climate change in earlier schooling experiences. As Isabelle explained, “No, cuz they’re like me. They didn't really learn about it [before]… My elementary school babied us. They had the place baby-proofed. Literally.” (Isabelle, interview).

However, I found that when tasked by adults at school with discussing climate change, participants and their peers could help to reinforce or clarify one another’s ideas. For example, when participants engaged with their sustainability project groups (outside of science class), they were tasked with collaboratively proposing an energy-saving solution for the school. In reflecting on this experience, some participants described interactions with their classmates around the topic of climate change. For example, when I asked Aliyah about whether she had talked to classmates about climate change, she said, “We talked about ways that we could use less energy in school. And ways that we could get to school without using a lot of energy” (Aliyah, interview). She noted, however, that this experience did not change her thinking about climate change, because she and her classmates “all had similar ideas” (Aliyah, interview). This example suggests that participants could have their ideas about climate change reinforced through communications with their classmates.

Another instance of participants communicating with their classmates about climate change occurred during the focus groups. During one of the focus group conversations that I facilitated, Sophia raised a question about the role of ice melt in causing flooding. Autumn interjected to help clarify Sophia's understanding, explaining, "As the Earth gets warmer and it heats up the sea, then it causes the water to expand, so that's why it's flooding, especially coastal areas" (Autumn, Focus group 2). This example suggests that classmates may provide information to one another about climate change.

Out-of-school context. Beyond attending to information communicated to them about climate change at school, participants perceived information about climate change through interactions outside of school. Participants' out-of-school sources of information on climate change included other people (e.g., parents, siblings, extended family) and media (e.g., television and movies, Internet).

Interactions with parents: "She's learning about up-to-date research. I'm learning by what I see in the environment". I interpreted parents as having a role in shaping 6th grade participants' perceptions of climate change. However, I noted that parents appeared more influential in shaping participants' environmental values (the *moral argument* (Truby, 2007) of their climate change stories) than in shaping their climate change knowledge (the *plot* (Truby, 2007) of their climate change stories). Participants' parents all agreed that climate change was happening and were concerned about it. Parents often reported speaking to their children about climate change in terms of conversations they would have about unusual weather they were experiencing. For example, Aliyah's mother said:

> I've had very interesting conversations with her. Climate change comes up when we talk about the past couple of winters being so cold, with the polar vortex. All

> the sudden it's like hotter now in the summer so early, compared to, you know, previous years. (Aliyah's mother, interview)

Parents also appeared to talk to participants about enacting environmentally-friendly practices in the home, though they did not typically connect these explicitly to climate change. An example is evident in my interview with Sophia:

> Sophia: My mom, she talks about recycling, and every time I hear about recycling I think about global warming.
>
> Emily: How do you see those two things as connected to each other?
>
> Sophia: Recycling, I don't know… They just kind of, they're both about keeping the Earth healthy I guess. (Sophia, interview)

Some parents expressed that they were cautious about not scaring their children by talking too in-depth about the possible negative consequences of climate change. As Sarah's mother explained, "We do talk about it. But again, not at length, you know. If there's a story that I read about, then sometimes I'll share it with Sarah. And sometimes she'll share things with me… But we try to be careful because we don't want to scare the kids, so we try to walk a fine line." (Sarah's mother, interview).

Several parents expressed the view that their 6th grade children were more knowledgeable about climate change than they were themselves. As Autumn's mother described it, "[Autumn's ideas] are probably more up to date, because she's learning about up-to-date research. I'm learning by what I see in the environment, and what I see around me" (Autumn's mother). Some parents spoke about their children coming home from school and sharing information about what they had learned about climate change. Likewise, some 6th grade participants spoke about their parents sharing information they had learned about climate change from other sources. For example, both Autumn and Bobby mentioned climate change information that their mothers had seen on Facebook. Such examples suggest that both parents and their 6^{th} grade children were positioned in the roles of climate change learners, and sometimes shared their learning with one another.

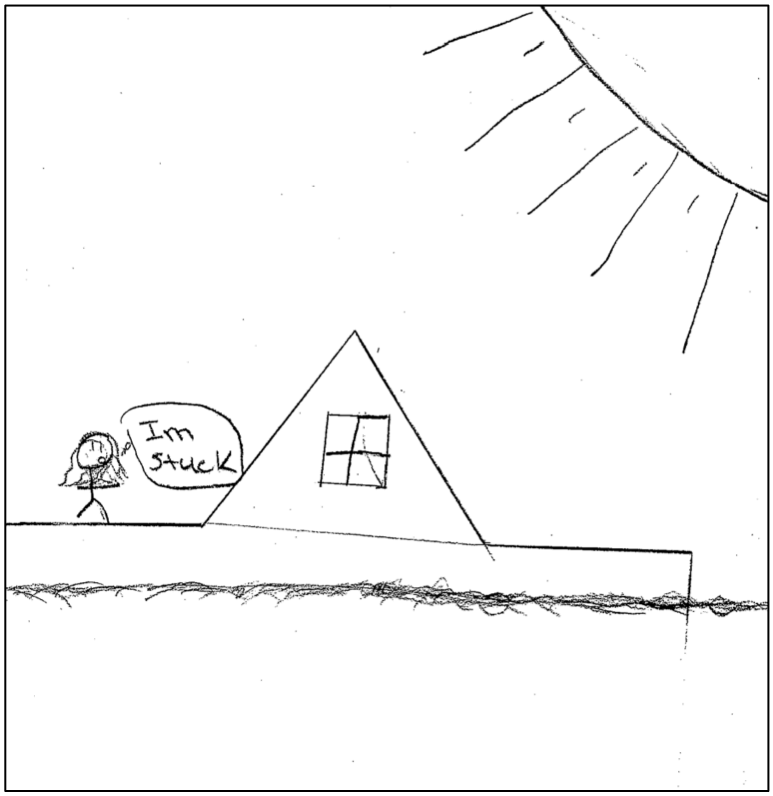
Beyond explicit conversations about climate change and the environment, I saw evidence that participants' perceptions were shaped by what they learned about their parents' experiences. Autumn's mother worked as a respiratory therapist, and I noticed that Autumn was especially concerned about the respiratory health consequences of the air pollution she associated with climate change. Similarly, Isabelle's mother had worked in emergency management, and Isabelle expressed concern about becoming a natural disaster victim. During her interview, Isabelle's mother explained:

> I worked in… emergency management and safety. So a lot of the stuff that I did there, I would bring home. Because they talk about, you know, "What ifs"… So I would come home with information about natural disasters, and if something happened, what are we as a family gonna do? Because I dealt with it all day. So you know, at home, I was like "We should be prepared". (Isabelle's mother, interview)

Figure 6 below provides an example of how Isabelle's mother's work may have shaped her perceptions of climate change, as expressed in Isabelle's drawing in response to the prompt: "*Draw what comes to mind when you think about climate change*".

Figure 6

Isabelle's Depicting Herself as a Natural Disaster Victim



However, Isabelle noted that her drawing was inspired by images she saw on the Internet. She explained,

Isabelle: I didn't know how to exactly draw. So I Googled it, and there was a little girl sitting on the roof holding her bear… Because they have people come out and they police it, and they'll come through the area looking for any survivors, but like, they can always miss that one child...

Emily: Do you know where that image was from that you saw? Was it from a specific natural disaster?

Isabelle: It was just an image on the Internet. (Isabelle, interview)

This example suggests that participants may have integrated climate change information from varied elements of the contexts in which they were embedded as they developed their ideas.

Finally, parents' stories of their own experiences as children, especially if they had grown up in Douglass County, also appeared to influence their children's climate change ideas. Autumn's mother told her about how the seasons had changed since she was a child growing up in the area decades ago:

Autumn's mother:	Like it's not a white Christmas all the time anymore. So we have talked about the seasons' change.
Emily:	It used to be snowy around Christmas usually?
Autumn's mother:	Yes, snowy, and you know, like rain around April… [Now] it's just totally different. (Autumn's mother, interview)

Similarly, Isabelle's mother, who had grown up in the area, was surprised that in recent years she could host Isabelle's November birthday party outdoors, recalling that it would have been too cold at that time of year when she was younger (Isabelle's mother, interview). Isabelle's father had photos from his childhood visits to the beach, where the family still vacations. Isabelle noticed differences between the way the beach looked then and now, and interpreted these changes as evidence of sea level rise. She explained, "When [my dad] was younger, there were lots of pictures. The beach and the dunes were super far apart... Now you can kind of jog down, take two minutes to get to the beach" (Isabelle, interview). Such examples suggest that parents' conversations with their children, either directly or indirectly related to climate change, appeared to shape how the 6th grade participants came to understand climate change.

Interactions with other family members: "My grandmother will be sitting watching the news". I interpreted other family members, such as siblings, grandparents, and extended family, as potentially having influence on participants' climate change ideas – though the nature of this influence varied with each 6th grader's unique family relationships. With other family members in their own households, participants could both communicate and educate about climate change. For example, participants with older siblings, such as James and Richie, sometimes learned about climate change from them. As Richie's mother explained, "[My older son], he's 17… He keeps talking to Richie." (Richie's mother, interview). Some participants also reported educating other family members in their households. For example, Sophia described reminding her family members to turn out the lights when they were not in use.

Several participants had family members, other than their parents, who were actively involved in their care. Isabelle, Autumn, Sophia, Aliyah, and Bobby all spent considerable time with their grandparents, who lived nearby and regularly took care of them after school. Both Bobby and Isabelle spoke about climate change being on the TV news at their grandparents' houses, and sometimes inciting discussion. As Isabelle described it, "I'll be helping to get dinner ready and my grandmother will be sitting…watching the news. And I'll overhear some things like, 'Recent flood here'… and [my grandparents] will be, like, 'This is because of global warming'" (Isabelle, interview). Such examples suggest that family members other than parents could be conversation partners when information about climate change was presented (e.g., on the news), as well as sources of information on climate change.

Additionally, other family members sometimes played a role in shaping participants' senses of connection to the natural world. For example, Autumn spoke about going for nature walks with her grandmother, taking photos of beautiful things they saw, and sending them to Autumn's mother via text message while she was at work. I noted that Autumn was particularly concerned about the aesthetic consequences of climate change, and I interpreted her grandmother's appreciation of the beauty of the natural world as a possible influence on Autumn.

Finally, having family members who lived in other parts of the country or world also appeared to shape participants' perceptions of climate change, giving them a frame of reference for understanding of conditions in other geographic regions. Sophia had traveled to visit family in Egypt several times in her life, and she spoke about the environmental degradation she noticed as possibly related to climate change (Sophia, interview). Isabelle had extended family in California, and was concerned that the drought they were experiencing at the time of the study was possibly related to climate change (Isabelle, interview). Autumn's father lived in Australia, and told her over Skype about the 107-degree temperatures he was experiencing in the desert, which Autumn posited could relate to climate change (Autumn, interview). Thus, it appeared that having family members in other areas of the country or world provided participants with information about what people were experiencing in different geographic regions, which may have influenced their understanding of the global scale of climate change.

Consumption of television and movies: "Was climate change the cause of the shark biting off that kid's arm in North Carolina?" I interpreted participants' consumption of television and movies to have an influence on their climate change ideas.

For some participants, television news – particularly images seen on the news, appeared to play an important role in shaping their climate change ideas. At times, hearing about climate change in these ways exposed participants to possible climate change impacts in other parts of the country or world. For example, Aliyah recalled a news story about people having to evacuate their homes:

> I remember that they said in some places the sea level is already rising. So people had to move inland, or some people live on islands, so they already had to move to bigger land. And they had to leave their islands, their home (Aliyah, interview).

When asked to draw what came to her mind when she thought about climate change, Aliyah drew herself having to leave home because of climate change (Figure 7).

Figure 7

Aliyah Depicting Herself Being Displaced by Sea Level Rise

Information from TV news stories also raised questions about climate change. For example, during one of the focus groups, Bobby changed the direction of the conversation dramatically when he said: "I have a question: Was climate change… the cause of the shark biting off that kid's arm in North Carolina?" (Bobby, focus group) referring to a recent incident in the news.

Aside from hearing information in the news, messages participants heard on television programs and in movies sometimes appeared to shape their climate change ideas. Television programs introduced participants to new areas of the world, and prompted their thinking about the impacts of climate change for these regions. For example, Isabelle spoke about seeing a *Discovery Channel* program set in Alaska, and learning about how people's ways of life were changing. She explained:

> It's getting warmer for them sooner, so they don't have as much stuff to hunt. And a lot of people that live up there... do rely off the salmon, they rely off the crops they grow, they rely off the animals they hunt. But when it gets hotter sooner, they don't have as many animals to hunt. You know? They have to change how they're planting crops all year round. Catching salmon is harder, 'cause you know such a drastic change in seasons is confusing the fish. (Isabelle, interview).

This example also reiterates that media images and messages appeared to be highly memorable for participants as they spoke about climate change.

In addition to providing information related to climate change, watching television and movies sometimes led participants to reflect on society. Isabelle was critical of the kind of consumptive society she saw marketed in television commercials, and saw this as linked to climate change. Yet she also gleaned hope from messages on television, such as seeing the *Make Your Mark on the World* campaign on the *Disney Channel*, which showed examples of young people as change agents. Similarly, she engaged the focus group in a conversation about *The Lorax* movie (Renaud & Balda, 2012), which all had seen, and its messages about environmental responsibility – particularly related to deforestation and resource consumption. This prompted Sarah to bring up a documentary she had seen with her family about issues related to Walmart's environmental and social responsibility. As these examples suggest, television and movies provided participants with information about current events related to climate change, raised questions for participants about climate change, introduced participants to other areas of the world, and at times prompted participants to reflect on environmental and social conditions.

Internet use: "I was bored, so I just clicked on a random video". In addition to television and movies, I interpreted Internet use as having an influence on participants' climate change ideas. The 6th graders and their parents consistently stated that they spent a great deal of time online. In some cases, participants referenced specific concrete information they had gotten online about climate change. These examples included Autumn's recollections of seeing climate change graphs while she explored the NASA website (Autumn, interview), Sophia's description of pop-up ads for solar panels, and Isabelle's description of a YouTube video she came across (Isabelle, interview):

> I watched a video on YouTube about, like, *It's Happening* or something. I didn't really understand it, but I just went on YouTube one day. I was bored, so I just kind of clicked on a random video and I watched it… It was about how climate

> change is happening, and it's getting too hot, and it showed a list of all these species are gonna die out (Isabelle, interview).

Aside from these examples, participants also spoke about getting climate change information online while they completed school-related tasks (reported above in the *School context* section).

Generally, however, references to participants' Internet use were abundant but vague. Parents consistently made comments such as, "I think he gets some information from the Internet also… He's always on the computer" (James's father); "[For] most [information] I think it's the Internet… Mr. Google is our best friend" (Sophia's mother); and "He is really smart about doing things on the Internet" (Richie's mother). However, parents rarely provided specific examples of how they saw their children engaged in using the Internet to find information about specific topics. Likewise, participants often cited the Internet as a source they would use to find information about climate change – but did not elaborate specifically.

Participants appeared to be aware that information from the Internet varied in its trustworthiness. For example, Richie explained that for climate change information he would not trust websites "with a dot.com", only websites with a "dot.gov or a dot.edu" (Richie, interview) – a rule he reported learning at school. When talking about the Internet sources she trusted, Isabelle stated: "I don't trust these off-brand, random people… I trust *Discovery* and them because they're scientists who are doing this for a living and they are getting paid for it. Not just some bored bum who is doing it as a hobby" (Isabelle, interview). As these examples suggest, participants were accustomed to using the Internet, and had received instruction about how to find trustworthy information, but they did not provide many concrete examples of messages (if any) they were receiving about climate change as a result of their Internet use.

Perceptual mode: Observing human behavior impacting climate change. After having climate change information communicated to them by others – that is, having established a general awareness of climate change as a phenomenon – participants could perceive information about climate change through two secondary modes. One of these was through observing human behavior they perceived as impacting climate change. Typically, these observations were related to people's use of technology in the world around them, both in and out of school. However, observations were sometimes related to people's environmental stewardship behavior in general.

School context. At their blended learning school, students carried laptop computers with them all day and were aware that the electricity used to power their devices came from fossil fuels. Living in a suburban community, most students rode in their parents' cars to travel to school, which they also knew to be powered by fossil fuels. These aspects of participants' everyday lives at school appeared to shape their ideas about climate change, particularly the scope of the problem and its relevance to their lives.

Personal electronics use: "There's this one kid who charges in every period." Participants were embedded in a school context in which the use of personal electronics was an important aspect of engagement in learning. Since participants had learned that electricity came from fossil fuels, they began to observe the pervasiveness of energy use around them, and to connect it with climate change exacerbation. A number of participants referenced charging laptops in their blended learning school as an activity that was exacerbating climate change. On this topic, Isabelle said:

> People will come to school and… They'll have all this stuff plugged in and they're not even using it… I feel like you could use your energy until you can't use it anymore so you don't have to use more energy than is already being used. They don't have to burn as much coal. Because kids will be like, "[Gasp!] I'm at 20%!"… Most kids'll freak out and be like "I have to charge." There's this one kid who charges in every period. (Isabelle, interview)

Sarah echoed this sentiment when she said, "There are a lot of kids in my class who just charge when they don't need it. And it's pointless" (Sarah, interview). During my classroom observations, I noticed that charging laptops was a common topic of discussion for students, and something Ms. Kane had to monitor constantly, rotating students to different seats as needed so they could sit near power outlets. Having been told that electricity use had a relationship to climate change (via the first perceptual mode: communication from others about climate change), participants appeared to become observant of their own and others' electronics use, and considered it to be a contributor to climate change they were witnessing in their everyday lives.

Commuting to school: "People who don't go to their neighborhood school, they don't have a choice. They have to take a bus or a car". Participants also observed the widespread use of cars in their suburban community – including for their own transportation to school – and connected these observations to climate change exacerbation. Students at Fairview Middle School came from all over Douglass County, and most parents often dropped their children off at school in their personal cars.

Awareness of this practice was evident in Aliyah's statement that: "People who don't go to their neighborhood school – they don't have a choice. They can't walk home, so they have to take a bus or a car" (Aliyah, interview). Such examples suggest that participants' embeddedness within a society reliant on fossil fuels - which participants had heard were causing climate change - was shaping their perceptions of who was exacerbating climate change and how. Namely, participants' noticed that behaviors they knew to be damaging were a regular part of their everyday lives, and in some cases, implausible to change.

Out of school context. Outside of school, participants' observations of their own and others' behavior, particularly around energy use and their concerted environmental stewardship efforts also appeared to shape participants' climate change ideas.

Home and community energy use: "I go around the whole house turning off lights". As with their school context, participants observed energy use in their homes and communities, and related it to climate change. Participants spoke variably about the electronics, heating and cooling systems, lighting, and cooking appliances in their homes as problematic for Earth's climate. Having heard that energy use contributed to climate change, participants were sometimes critical of their family members' wastefulness. As Isabelle described,

> When my mom cooks, she'll open all the windows and have the A/C and the fans going… And she'll have the microwave, the stove, the oven, the toaster, the sink, you know, the crockpot with the chili and stuff. And she'll have the frying pan. She'll have everything going at once (Isabelle, interview).

Other participants observed members of their families leaving lights on in the house, and interpreted this behavior as exacerbating climate change. Sophia said, "I have science last period, so when I get home, I come and go around the whole house turning off lights" (Sophia, interview). This statement suggested that information communicated to Sophia at school (perceptual mode: attending to information communicated by others) may have changed her observations of practices in her home environment (perceptual mode: observing human behavior impacting climate change). Finally, participants observed their own and others' electronics use at home and interpreted it as exacerbating climate change. Sarah explained:

> Sarah: I have this little alarm clock. I don't use it that much. I could probably just unplug it… Because even if I'm not using it, it's still… energy's flowing through there.
>
> Emily: And how does unplugging… How does that help?
>
> Sarah: There's…less electricity used. And therefore there's less fossil fuels, which means less greenhouse gases going into the air (Sarah, interview)

Participants made similar statements in speaking about their own and their family members' use of electronics such as televisions, iPads, Kindles, fans, and cell phones. However, they did not typically make explicit connections to fossil fuels, but rather, to climate change exacerbation or environmental damage in general.

Beyond energy use at home, participants also observed (visible) air pollution in their communities from buildings, cars, and trucks, which they often associated with the exacerbation of climate change. For example, Bobby as described: "Like a lot of factories, and like, big 18-wheelers, when they blow their horns, the gas comes out. And it goes up into the air, and the air is polluted" (Bobby, interview). They also spoke about the widespread use of cars in general in their community as an observation they connected to climate change exacerbation.

Environmental stewardship behaviors: "I think he watches what we do". Finally, the environmental stewardship behaviors participants observed in their homes and communities appeared to have an influence on their perceptions of climate change. As James's father stated, "I think he watches what we do" (James's father, interview). It appeared that some of the environmental stewardship actions in which parents were engaged made an impression on participants. For example, Aliyah commented on her mother's use of public transportation to commute to work. Sophia spoke about her mother's insistence that they turn out their lights when not in use, because it will save both energy and money. Richie spoke about his parents' decision to install solar panels on their home. He explained, "They actually changed to solar power now… They said they liked the idea 'cuz it was getting so hot in our area, so they could do a change. And other people in our neighborhood changed to solar panels" (Richie, interview).

Beyond behaviors related directly to reducing fossil fuel consumption, participants also cited general environmental stewardship behaviors they had observed around them when speaking about climate change. For example, during one of the focus groups, Sophia described her neighbors' practice of picking up litter:

> I have neighbors that really care about the Earth. They go out every single day I think, they go out with a big trash can and a little thing and gloves, and they pick up trash…all the way like, two blocks away, they're still picking up trash…And they really make a difference. (Sophia, focus group).

Participants also spoke about environmental stewardship behaviors such as energy saving, recycling, and taking short showers practiced in their homes that they perceived as helpful in mitigating climate change. In general, observing others engaged in behaviors that participants perceived as positive for the environment appeared to shape their ideas about climate change, even when they did not explain precisely how these behaviors could have an impact on climate.

Perceptual mode: Observing environmental changes associated with climate change.

In analyzing data from participants, I noted participants' perceptions of the natural world in relation to climate change. In particular, participants spoke about changes in the natural environment that they were observing visually, as well as changes they were feeling physically.

Visual observations of environmental change: "[The horses are] up to their knees. It's gotten deeper." Participants discussed a variety of firsthand visual observations that they perceived as evidence of climate change. For example, Isabelle spoke about recent occasions on which she experienced strong summer storms. She also perceived the water at the beach she visits each summer to be getting deeper. She explained:

> On the way to the beach, you've got to go over a marsh. It's gotten deeper. And the horses when they stand in it, they're up to their knees. They're no longer like, you know, just hoof-deep. They're up to their knees. It's gotten deeper (Isabelle, interview).

Sophia reported seeing less snowfall in recent winters than she remembers in comparison to years past, explaining: "The last time we had snow was last winter… It only snowed a few days and that was it. And usually [in the past] it would snow like almost every day… Now it's not snowing as much" (Sophia, interview). Finally, Autumn simply noted that she had seen "a dramatic change in the weather" (Autumn, interview). Parents also made similar statements, as I described in the section on participants' sources of climate change communication.

Felt observations of environmental change: "Every year it gets hotter". Participants also perceived information about climate change through felt changes in their natural settings. All of the participants reported feeling hotter temperatures or experiencing heat waves. For example, when I asked Aliyah whether she thought climate change was definitely happening, she replied, "You can tell 'cuz it gets warmer every year" (Aliyah, interview). Similarly, Sarah said, "Summers here used to be, I guess, nice. But now there are big heat waves" (Sarah, interview). And James explained, "I've been realizing that every year it gets hotter. It wasn't this hot in the spring last year. It gets… really really hot" (James, interview). Isabelle cited an experience that brought increasing temperatures to her attention while on a summer family camping trip:

> I can't sit in the car anymore. Like, I used to call my friends... I'd sit in the car and do that. [Now] I can't do that without overheating… My dad used to hide the marshmallows from me on the dashboard… He would watch me so he could make sure I didn't eat the marshmallows. He can't do that anymore. He has to keep them in the freezer or they'll melt. They'll melt together, it will be goo" (Isabelle, interview).

Beyond talking about their experiences with increasing temperatures, several participants depicted themselves overheating in their drawings (Figure 8). Also related to warmer temperatures, some participants spoke about noticing changes in phenology, such as summer arriving earlier, hotter temperatures persisting into the fall, and flowers blooming earlier (exacerbating allergies) in the spring.

Figure 8

Participants Depicting Themselves Experiencing Hot Temperatures

Richie depicting himself sweating	*Aliyah depicting herself using a fan*

Finally, participants were also aware of changes in natural settings outside of their immediate experiences. For example, they had heard about climate change effects experienced by others (i.e., reported to them by other people, such as family members with seasonal allergies) or climate change effects occurring in other parts of the world (i.e., reported to them by media sources, such as images of natural disasters). Taken together, messages that participants had heard from others about climate change, along with their observations of humans and the natural world, corroborated their view that climate change was occurring in the world around them, and that humans were causing it, feeling its effects, and possibly, helping to resolve it.

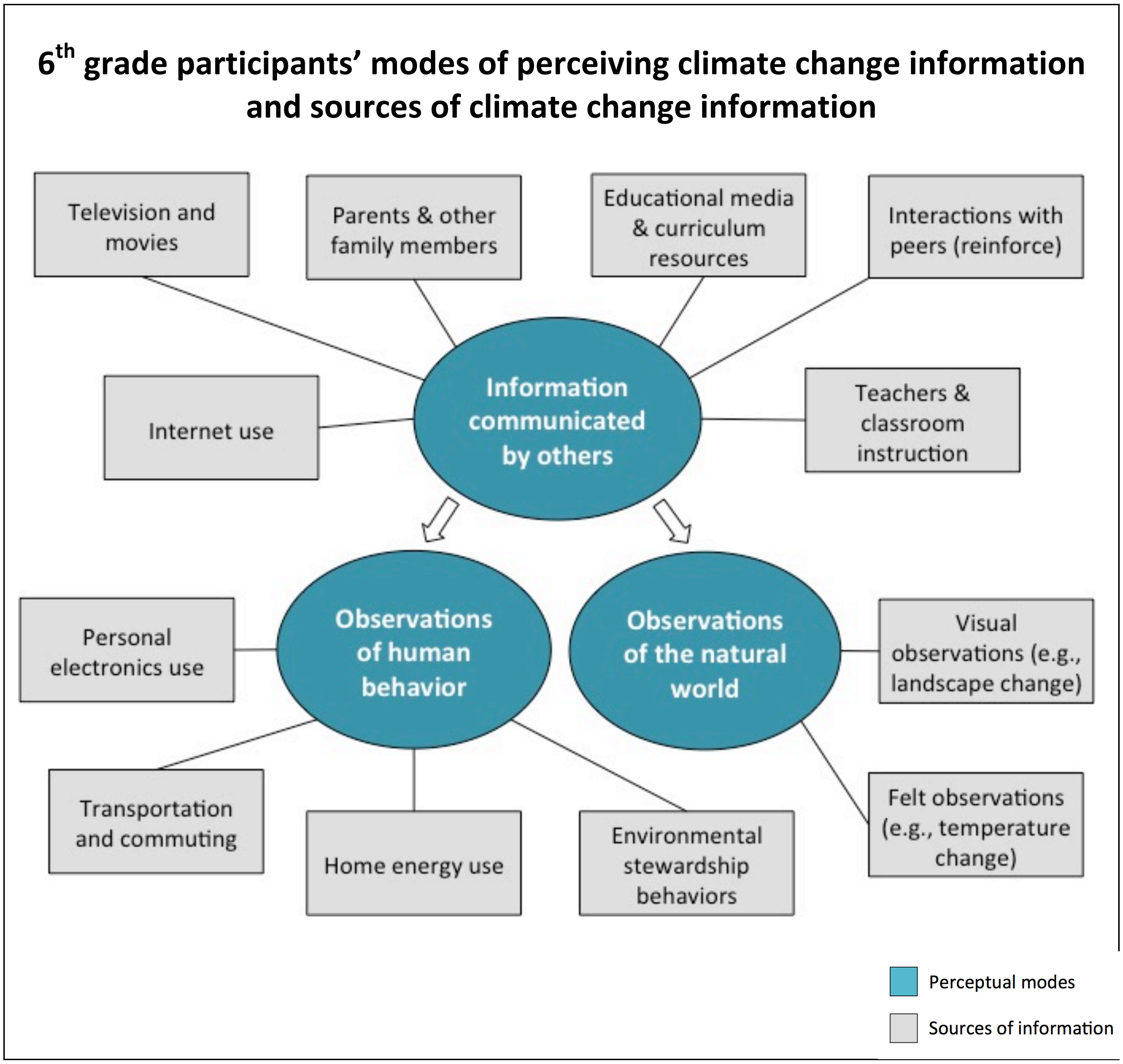
Summary of perceptual modes and sources of information. I have just described three modes by which I interpreted participants to perceive information about climate change, both through interactions within their school-based and out-of-school contexts. I represent the categories that emerged for each perceptual mode in Figure 9. I began with participants' primary means of perceiving information about climate change: by attending to information communicated by others. I highlighted the overarching sources of information communicated by others that emerged as I analyzed the data. In school, I described how participants perceived information through interactions with science educators during instruction; with online media in the classroom; and with classmates. Outside of school, I described how participants perceived information through interactions with parents and other family members, their consumption of television and movies, and their Internet use.

Second, I described how participants' observations of human behavior in the world around them appeared to shape their perceptions of climate change. In school, participants observed the prevalence of personal electronics use, as well as families' use of personal cars to commute to school. In their homes and communities, participants observed energy use, including sometimes what they perceived as wasteful energy use habits. These observations appeared to strengthen participants' view that climate change was occurring in the world around them, because these activities – which they had learned (from trustworthy communicators) were contributing to climate change – were pervasive in their daily lives. However, participants also observed environmental stewardship behaviors practiced in their homes and communities. These observations appeared to shape participants' perceptions of climate change as something that, although occurring, could be mitigated to some degree by the positive behaviors of people around them.

Finally, I described how participants interpreted information about climate change through their personal observations of the natural world. After developing awareness of climate change through communication with others inside and outside of school (the primary perceptual mode), participants were alert to occurrences within their natural environments that fit the description of climate change consequences. As they experienced their natural environment, participants visually observed and physically felt changes in the world around them, which they then attributed as certainly or likely related to climate change.

Figure 9

Emergent Categories From the Application of the "Sources of Information" Analytic Lens



Conditionally-mediated perceptions as forming participants' climate change *story world*. In Chapter 3, I described *my interpretation* of the conditions in which participants were embedded (globally, nationally, regionally, locally, in-school, and out-of-school). Now, I turn to my interpretation of the ways in which participants drew on climate change information obtained through interactions within these conditions to describe the *story world* (setting) in which they understood climate change to be taking place. I frame story world as (my understanding of) *participants' interpretations of their conditions* in relation to climate change. This aspect of my data analysis represents my application of the *perceptions* analytic lens (Table 10). I organize my description of participants' *climate change story world* by exploring Truby's (2007) story world elements (natural setting, human-made (social) setting, technology, and time) relative to the data.

Table 10

Alignment of the Story World Framework Element with the "Perceptions" Analytic Lens

Storytelling framework element	Analytic lens and related data collection question(s)	Structural coding questions	Data sources coded
Story world continued (Truby, 2007)	b) Climate change perceptions [Relevant data collection question: *What is the nature of learners' ideas (i.e., their **perceptions**...) in relation to climate change?*]	*How did participants show evidence of their perceptions of the world in relation to climate change?* Parent codes: ▪ Visual information ▪ Verbal information ▪ Physical (felt) information	• Learner-generated drawings and accompanying written reflections • Individual interviews (learners) • Focus group interview

Story world element: Natural setting. The first element comprising Truby's (2007) notion of story world is the natural setting. Natural settings can include aspects of the story world, or context, such as weather, oceans, islands, forests, deserts, and ice. In describing the study context in Chapter 3, I briefly discussed the natural settings – on global, regional, and local scales – in which participants were embedded. Globally, participants were situated on a planet experiencing unprecedented physical changes, including warmer average global temperatures, melting of polar ice, rising sea levels, inundation of islands, desertification, precipitation changes, and increasingly intense and frequent extreme weather events (IPCC, 2014). Living in the Mid-Atlantic region of the United States, participants were situated within a coastal region vulnerable to heat waves, coastal flooding, sea level rise, intense precipitation, ecosystem changes, and hurricane vulnerability (U.S. Global Change Research Program, 2014). In Douglass County, where participants resided with their families, local temperatures and precipitation levels were higher than normal (averages over the past 30 years), including during the time of the study (wunderground.com, 2015).

Above, in describing participants' sources of climate change information, I described how participants visually observed and physically felt changes in their immediate natural environment that they associated with climate change. In particular, they interpreted seasons as feeling different than they had before, and temperatures as warmer than before. At times, they drew on information they had gotten from their parents about local conditions in the past. Beyond their immediate local environment, participants perceived changes in the natural world by seeing images on television and on the Internet, such as images of flooding or images of Arctic animals in peril.

Based upon this information, I interpret participants to be depicting the ***natural setting*** element of their climate change story world as a world in which:

- Temperatures are getting warmer;

- Weather is becoming more extreme and unpredictable (e.g., storms, hurricanes, droughts; earlier spring);
- Polar ice is melting;
- Coastal areas are experiencing floods and rising seas;
- Arctic animals are losing their habitats; and
- Nature (air, land, water) is becoming more polluted.

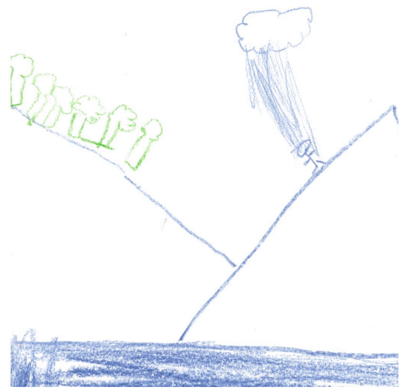
In Figure 10, I provide examples of the ways participants depicted each of these aspects of natural setting in their drawings. I did *not* interpret participants to depict the natural setting of their story world as including features such as warming and acidifying oceans, changing habitats for local plant and animal species, or melting permafrost. Though scientists might interpret these (and other) phenomena as important dimensions of *their* climate change story world, 6th grade participants were not aware of, did not to attend to, or did not communicate about these elements of the conditions in which they were embedded. Therefore, I did not interpret them as part of the natural setting of participants' climate change story world.

Figure 10

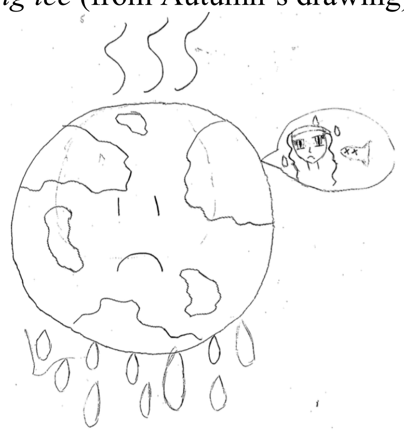
Depictions of Natural Setting Elements of Participants' Climate Change Story World

Hot temperatures (from Richie's drawing)

Extreme weather (from Bobby's drawing)



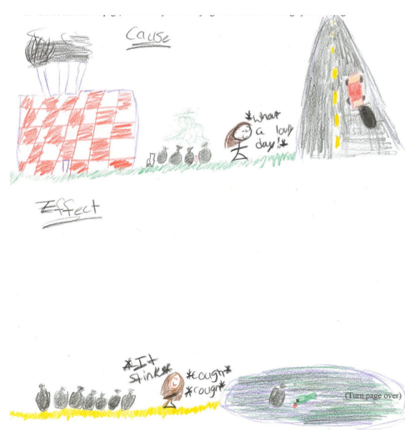
Melting ice (from Autumn's drawing)



Rising seas (from Aliyah's drawing)

Habitat loss (from Sophia's drawing)

Pollution (from Isabelle's drawing)



Story world element: Human-made (social) setting. The second element of Truby's (2007) story world is the human-made setting. For Truby, the human-made setting includes aspects of the story world such as people, houses, and cities. Through the human-made setting, the storyteller expresses the society in which the story is unfolding. In applying the notion of human-made setting to this study, I considered the aspects of participants' conditions such as their communities, their school, their homes, and the people with whom they interact in these spaces. Also within the human-made setting, I included people with whom participants may not interact directly, but who may shape their perceptions of climate change (e.g., news reporters, media developers, curriculum writers).

In Chapter 3, I described as an aspect of participants' human-made setting the social context of Douglass County, where participants lived and attended school. Here, residents were generally convinced and concerned about climate change, but disagreed about some aspects of the science behind it (e.g., human causation, presence of scientific consensus) (Yale Project on Climate Change Communication, 2014). I described Fairview Middle School, the blended-learning charter school that participants attended, as an aspect of the human-made setting. Everyone engaged with the life of the school were part of the shared human-made setting in which participants were learning about climate change. I also described how the human-made settings of participants' out-of-school lives were unique. Participants resided in homes with unique family structures. Participants' parents and grandparents had unique cultural and professional backgrounds. Out of school, participants engaged with different kinds of media, including television the

Internet, which they sometimes discussed with family members. All of these were aspects of the unique human-made settings in which participants were embedded.

In the previous section, I described how participants perceived information through their interactions with people (e.g., teachers, family members) and cultural objects (e.g., curricula, television) that appeared to shape their ideas about climate change. Participants were aware of climate change becoming a topic they were hearing more about in school and in the news. They were seeing images, particularly of climate change impacts, in educational materials, on television, and on the Internet. They were observing people around them engaging in behaviors they understood as exacerbating and as mitigating climate change.

Based on the evidence of participants' perceptions of their social contexts in relation to climate change, I interpret participants to be depicting the **human-made (social) setting** of their climate change story world as a world in which:

- Science educators are teaching about climate change, and middle school students are learning about climate change
- People are creating materials convey messages about climate change (e.g., curriculum materials, Internet images)
- People are communicating about climate change through media (e.g., television, websites, social media)
- People are talking about environmental changes they are noticing* (e.g., strange

  weather); **connection to the* ***natural setting*** *element of story world*

- People's lives are being impacted by climate change consequences, or will likely be impacted in the future
- People are engaged in behaviors* at school, at home, and in their communities that can both exacerbate and mitigate climate change; **connection to the* ***technology*** *element of story world*

Unlike the description I provided in Chapter 3 of my interpretation of participants' conditions, through my analysis of the data, I did not interpret participants to include notion of people disagreeing scientifically or politically about climate change as an important part of their story worlds. Participants only referred to climate change as being controversial when I explicitly probed this during the focus group. Even then, only a few participants had heard about people who did not believe that climate change was occurring, or did not believe that that human activities contributed to climate change. Participants quickly discounted arguments of this nature, based upon information from trusted sources of communication (e.g., school-based science instruction, images of climate change consequences, felt experiences of climate change).

Story world element: Technology (tools). The third element of Truby's (2007) story world is technology, or tools. Truby suggested that "any tool a character uses becomes part of his identity" (p. 176). In Chapter 3, I described some of the technologies that were part of participants' contexts, or story world. At their blended learning school, students carried laptop computers with them all day. Most students also used laptops, phones, and other electronics outside of school for entertainment. Living in a suburban community, most students rode in their parents' cars to travel to school. Participants' homes and school were powered by fossil fuel energy. In general, they were surrounded by technology and it was a central part of their lives.

In the previous section, I described how participants' climate change perceptions were based, in part, on their observations of human behaviors that they interpreted as exacerbating or mitigating climate change, including through their use of technology[3]. Participants spoke often about witnessing air pollution from factories, cars, and trucks, which they associated with the exacerbation of climate change. Participants were also embedded in school and home contexts in which the use of electricity and electronics was nearly constant. Besides the charging of electronics as something they were associating with climate change exacerbation, participants also spoke about the use of technologies and tools in their everyday lives like gas stoves, light bulbs, televisions, and air conditioners in relation to climate change. Though participants' perceptions of climate change appeared to be shaped by the technology use they saw to be detrimental, in a few cases participants' perceptions also appeared to be shaped by observing technology use they saw as mitigating climate change, such as the use of renewable energy.

Based on evidence of participants' observations of technology use in the contexts in which they were embedded, I interpret participants to be depicting the **technology** dimension of their climate change story world as a setting in which:

- People use personal electronics all day, such as phones and laptops, which are powered by fossil fuels. Charging these devices exacerbates climate change.

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[3] I note that technology (e.g., computers and Internet, television) was also a means of communicating information about climate change, though I included such examples in the previous section on human-made setting (focusing on the communication aspect).

- People are reliant on cars for their everyday transportation, which are powered by fossil fuels that exacerbate climate change and pollute the air.
- Factories powered by fossil fuels exacerbate climate change
- People's use of technologies at home for cooking, lighting, heating and cooling were powered by fossil fuels that exacerbate climate change
- People could make efforts to limit their use, or use renewable sources of energy, in order to help mitigate climate change

I noted that the technology use that participants observed, and perceived as exacerbating climate change, related generally to the energy use practices of individuals (e.g., charging laptops; leaving lights on). Though participants mentioned other types of fossil fuel-based technologies, such as factories, they appeared to see these technologies as separate from their own lives.

Story world element: Time. The final element in Truby's (2007) notion of story world is time. In a story, time may be expressed in a variety of ways, such as through the use of seasons, holidays and rituals, or a single day. Stories may be set in past, present, or future times. If set in the past, stories may give the audience "a pair of glasses through which [they] can see themselves more clearly today" (Truby, p. 184). And if set in the future, stories may provide a means of highlighting "the forces and choices that face us today and the consequences if we fail to choose wisely" (Truby, p. 185).

In Chapter 3, I described some aspects of the time in which the study was taking place: In 2015, participants were living amidst much political and media attention to climate change, during the hottest year in recorded history. They were going to school amidst the curricular shifts that followed the 2013 release of the Next Generation Science

Standards, which included climate change within the science curriculum for the first time. Participants were engaged in the study toward the end of the school year (in May and June), when outdoor temperatures were unseasonably warm and participants were eager for summer vacation to begin. My conversations with participants mostly related to the present (the time in which the study was occurring), and their ideas about climate change at that time. However, occasionally, participants spoke about the past and future in relation to climate change in ways that provided insight into their ideas about its relevance to their own lives.

In the last section, I described several ways in which participants developed perceptions of the past and future in relation to climate change. When participants compared the present to the past, they often drew upon visual and written information (e.g., an educational video featuring an animated graph of change in atmospheric carbon dioxide and temperature since the Industrial Revolution). They also perceived information about the past through conversations with their parents, who communicated memories of how local environmental conditions used to be in comparison with the present. Finally, participants perceived change over time when they considered their own memories of environmental conditions in past years compared to the present. With regard to the future, participants perceived climate change as posing risks for future generations, including themselves. In these cases, they were considering what Truby (2007) described as "the forces and choices that face us today and the consequences if we fail to choose wisely" (Truby, p. 185). However, by observing human behaviors they perceived as mitigating climate change, participants sometimes perceived human behaviors as having the potential to improve future conditions.

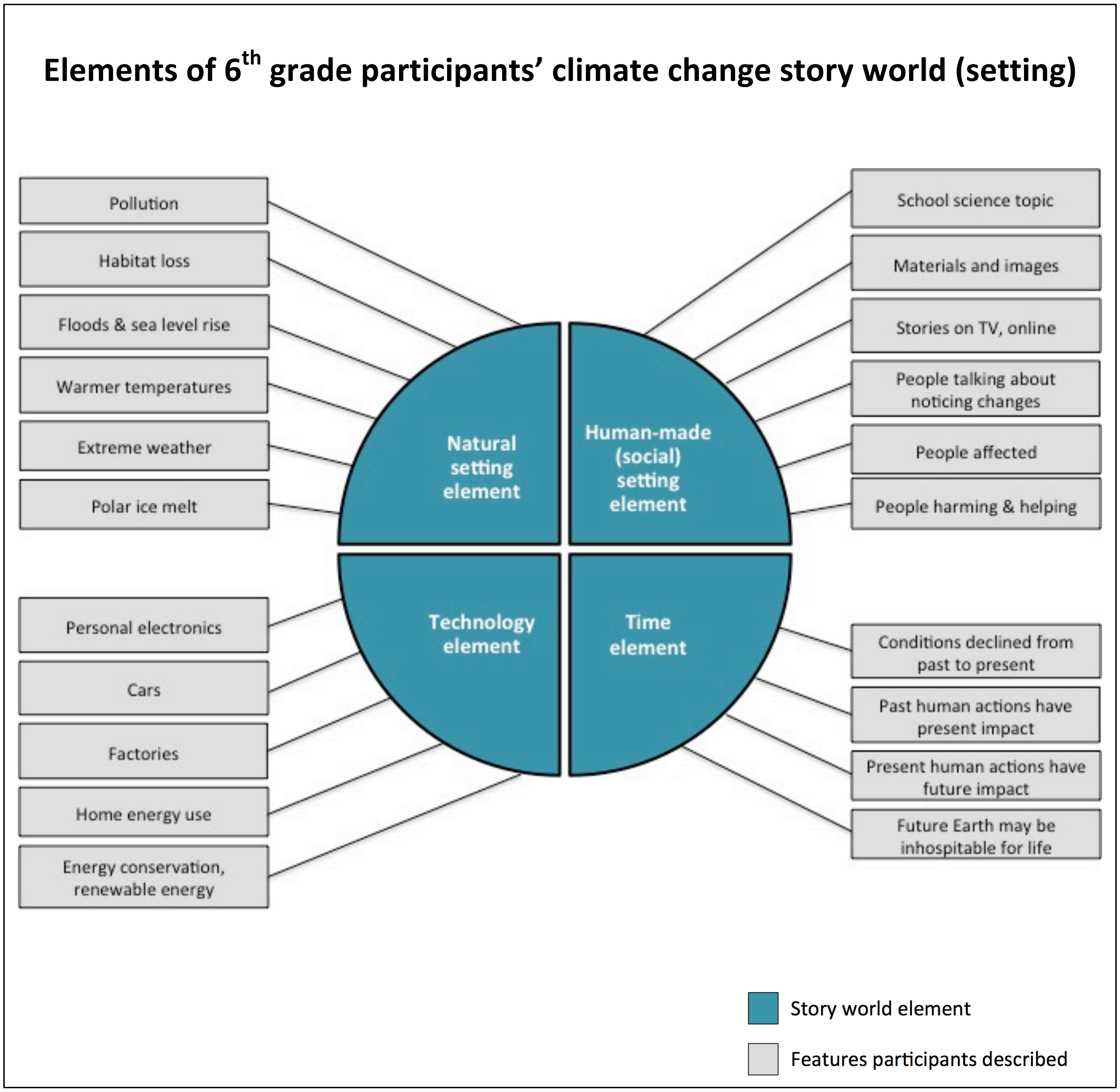
Based upon my interpretations of the ways in which participants perceived information related to climate change and time, I interpret the ***time*** dimension of participants' climate change story world to be a world in which:

- Environmental conditions have declined over time
- Past human behaviors are already having an impact on current conditions
- Human behaviors of the past and present will have ramifications for the future
- Without a change in human behavior, future conditions on Earth will be undesirable, and possibly inhospitable, for living things

I did not interpret the time dimension of participants' story world to include a clear notion of *how far into the future* the most negative outcomes of climate change exacerbation might occur. Statements from participants related to time suggested to me that they had generally not developed a precise sense of scale in relation to the timeline of climate change, and may have sometimes conflated the notions of weather (short timeline, i.e., days) and climate (long timeline, i.e., decades).

Figure 11

Emergent Categories From the Application of the "Perceptions" Analytic Lens to the Relevant Data Sources, Organized by Truby's (2007) Four Story World Elements



Story world summary. In this section, I began by describing how participants perceived climate change information from the interactions with the conditions in which they were embedded. I then described how I understood participants to be drawing on these perceptions to make their own interpretations of their conditions in relation to climate change. I considered participants' interpretations of their contexts to be their story world (Truby, 2007), or the setting for their figured worlds of climate change. I described four elements of participants' climate change story worlds, including the natural setting, the human-made (social) setting, the technological setting, and the temporal setting (Truby, 2007) in which the stories they told about climate change were unfolding. I also acknowledged that individual participants varied in their emphases, but generally shared a vision of the setting in which their figured worlds of climate change were occurring. In Figure 11, I depicted how these elements comprise the whole of the story world, which I consider to be a product of participants' contextually-mediated perceptions of climate change. I turn now to a discussion of how participants organized disparate pieces of perceptual information about climate change into a more cohesive climate change *plot* they saw as unfolding within this story world.

Plot: Action Sequences in Figured Worlds of Climate Change

In this section, I examine how participants made sense of their climate change perceptions, or the information they saw, heard, or felt as they became aware of climate change. I frame participants' sense-making of this perceptual information as their climate change *knowledge* (Roncoli et al., 2009). Connecting to Truby's (2007) storytelling framework, I consider participants' climate change knowledge to represent the *plot* of their climate change stories. In Table 11, I represent how I connected the Truby's notion of "plot" with the analytic lens of "knowledge".

Table 11

Alignment of the Plot Framework Element with the "Knowledge" Analytic Lens

Storytelling framework element	Analytic lens and related data collection question(s)	Structural coding questions	Data sources coded
Plot (Truby, 2007)	c) Climate change (science content) knowledge [Relevant data collection question: *What is the nature of learners' ideas (i.e., their…* ***knowledge****…) in relation to climate change?*]	*How did participants provide evidence of their sense-making of information about climate change (i.e., communicate knowledge about climate change as a sequence of causally-connected events)?* Parent codes: ▪ Ideas about climate change *causes and mechanism* ▪ Ideas about climate change *effects* ▪ Ideas about *human activities*	• Written artifacts (student work) • Participant-generated drawings and accompanying written reflections • Individual interviews (learners) • Focus group interview

Truby describes plot as a sequence of causally-connected events that either 1) lead to a change for the characters, or 2) explain why change was impossible. In applying Truby's notion of plot to this study, I examine and piece together participants' knowledge of *what happens* as the phenomenon of anthropogenic climate change plays out. In examining participants' ideas about climate change through data sources, I interpreted a *sequence of events* that comprised participants' stories of climate change. Though participants varied in their understandings and descriptions of specific aspects of climate change, the data suggested that they shared a broad general plotline made up of causally connected events.

Their story of climate change begins *in media res*, or in the middle of things, in that all participants shared the view that **human activities (past and present) had *already* begun to disrupt the normal functioning of Earth systems, resulting in warmer temperatures on Earth (Causal Event).** Participants described how **warmer temperatures were beginning to have consequences for life on Earth (Causal Event).** These consequences could be exacerbated or alleviated in the future, depending on human decision-making and future action. **If humans changed their behaviors in ways that reduced the disruption to the normal functioning of Earth's systems, then life on Earth might improve – or at least continue (Causal Event).** This outcome represents the ending that Truby describes as *leading to a change* for characters (i.e., improved environmental conditions). Conversely, **if humans continued or expanded current behaviors disrupting Earth's systems, negative consequences would be exacerbated, resulting in declining conditions and the suffering (or death) of living things (Causal Event).** This outcome represents the type of ending that Truby described as explaining that *change was impossible*.

To elaborate on how participants reasoned about climate change information, I describe each of these causal events as I interpreted them through the data. I examine how participants' knowledge of climate change, which was at times scientifically supported and at times not scientifically supported, was evident as they described each of the events in the sequence.

Causal event: Human activities disrupt the normal functioning of Earth's systems causing Earth to become warmer. All eight of the 6th grade participants reported that human activities, past and present, were already causing Earth's temperatures to rise (student interview data). Participants' parents, teachers, science curriculum, and classroom visitors from the university likewise shared and communicated this view (parent interview data, teacher interview data, curriculum review data, field notes). However, residents of Douglass County, where participants lived, varied in their ideas regarding whether or not climate change was already happening and caused by human activities (Yale Project on Climate Change Communication, 2014). I gained information about participants' explanations of this *event* in their climate change plot by analyzing data from participants' computer-based climate change content knowledge assessments, their individual interviews, and their focus group participation.

Knowledge of the atmosphere-temperature relationship. Participants all appeared to hold the scientifically-supported view that global warming and climate change were related to the disruption of the normal functioning of Earth's systems. After instruction, when explicitly asked about the role of the atmosphere, most expressed an understanding that Earth's temperatures were increasing as a result of changes in the amounts of gases in the atmosphere. However, some participants provided explanations that were not scientifically supported. For example, Isabelle conceptualized the atmosphere as getting *thicker* and holding more heat in, stating, "If the atmosphere keeps getting thicker, then it's gonna melt the polar ice caps" (Isabelle, interview). After instruction, Aliyah, Sarah, Sophia, and Bobby all showed some evidence of a view that changes in the amounts of gases in the atmosphere were causing destruction of the ozone layer. For example, Bobby described the ozone layer as "breaking" (Bobby, interview) and Sophia described a "hole in ozone layer" (Sophia, content assessment). However, after instruction, Autumn and Richie changed their views that ozone layer destruction was causing global warming – a point that was explicitly addressed during classroom instruction.

Despite the varied ideas that participants communicated about the role of the atmosphere, they appeared to share an understanding that the normal functioning of the atmosphere was being disrupted. Participants referred to heat being trapped or "held in" and unable to escape. They sometimes drew on metaphors introduced at school, such as a greenhouse holding in heat, the atmosphere trapping heat like a blanket, or the atmosphere functioning as a bag around the Earth. For example, Richie described: "It's just warming it up because it's like a blanket going up and down. Waves. And the heat can't escape" (Richie, interview). Though participants varied in how they explained the warming of the Earth, all saw it as a central aspect of climate change, and as a result of human activities.

Knowledge of the role of carbon. Participants shared the view that the disruption of the normal functioning of the atmosphere was a product of human use of fossil fuels, such as coal and oil. They were also aware that fossil fuel combustion produced carbon dioxide. While all participants agreed with this point, several participants such as James and Bobby also held the alternative conception that nuclear power was a major generator of carbon dioxide pollution. Participants varied in their understandings of the role of carbon dioxide in the mechanism of the greenhouse effect. For example, during the focus group, Isabelle and Autumn discussed how excess carbon dioxide in the atmosphere from factories meant that:

Isabelle: UV rays can come in but they can't go out…

Autumn: Like a greenhouse (Isabelle and Autumn, Focus group).

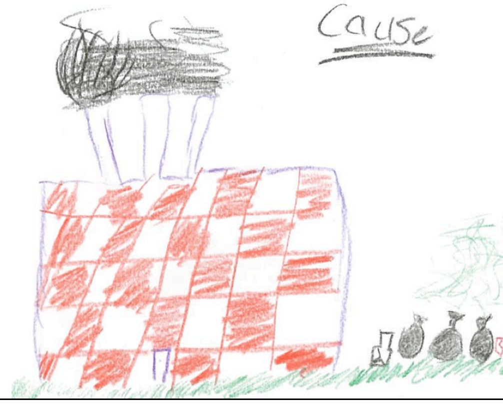
Statements like these suggested that participants had a general sense of heat being trapped, or not escaping, as a result of added gases. However, participants were not fully aware of the nuances of wavelength and the chemical structures of greenhouse gases. Further, some participants appeared to understand only visible air pollution (e.g., “smoke from power plants” (Sophia, unit test)) as increasing the Earth’s temperature, and many participants included visible air pollution in their drawings (see Figure 12 for selected examples).

Participants were all aware that trees and plants take in carbon dioxide during the process of photosynthesis. Some used metaphors like carbon dioxide being “swallowed up” (Sarah, interview) by trees. Others referenced trees and plants more generally as filtering the air and making it cleaner. Participants all appeared to agree that reducing the amount of trees and plants through deforestation or development would have a negative impact on climate.

Figure 12

Depictions of Visible Air Pollution as a Cause of Climate Change

Isabelle's depiction of factories and decomposing trash as sources of air pollution



Sarah's depiction of smokestacks and cars as sources of air pollution

Richie's depiction of CO_2 from factory emissions as a source of air pollution

Knowledge of the role of human activities. All participants agreed that human activities, particularly fossil fuel use, pollution, and deforestation increased global temperatures.

Fossil fuel use. When explicitly asked on their written assessments about the increased amount of carbon dioxide in the atmosphere, all participants were aware of the contribution of fossil fuels. Participants frequently mentioned the production of carbon dioxide from human activities, however they did not always specifically state the relationship between fossil fuel combustion and carbon dioxide production. Therefore, it was unclear at times how or whether participants understood climate change exacerbation from human activities in terms of the carbon cycle. Participants' most commonly cited activity that required fossil fuel combustion was driving cars. Cited nearly as often were factories powered by fossil fuels. For example, as Autumn described: "Business, industries, sometimes power plants, they burn fossil fuels for energy because some people just don't care, they just want money. So, it's causing damage to the Earth" (Autumn, interview). Another common activity that participants cited as dependent on fossil fuels was energy use at home and school. In particular, participants frequently associated leaving lights on and powering electronics as activities that wasted energy and contributed to climate change. However, in most of these cases, they did not directly associate the production and consumption of fossil fuel-based energy with the carbon cycle or the greenhouse effect, but rather, with pollution in general.

Pollution. Participants cited pollution, primarily air pollution, as exacerbating climate change. However, participants did not always associate the pollution with fossil fuel use. Other than fossil fuel combustion, participants mentioned as sources of pollution: littering, smoking, and the use of ozone-depleting or toxic chemicals. It was unclear whether they saw these forms of pollution as related to the carbon cycle or the greenhouse effect, or simply as related to general environmental degradation. When I probed for more information about how some forms of pollution (e.g., littering) were relevant to climate change, participants sometimes provided explanations that they were able to relate to fossil fuel combustion. For example, when I asked Isabelle why avoiding littering was helpful for climate change, she explained: "I think that would help because… it stops recycling trucks and trash trucks which use a lot of gas. They pollute the air a lot to come and get it and take it back to the factory" (Isabelle, interview). However, in most cases, participants offered more general explanations such as the explanation that pollution was "destroy[ing] ecosystems" (Autumn, content assessment). In general, participants' statements illustrated a shared belief that pollution from human activities was exacerbating climate change, even if they did not articulate precise cause-effect relationships.

Deforestation. The final major human activity that participants cited as exacerbating climate change was deforestation. Participants were aware of the role of trees and plants in taking in carbon dioxide and providing oxygen. Participants spoke about the detrimental impacts of cutting down trees for development (e.g., building houses and buildings), because it would mean less carbon dioxide removed from the air. Some also took the view that the carbon stored in trees and plants would be released into the atmosphere as a result of deforestation. For example, Autumn stated that "deforestation takes all the carbon dioxide absorbed into the plants and spreads [it] into the air" (Autumn, content assessment). Overall, participants appeared to agree that fewer trees would mean more carbon dioxide and warmer temperatures, though it was sometimes unclear whether they considered the increased temperatures to be a product of the enhanced greenhouse effect.

Causal event: Warmer temperatures make Earth less hospitable for living things. There was very broad agreement amongst participants that hotter temperatures on Earth were associated with climate change. Participants generally discussed temperature as a precursor to other consequences: typically, that warmer temperatures caused physical changes on Earth, which had consequences for living things. For example, Bobby spoke about how global temperatures were not as cold as they used to be, which meant that, "Seals don't have enough icebergs to stay on" (Bobby, focus group). At other times, participants discussed the ways in which warmer temperatures could have direct consequences for living things, including themselves. For example, Aliyah stated, "I don't like the heat. So, I don't like when it's hot so it affects myself a lot because when it's hot, I will be inside more. So I'm not as active. And I'm probably sitting in front of the TV with the air conditioning blasting, using more energy" (Aliyah, interview). In general, participants saw warmer temperatures as the catalyst to other negative changes for living things on Earth.

Knowledge of physical changes on Earth. In describing their knowledge of climate change consequences, participants referenced the ways in which warmer temperatures would create physical changes on Earth. Though most understood climate change as impacting geographic regions of the entire world, they often highlighted physical consequences affecting coastal regions and polar regions. Their most commonly cited physical changes included precipitation changes, sea level rise, ice and snow melt, flooding, and seasonal changes.

Precipitation changes. Participants cited both increased and decreased precipitation as consequences of climate change. For increased precipitation, participants referenced storms and extreme weather, and several explicitly mentioned hurricanes. Sophia posited an explanation for increased precipitation by drawing on her knowledge of the water cycle, stating, "In rivers and stuff, the hotter it is the more it gets evaporated, so the water will get evaporated and it might rain more, which will cause more floods" (Sophia, interview). Bobby mentioned acid rain as a possible consequence of climate change, which he depicted in his drawing (Figure 13), explaining: "I was thinking about how the clouds were starting to be like… there's starting to be like acid rain, like dirty water in the rain" (Bobby, interview). Participants also discussed drought, or lack of precipitation, as a possible impact of climate change. James depicted drought in his drawing (Figure 13). In general, where participants discussed drought, I interpreted them to be associating warmer temperatures with creating hot, desert-like conditions on Earth.

Figure 13

Depictions of Precipitation Changes as Consequences of Climate Change

Bobby's depiction of acid rain as a consequence of climate change | *James's depiction of drought as a consequence of climate change*

Sea level rise. All participants understood sea level rise to be a consequence of climate change. Participants demonstrated this knowledge on their climate change content assessments, as well as in their climate change drawings (see Figure 14). However, participants rarely explained the mechanism of sea level rise, though they did often associate it with ice melt. For example, on her content assessment, Sarah explained: “Polar caps are melting, and where is that melted ice supposed to go? It will cause the sea levels to rise, and can cause floods and other problems for the people who live on the coast” (Sarah, content assessment). Participants often followed mentions of sea level rise with a comment on impacts for living things.

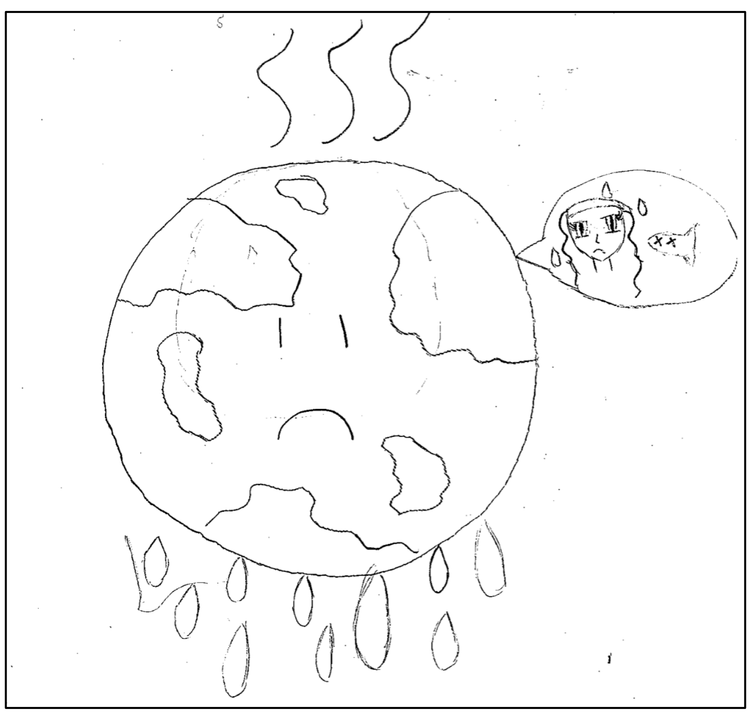
Figure 14

Richie’s Drawing Depicting Sea Level Rise as a Consequence of Climate Change

Ice and snow melt. As frequently as they mentioned sea level rise, participants discussed ice and snow melt as consequences of the warmer temperatures associated with climate change. Some referenced the in-class activity in which they examined photographs of various ice or snow-covered regions of the world decades ago and then more recently. For example, Richie explained: “We did the project where we went around the room, there was a map that showed us how the white, or the ice, was big in a year and then it came down a few years after” (Richie, interview). Several participants represented ice melt in their drawings (see Figure 15). They were particularly focused on the melting of the polar ice caps, and at times, on the subsequent effects for polar ecosystems. However, some also explicitly mentioned that polar ice melt would have global impacts, particularly in terms of sea level rise affecting coastal regions.

Figure 15

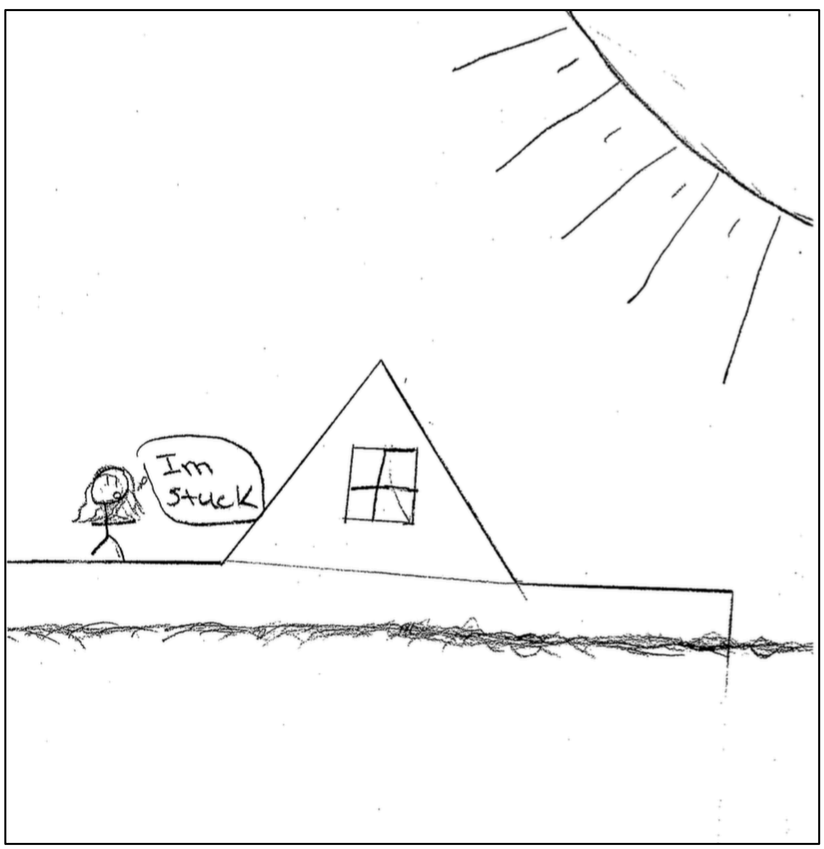
Autumn’s Drawing Depicting Melting Ice as a Consequence of Climate Change



Flooding. Participants often associated flooding with warmer temperatures, either resulting from rising sea levels causing inundation in coastal communities, or from increased precipitation. As with sea level rise, participants often discussed the impacts of flooding in relation to human lives. In one of her drawings, Isabelle depicted herself stranded on a roof as a result of flooding (see Figure 16). Participants also related flooding to disruption to recreational activities (e.g., camping, gardening) and as a threat to human safety.

Figure 16

Isabelle's Drawing Depicting Flooding as a Consequence of Climate Change



Seasonal changes and phenology. The final climate change consequence that participants highlighted in the data related to the ways in which warmer temperatures had the potential to change the characteristics of the seasons. For example, participants spoke about seasonal changes in terms of their own experiences noticing changes in their local environment (e.g., temperatures were becoming hotter earlier in the spring). As James explained, "I've been realizing that every year it gets hotter. It wasn't this hot in the spring last year. It gets hot, it's like really really hot" (James, interview). In a few cases, participants elaborated beyond their own observations of temperature and precipitation differences, and discussed how changes in the timing and characteristics of the seasons changed phenological events such as bloom times for plants and migration habits of animals. Overall, participants provided a variety of examples of ways in which the characteristics of the seasons were no longer the way they had been in the past.

Knowledge of impacts for living things. The final category of consequences that participants described entailed the ways in which warmer temperatures and resulting physical impacts (described above) had the potential to threaten – or were already threatening – the health and survival of living things, both human and non-human.

Threats to plant and animal survival. Participants described how climate change could lead to the disappearance and death of animals, particularly Arctic animals. Participants often referenced habitat loss from ice melt, or simply described how animals would become unable to survive in their changing habitats. In a few cases, participants mentioned changes in animal species' ranges and migration patterns. For example, Bobby explained,

> Birds are not flying as far south anymore, so. Yeah, when they're supposed to like, say they bird's up in New York, they're not flying all the way down to Florida. They're starting to fly down to South Carolina, Georgia. Yeah, and staying right there. (Bobby, interview).

Participants also discussed plant death – often associated with drought – as a consequence of climate change. At times, they connected this with the survival of other living things, including humans, who depend on plants as a food source.

Threats to human health, safety, and survival. Participants referenced the adverse consequences of climate change for human health and survival in terms of climate change-induced health problems, threats to food security, increased risk of death, and risks to human safety – particularly in relation to flooding and extreme weather. Participants often associated climate change-related air pollution with human respiratory problems, such as cars releasing carbon dioxide making air more dangerous to breathe. In a few cases, participants also discussed the exacerbation of allergies and asthma in conjunction with climate change. For allergies, they described earlier and longer bloom times of plants. For asthma, participants' explanations were mostly related to air pollution in general.

Disruptions to humans' lives. Beyond consequences of climate change that could directly impact human health and survival, participants also mentioned climate change consequences that could disrupt human lives. The most common idea in this category was that humans would feel uncomfortable as a result of warmer temperatures, with participants often citing their own experiences of feeling overheated or sweating more than usual – which they associated with global warming. Participants also mentioned a variety of ways in which people's daily lives (e.g., work, recreation) might change as a result of climate change. For example, in the focus group, Isabelle suggested that farmers' growing practices could be affected. Autumn and Aliyah both mentioned that people in their communities could do fewer outdoor activities. Finally, some participants mentioned a loss of beauty as a consequence of climate change, or discussed having to live in a dirtier environment.

Causal event: People change their actions in ways that reduce disruption to the normal functioning of Earth's systems, leading to improved conditions for life on Earth. In considering the events that will follow the present degradation of conditions for life on Earth, participants described two possible futures, or actions yet to unfold in the *plot* of their climate change stories. In the first scenario, humans sufficiently change their actions in ways that reduce disruption to the normal functioning of Earth's systems. As a result, conditions improve and life on Earth continues. When participants considered the ways in which human activities could help to mitigate climate change, they often suggested *stopping or reducing* the activities they saw as exacerbating climate change. That is, they suggested that people should reduce their use of fossil fuels, reduce pollution, and reduce or stop deforestation. Beyond these categories, participants also emphasized learning as an important means of climate change mitigation (e.g., through scientific research and "spreading the word" about climate change), as well as government-level or community-level actions such as mandated regulations and fines for polluters.

Reduction of fossil fuel use. Participants cited reduced fossil fuel use, or the use of energy sources other than fossil fuels, as an important means of climate change mitigation. Participants suggested driving less (e.g., walking, biking, carpooling, using public transportation), reducing energy use (e.g., during off lights), and using renewable sources of energy (e.g., solar panels). Several participants suggested reducing the number of factories in operation, such as Bobby's suggestion that we should "Stop having factories that use all the gases, like smog, like the black smoke" (Bobby, interview). Others suggested other means of reducing fossil fuel use, such as buying or growing food locally, instead of relying on food that needed to be shipped long distances. For example, Aliyah stated, "I know when I go to the grocery store, we have a lot of international food. We could use more locally grown food so you wouldn't have to fly it all over, and that would use less energy" (Aliyah, interview). Participants had a tendency to think in terms of actions that individuals (rather than groups) could take to reduce their fossil fuel consumption.

Reduction of pollution. Participants suggested a variety of activities that they believed would help mitigate climate change by reducing pollution. These included improved management of solid waste, reducing air pollution, and being generally less wasteful. Regarding solid waste management, participants suggested that recycling could help mitigate climate change. Here, most participants provided a rationale that recycling was a positive action for the environment, but few explicitly related it to reducing carbon emissions. Some participants also suggested picking up trash or avoiding littering. Again, participants did not often provide specific explanations about the relationship of these actions to climate change in particular.

Several participants selected "banning chemicals that break down the earth's ozone layer" on their content assessment as a way to address climate change, suggesting that some saw aerosol pollutants as an important contributor to climate change.

Forest restoration and reduction of deforestation. On their climate change content assessment, most participants identified the option of "Plant more trees or reduce the number of trees being cut down" as an effective climate change mitigation strategy.

In individual interviews and focus groups, participants also suggested not cutting down trees, or planting trees, as actions that could help to address climate change. Since participants associated trees with taking in carbon dioxide and turning it into oxygen, they sometimes expressed the view that reduced oxygen was an impact of climate change, and that humans could die from lack of oxygen. In these cases, participants did not seem to consider global warming in terms of loss of the land carbon sink leading to increased atmospheric carbon dioxide and an enhanced greenhouse effect. Rather, they focused on the loss of trees as reducing humans' ability to safely breathe the air.

Expansion of climate change understanding (education, awareness, and research). Amongst participants, I interpreted a shared view that it was important to understand climate change in order to take positive action. They appeared to believe that typically, if people learned about the potential consequences of climate change, they would be motivated to change their behavior. However, participants also raised concerns that even when some people know about climate change, they may not care or change their behavior. As Sophia explained during one of the focus groups:

> Learning about global warming, it has a big effect. If you would just teach someone about it, [how] it affects them and the way they live, they will make a change. Most likely they will. Or, sometimes people just don't care whatsoever, which is, they'll just ignore it (Sophia, focus group).

In a few cases, participants mentioned engaging in protests or demonstrations as a possible means of spreading the word and encouraging action. Richie suggested raising money to support groups that are trying to stop climate change as a possible action to raise others' awareness. Beyond educating individuals, some participants also spoke about the benefits of expanding scientific understandings of climate change through research.

Imposition of fines and regulations. During the interviews, I asked participants to consider climate change mitigation beyond the individual action level, asking them what communities or governments could do. In response, participants suggested imposing regulations or fines related to energy use as a means of mitigating climate change. As Isabelle stated:

> [Governments] could be like, "You are legally allowed to use this much energy in this area. This 100 miles is only allowed to use this much energy." It's not gonna be like an itsy bitsy amount, but at the same time, they're gonna be given a regulation, because when you patrol people, and you're able to say like, "This is what you have to do, it's law", they'll most likely listen more than when you're just like, "Hey, could you use a little less energy?" (Isabelle, interview)

As Isabelle's statement demonstrates, participants often appeared to see the role of government as a top-down rule-maker and rule enforcer more than as a democratic entity shaped by citizens.

Causal event: People fail to change their actions, leading to greater suffering or death for life on Earth. The alternate possible future that participants described entailed a scenario in which people fail to change their actions in ways that reduce disruption to the normal functioning of Earth's systems, causing greater suffering for life on Earth, and possibly leading to death for living things. Participants shared the view that human activities were already harming conditions on Earth, and that living things were already feeling the consequences. In a scenario where human actions that exacerbate climate change continued or increased, such as fossil fuel use, pollution, and deforestation (*Causal event: Human activities disrupt the normal functioning of Earth's systems causing Earth to become warmer,* above), participants described increased threats to plant and animal survival; to human health, safety, and survival; and increased disruptions to human lives *(Causal event: Warmer temperatures make Earth less hospitable for living things*, above).

Participants described how failure to change human actions could ultimately pose threats to the survival of animal and plant species. In particular, participants highlighted threats to animal species in the Arctic. For example, Sophia drew a "before and after" illustration of climate change, depicting the death of Arctic animal species after global warming occurred (Figure 17), explaining, "After global warming the animals die and all that is left is the remains and fossils" (Sophia, written explanation of drawing). During one of the focus groups, Autumn suggested that "Some animals may live in the cold, or tundra, and when it gets hotter, like the penguins, they won't have any place to live. They might just go extinct" (Autumn, focus group). When describing threats to animal species, participants did not mention threats to species native to their region, but rather to species native to Arctic climates.

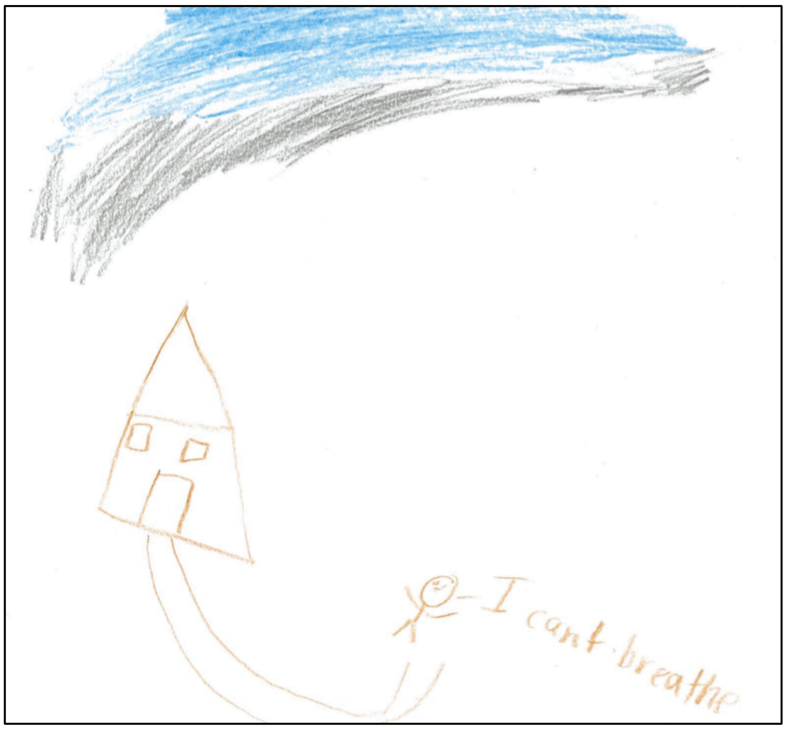
Figure 17

Sophia's Depicting Threats to Plant and Animal Survival as a Consequence of Climate Change

Participants generally agreed that in the future, human death could be a potential consequence of inaction on climate change. Some examples of evidence included James's statement that "If we keep like we're behaving with this stuff, we're gonna all die" (James, interview), Autumn's statement that "We might go extinct because we affected the Earth's climate, and it's not suitable for us anymore" (Autumn, focus group), and Bobby's statement that "We could die because of a loss of food" (Bobby, focus group). Some participants held the view that exacerbating climate change, particularly through deforestation, would make the air more dangerous to breathe because there would be less oxygen and more carbon dioxide (Figure 18). Several participants elaborated on the notion that changing temperatures and precipitation would make agriculture more difficult, presenting potential threats to food security. And finally, several participants associated climate change with threats to human safety, particularly in relation to flooding, which they saw as creating dangerous conditions.

Figure 18

James Depicting Difficulty Breathing as a Consequence of Climate Change



Participants also saw climate change as threatening to displace human populations in the future, particularly those near coastlines or inhabitants of island nations. Some participants saw this as personally threatening, as residents of a coastal state. As Richie described, “We live on the East Coast. And it’s probably gonna flood our area. And more people have to move into the middle of America” (Richie, interview). Aliyah drew a picture of herself being displaced from home as a result of climate change (see Figure 19).

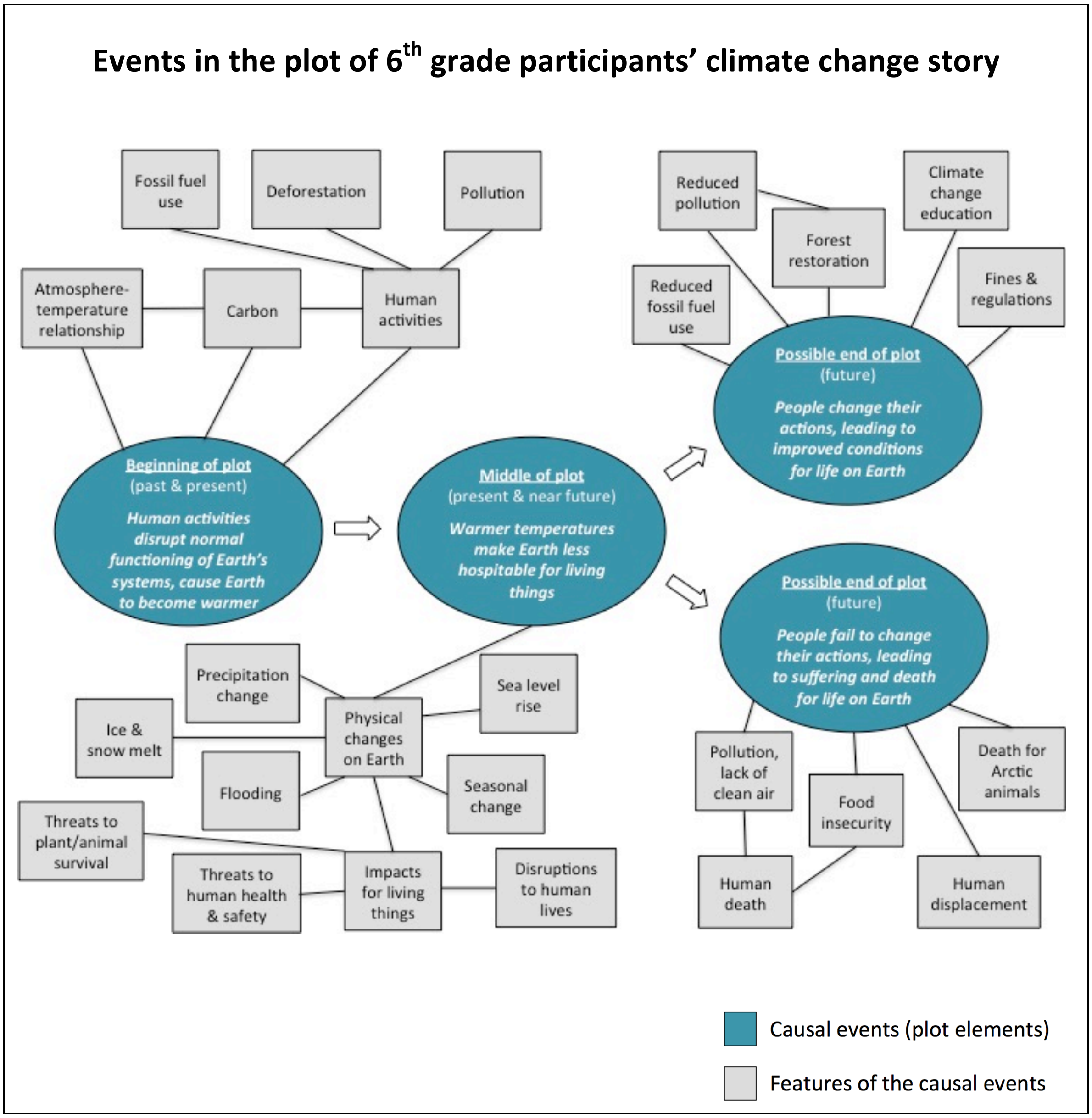
Figure 19

Aliyah Depicting Human Displacement as a Consequence of Climate Change

Plot summary. In this section, I have described the elements of the *plot* of participants' stories of climate change, or the sequence of events that participants understand to be occurring as climate change plays out (Figure 20). I frame this plot, or sequence of events, to be a representation of participants' knowledge of climate change. I interpret participants' knowledge as still evolving as they make sense of their climate change perceptions and interpret new information available to them within their story world (contexts).

Figure 20

Emergent Series of Causal Events from the Application of the "Knowledge" Analytic Lens



Returning to Truby's (2007) description of plot as a sequence of causally-connected events that either: 1) lead to a change for the characters, or 2) explain why change was impossible, I interpret the climate change plot related by participants as having two possible endings. Ultimately, the question of which of the endings plays out hinges on human activities. The first ending - which leads to: 1) a change for the characters (i.e., living things on Earth) - entails humankind engaging in sufficient action to mitigate climate change and maintain the Earth as suitable for life. The second ending - which 2) explains why change was impossible - entails humankind continuing current behaviors that exacerbate climate change, to the point where life on Earth becomes precarious. In the next section, I turn to an examination of the *characters* that I interpreted as emerging in participants' climate change stories, and how they carried out this sequence of causally-connected events in the plotline.

Character: Identities Within Figured Worlds of Climate Change

In examining data from participants' drawings, interviews, focus group participation, and open-ended responses to assessment items, I analyzed the *characters* (or actors) that existed within participants' climate change *story world* and carried out the causally-connected events that comprised the *plot* of their climate change story. Because all participants referred to climate change in relation to themselves and others—that is, they cast themselves and others as characters in their stories of climate change—I used these instances to interpret information about participants' *climate change identities*.

In *Anatomy of a Story*, Truby (2007) suggested that characters are best conceptualized as "part of a web, in which each helps define the others" (p. 57). In this view, characters may be defined not only by who they are, but who they are not. Truby also noted that characters are expressions of selves, which may have conflicting needs or desires, and may play a variety of roles. I took the view that the roles in which participants cast *others* (and not themselves) could provide information about participants' climate change identities, just as the roles in which they cast themselves could. Secondly, I took the view that it was possible for participants to see themselves as playing a variety of roles in the story of climate change, some of which were possibly conflicting. That is, their climate change identities might not be confined to the actions of only one character in the story of climate change.

Table 12 shows how I connected my analytic lens of "identity" with Truby's (2007) notion of "character", and aligned these with my data collection questions, structural coding questions, and relevant data sources.

Table 12

Alignment of the Character Framework Element with the "Identity" Analytic Lens

Storytelling framework element	Analytic lens and related data collection question(s)	Structural coding questions	Data sources coded
Character (Truby, 2007)	d) Climate change identities [Relevant data collection question: *To what extent, if any, do learners see climate change as relevant to their own lives?*]	*What characters emerged in participants' stories of climate change, and in what roles did participants cast themselves and others?* Parent codes: ▪ Roles of others ▪ Roles of self (individual) ▪ Roles of self (as group member)	• Individual interviews • Participant-generated drawings • Focus group interviews

Character web. As the 6th grade participants related their ideas about climate change, I interpreted a common character web generally shared by participants. This character web included five main character types: *Those Who Harm*, *Those Who Suffer*, *Those Who Help*, *Those Who Cannot Help*, and *Those Who Interpret*. Within each of the five character types, I discerned one to three subgroups of characters. In total, I distinguished eleven unique character groups (see Table 13).

Table 13

Emergent Character Web Within Participants' Story of Climate Change

Character Types	Character Subgroups	Character Actions
Those who harm	***The Guilty***	Knowingly engage in actions that exacerbate climate change; may be concerned about climate change, but do not or cannot change their behaviors
	The Oblivious	Unknowingly engage in actions that contribute to climate change
	The Villains	Knowingly engage in actions that contribute to climate change; are not concerned about climate change; prioritize personal gain; often greedy
Those who suffer	***The Victims***	Experience the negative consequences of climate change
Those who help	***The Everyday Heroes***	Consciously limit their contribution to climate change through individual actions
	The Social Influencers	Actively persuade others to change their personal behaviors
	The Group Shifters	Catalyze group-level action to address climate change – sometimes from the top down, sometimes from the bottom up
Those who cannot help	***The Powerless***	Would like to change conditions but lack the power to act
Those who interpret	***The Witnesses***	Notice changes in the world around them associated with climate change
	The Learners	Seek out or interact with evidence-based information about climate change; come to a greater understanding
	The Communicators	Disseminate information about climate change

Those Who Harm. When describing the causes of climate change, participants described the actions of individuals and groups that exacerbated the problem of climate change, sometimes including themselves. I include all characters in this category within the character type: *Those Who Harm*. Within the type of *Those Who Harm*, I noted three subgroups of characters. I name the first subgroup *The Guilty*. These include actors in the narrative who knowingly engage in actions that contribute to climate change, and may be concerned about climate change, but do not or cannot change their behaviors. An example would people who drive long distances to work or school, would prefer a shorter commute or another means of transportation, but have no alternative.

The second subgroup, *The Oblivious*, unknowingly engage in actions that contribute to climate change. They are not concerned, because they are unaware of a problem, and therefore, do not change their behaviors. An example might include people who are unaware that the personal technologies they use every day are powered by fossil fuel energy.

The third subgroup, *The Villains*, are like *The Guilty* subgroup in that they knowingly engage in actions that contribute to climate change. Unlike *The Guilty*, however, *The Villains* do not care about their contribution to the problem, and are likely to prioritize personal or financial gain over environmental stewardship. An example would include companies whose factory operation entails fossil fuel combustion, which they are aware exacerbates climate change, but they are unwilling to risk the economic consequences of changing their practices.

Those Who Suffer. When describing the effects of climate change, participants described those who would experience its negative consequences. I named this group of characters *The Victims*. At times, participants cast *Victims* in groups, such as people who live in specific geographic areas they saw as vulnerable to climate change, including coastal populations, island populations, Arctic populations, or desert-dwelling populations. Some participants considered everyone on Earth as members of this group. They also included non-human groups – particularly Arctic animals – as *Victims* of climate change. Participants sometimes also cast themselves, as individuals or as groups (e.g., their generation) in the roles of *Victims* of climate change. At times, participants posited that *Victims* of climate change would suffer the negative effects of climate change in the future. In other cases, they framed *Victims* as experiencing climate change consequences now.

Those Who Help. Participants described people or groups who tried to change human behaviors – their own or those of others – to mitigate or reduce the negative effects of climate change. Within this type, I distinguished three subgroups of characters. The first and most popular subgroup, *Everyday Heroes*, were characters who individually changed their personal behaviors in ways that participants considered to be better for Earth's climate. This group included, for example, people who carpooled or took public transportation instead of driving their own cars, or people who tried to curb their personal fossil fuel-based energy use.

The next subgroup within *Those Who Help* was *The Social Influencers*. Characters within this group tried to persuade others – by words or by example – to change their own individual behaviors (e.g., to change others from *Oblivious* characters to *Everyday Hero* characters). An example of a character within the *Social Influencer* group would be a person who encourages others to decrease their carbon footprint by reducing their energy consumption.

The final, and least common, subgroup within the *Those Who Help* type was *The Group Shifters*. These characters were typically larger entities (governments, companies) who sought to change the behaviors collectively rather than individually. *The Group Shifters* could influence others from the top down, such as a government setting emissions limits for companies or households. They could also work from the bottom up, such as a group of students organizing a fundraiser to support an organization working to mitigate climate change.

Those Who Cannot Help. Implicit in the group *Those Who Help,* is some level of power to make a change. Such power is absent amongst *Those Who Cannot Help*. I named the members of this group *The Powerless*, comprised of people who might like to change conditions, but lack the power to do so. Examples of characters in this group include young people who are not allowed to make certain personal changes for safety or logistical reasons – such as riding a bike to school rather than getting a ride in the car. Other more general examples would be people who are dismissed or ignored when they try to speak up about climate change.

Those Who Interpret. The final character type, *Those Who Interpret*, encompasses the subgroups of characters that are either taking in or disseminating information about climate change. Those who are cast in roles of *Interpreters* are not specifically contributing to climate change or seeking to mitigate it, though they may simultaneously play other roles (e.g., *Those Who Help*; *Those Who Harm*) in which they are doing so. Within the *Those Who Interpret* type, I noted three subgroups. The first subgroup is *The Witnesses*. These are characters that are observing changes in their surroundings that they interpret to be evidence of climate change. *The Witnesses* may also inhabit the subgroup of *The Victims*, if the changes in their surroundings are causing them to suffer. Examples of *Witnesses* include characters that are noticing hotter local temperatures than they would expect, or are observing changes in their local landscapes, such as ice melting sooner in the springtime.

The second subgroup within the type *Those Who Interpret* is *The Learners*. *Learners* are those who seek out or interact with evidence-based information, and come to new understandings of climate change. Often, *Learners* are students in school who are engaged with climate change education, or those who engage with information about climate change online or on television.

The final subgroup within *Those Who Interpret* is *The Communicators*. These characters disseminate information about climate change, either through direct or indirect interaction with their audiences. They may also be involved in roles as *Social Influencers* (within the *Those Who Help* type) if by disseminating climate change information they are also seeking to change others' behaviors. Examples of *Communicators* may be, for example, science teachers or developers of educational media (e.g., online videos about climate change).

Self and others within the character web. All of the 6th grade participants depicted themselves as playing multiple characters at once, sometimes with conflicting needs and desires (Truby, 2007), within in their stories of climate change. At times, participants spoke about themselves as individuals, using the singular *"I"*, playing characters. At other times, they spoke about themselves as members of groups (e.g., as the youth generation, as members of the human race), using the plural *"we"*, playing characters. They also spoke about other people (e.g., their parents, their teacher) and groups (e.g., companies, the government) as playing certain characters. When they cast others as certain characters, but not themselves, there was also opportunity for me to interpret information about participants' climate change identities. That is, at times, participants may have been defining themselves by who they were *not* (Truby, 2007).

Self and others as Those Who Harm:* "*It's all of us. And that's why it's such a big impact". The character type *Those Who Harm* was the type in which participants most often cast others, and decidedly more often than they cast themselves. Although participants readily listed the climate change contributions of others, they generally acknowledged that they also played a role. When participants did cast themselves among *Those Who Harm*, they more often cast themselves as members of groups than as individuals who were causing harm.

The Guilty. The Guilty are characters who knowingly engage in actions that exacerbate climate change and may be concerned about climate change, but do not or cannot change their behaviors. Within the group *The Guilty*, participants adopted the view that everyone – including themselves – was doing something to exacerbate climate change, casting humankind as a whole within this role. However, they highlighted the culpability of others those engaged in practices that relied on fossil fuels, such as drivers, travelers, and homeowners using energy. In some cases, participants cast as *Guilty* those who caused any kind of pollution, such as people who smoke or people who litter. The notion that everyone is among *The Guilty* emerged during one of the focus groups, in which Sarah argued that corporations (others) played a major role in exacerbating climate change, but regular people should not dismiss their own roles. She said,

> It's not just corporate's fault but it's also our fault. Because just in the U.S. alone, the rich make about one percent, and then the rest of us are 99 percent… So, if it was just that one percent, the corporates that were really causing the problem, then we wouldn't be making such a big deal about it. But it's all of us. And that's why it's such big impact. (Sarah, focus group)

Beyond casting everyone, including themselves, as a member of a group (humankind) that played the role of *The Guilty*, some participants referenced their membership in other groups that contributed to climate change. For example, Aliyah noted that people in her community, including herself, were spending more time inside and using their fossil fuel-powered air conditioners more. Isabelle cast herself as a member of the 6th grade class that played the role *of The Guilty* when they were wasteful in their electricity consumption. She said, "We use so much [electricity]. To charge your computer, you have to. They burn coal and oil so you can use electricity… We'll leave a classroom and we'll leave a bunch of lights on" (Isabelle, interview). Several participants also cast themselves as individuals in the role of *The Guilty*. Sophia talked about her habit of taking long showers, which she associated as a behavior contributing to climate change. Autumn described how she sometimes wasted energy. And Isabelle said that she was sometimes too lazy to walk her sister to school, which meant an additional car trip for her mother and additional use of fossil fuels. Overall, though participants viewed some of their collective or individual actions as placing them within the role of *The Guilty*, they were more likely to see others in this role.

The Oblivious. The Oblivious are characters who unknowingly engage in actions that contribute to climate change. Nearly as often as they cast others as *Guilty*, participants cast others as *Oblivious*. Within this group, participants often cast those who waste energy, overuse personal technology, or simply fail to consider the impact of their actions. For example, Sophia cast the older generation (adults) in the role of *Oblivious*, stating,

> What I don't understand is that, like, shouldn't people older be wiser? They should know all this stuff, but, people younger are learning about it. The older people should be the ones taking action because they're older, they should be more responsible for the Earth (Sophia, focus group).

In casting the older generation as *Oblivious,* Sophia positioned the younger generation (including herself) as separate from this group. Finally, some participants cast as *Oblivious* those who simply did not know about climate change – such as younger children – or those who chose to avoid the topic of climate change.

On a few rare occasions, participants cast themselves individually as *Oblivious*. In these instances, participants referred to themselves when they were younger. For example, Autumn said, "Earlier I didn't really notice what was happening. And I wouldn't say that I didn't care, I just didn't… notice" (Autumn, interview). Participants also rarely cast themselves as members of groups that were *Oblivious*. In these rare instances, participants only considered themselves as *Oblivious* when humankind was the group in question. For example, Aliyah referenced the ways in which humankind's pursuit of *progress* has led to environmental degradation – including climate change - as an unintentional byproduct. She appeared to cast herself within the "we" of humankind in making statements such as, "We [modern humans] use a lot more energy than they [humans in the past] used to" (Aliyah, interview). Here, Aliyah noted that humankind as a group may not be considering the notion that increasingly affordable technology could be exacerbating climate change.

The Villains. The final subgroup within the *Those Who Harm* character type was the subgroup, *The Villains*—in which people knowingly engaged in behaviors that contributed to climate change, and they did not care or try to change the behaviors. I interpreted no instances in which participants cast themselves in this role personally or as members of groups. However,

all participants cast others within this role. Others in *Villain* roles included advertisers, oil companies, corporations and factories, those engaged in deforestation, developers, and those who do not care about or ignore climate change. Typically, participants portrayed *Villains* as greedy, selfish, and prioritizing personal or financial gain over the environment, and not caring that their actions exacerbated climate change. During one of the focus groups, participants discussed Dr. Seuss's *The Lorax* as they articulated their ideas about others as climate change *Villains*.

Isabelle: Big companies and stuff say that they're doing things that are better for the environment, but they're not. Like in the movie *The Lorax*, the short guy who owned the big Air-in-a-Bottle company thing – he didn't really care. He acted like what he was doing was better for the planet. Like making fake trees and stuff and saying real trees were gross and they carried diseases and bugs and stuff. So he made it seem like what he was doing was really good for the environment, until like the end of the movie when he started singing about like letting it die, you know. Then people realized so…

Emily: Did everybody see that movie? *The Lorax*?

All: Yeah

Sophia: I think for the ending, they took all the trees and made stuff with it, and then at the end when there was no more trees left, they just left like nothing ever happened. (Isabelle and Sophia, focus group)

This led to further discussion of participants' mistrust of those who are interested in financial gain, particularly when it comes at the expense of the environment.

Self and others as Those Who Suffer: "A not-so-pleasant environment for humans and animals and plants." People who participants cast as *Those Who Suffer*, or *The Victims*, of climate change were those who experienced its negative consequences. All of the participants cast both themselves and others as climate change *Victims*. Participants described detrimental impacts of climate change in their own lives as including problems such as feeling overheated, having difficulty breathing, experiencing dangerous extreme weather, experiencing negative aesthetic changes, or being displaced as a result of sea level rise. The *Victim* identity was the identity that participants were most likely to draw when they included themselves in their climate change drawings (see Figure 21). Isabelle drew herself stranded in a flood, explaining:

> I have family down by the beach and stuff. And one of the scariest things, like this is a silly fear, but I'm down there and it starts to pour, and there's a horrible flash flood, and things get ripped away and I'm left there alone sitting on a roof, scared in the freezing cold rain, with water slowly rising closer and closer… Like, it's

> silly, but I'm like really scared that'll happen. Like my parents aren't anywhere to be found, my sister, nothing. And I'm left there alone as the water rises. (Isabelle, interview)

Also casting themselves as climate change *Victims*, James depicted himself having difficulty breathing as a result of climate change (Figure 21), and Aliyah depicted herself being displaced from home (Figure 21).

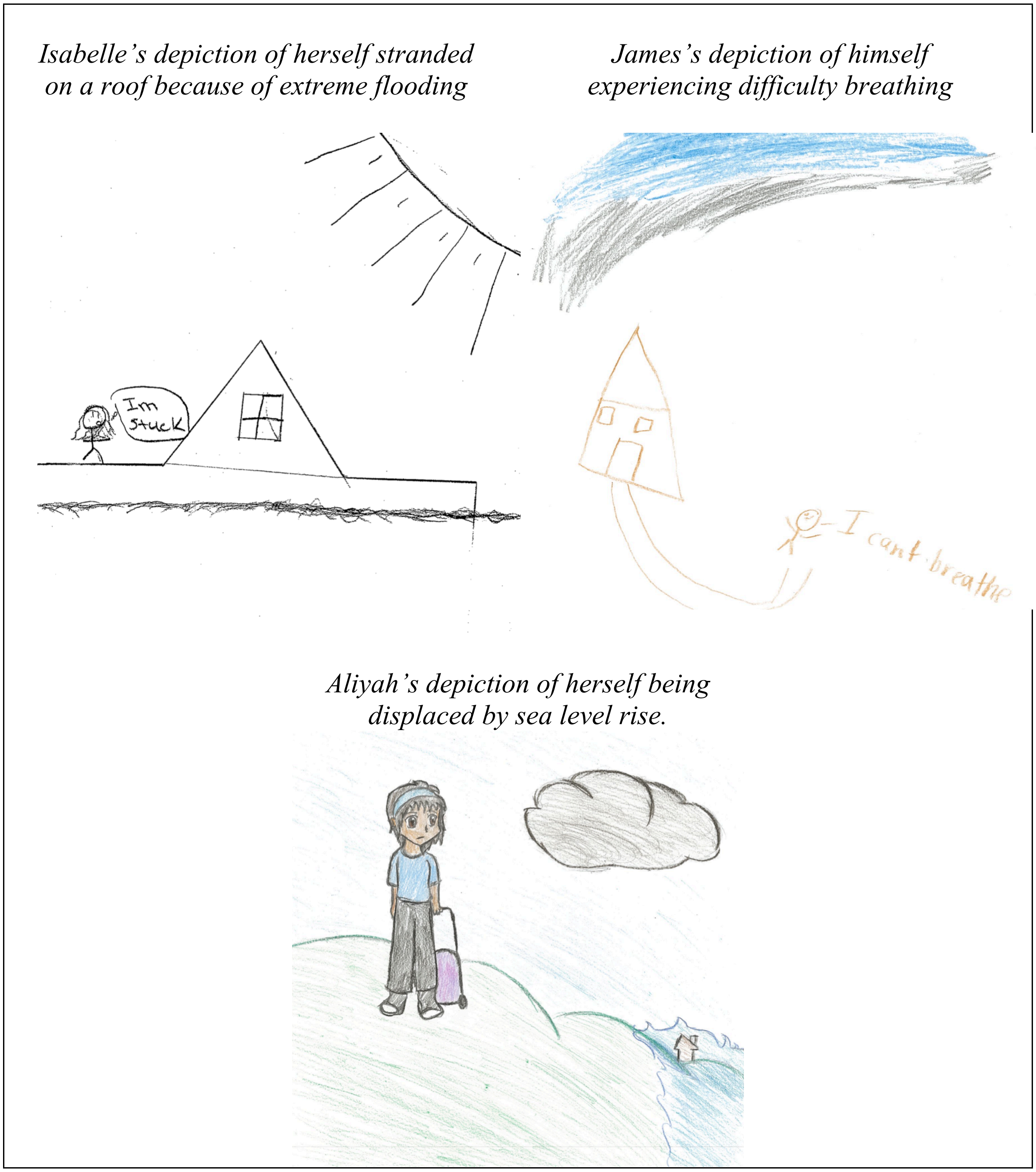
Most participants appeared to cast themselves within groups of people they saw as climate change *Victims*. Most commonly, participants saw themselves as members of humankind – a group they saw as suffering, or having the potential to suffer in the future – as a result of climate change. Sarah emphasized the global impact of climate change for humankind, stating:

> It can melt the polar caps, increase temperature, and cause droughts. Overall provide, I guess, a not so pleasant environment for humans and animals and plants... It doesn't just affect like, California, the North and the South Pole... I realized that this is the global spread effect… It's not just a problem that's affecting certain areas, it's affecting all of us. (Sarah, interview)

At times, participants also cast themselves as members of more specific groups that they saw as suffering as a result of climate change, either presently or in the future. Richie saw himself as a resident of the East Coast, a group that would likely become *Victims* of climate change in the future as a result of sea level rise. Richie explained, "We live on the East Coast. And it's probably gonna flood our area. And more people have to move into the middle of America" (Richie, interview).

Figure 21

Participants' Depictions of Themselves as Climate Change Victims



Isabelle's depiction of herself stranded on a roof because of extreme flooding

James's depiction of himself experiencing difficulty breathing

Aliyah's depiction of herself being displaced by sea level rise.

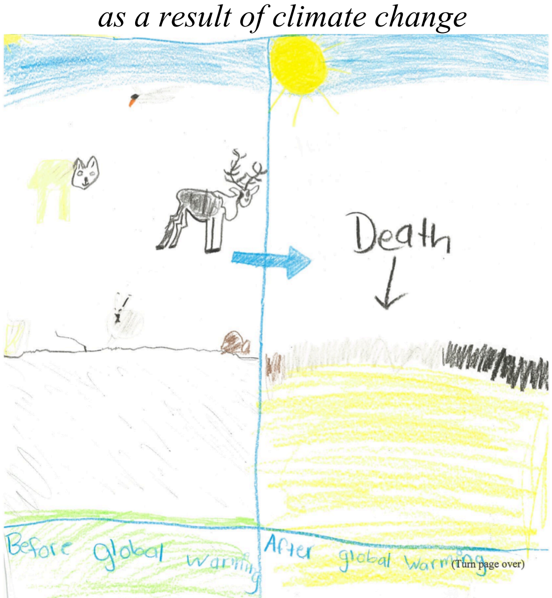
Isabelle spoke about how the younger generation – including herself – would be adversely affected by adults' current inaction on climate change. She said, "I think it's scary. Cuz we're only children. Yet, like, adults really aren't taking action. They're leaving it on us." (Isabelle, interview). As this example suggests, participants cast themselves both as members of broad groups (e.g., humankind) that could be *Victims* of climate change, and as members of more specific groups (e.g., East Coast residents, the younger generation) that could be placed in the *Victim* role.

Beyond considering themselves as climate change *Victims*, all participants also placed others in this role. Often, they cast animals – particularly Arctic animals – as climate change *Victims* (Figure 22). As Sophia explained, "All the snow melts which means that all the animals living in the Arctic die. After global warming the animals die and all that is left is the remains and fossils" (Sophia, drawing).

Figure 22

Participants' Depictions of Animals as Climate Change Victims

Sophia's depiction of animals dying as a result of climate change



James's depiction of animals starving as a consequence of climate change*

*Text in James's drawing reads: "My family" "Where are they and the food"

Beyond casting animals as others who were climate change *Victims*, participants cast various groups of people in the role of *Victims*. At times, participants recognized people in specific geographic areas as especially vulnerable to adverse consequences of climate change, including people living near coasts, in deserts, in polar regions, and in areas experiencing drought (e.g., California, at the time of the study). Participants who were particularly focused on the health impacts of climate change suggested that young children and those with asthma would be particularly at risk of health complications if carbon dioxide levels continued to rise. Finally, some participants considered future generations as climate change *Victims*. For example, during the focus group, Sarah explained:

> I guess if people have children or something… their children's children, and their children's children's children, they're gonna be affected too, so if they don't stop it, then their affecting the lives of those that they care about. And they're saying, "You know what? I don't care about this person. Forget them. I want to continue my ways." That's essentially what they're saying by not doing anything. (Sarah, focus group)

Overall, participants articulated a view that all of humankind – including themselves and some specific groups of humans - and many living things would be affected by climate change.

Self and others as Those Who Help: "Everyone should come up with their own idea for what they should do…in order to, kind of, go green." All participants cast themselves and others as *Those Who Help*, or characters who have the capacity to make positive changes to address climate change. However, participants cast themselves and others differently within the groups of *Helper* characters, typically casting others as characters who had more power to make a difference than they did themselves.

Everyday Heroes. Almost all participants cast both themselves (as individuals and as group members) and others in the roles of *Everyday Heroes*, or people who consciously changed – or had the potential to change - personal behaviors to limit their contribution to climate change.

Participants cast as *Everyday Heroes* people who conserve energy, use renewable energy, reduce their driving, recycle, plant trees, or generally practice environmentally-friendly behaviors. Autumn suggested that everyone should do what they can to "go green", explaining:

> Everyone should come up with their own idea for what they should do because it's mostly important for what they think they can do. Like be unique, in order to like, kind of go green. Like buy solar panels, if people can afford solar panels. I think that would be a good thing (Autumn, interview).

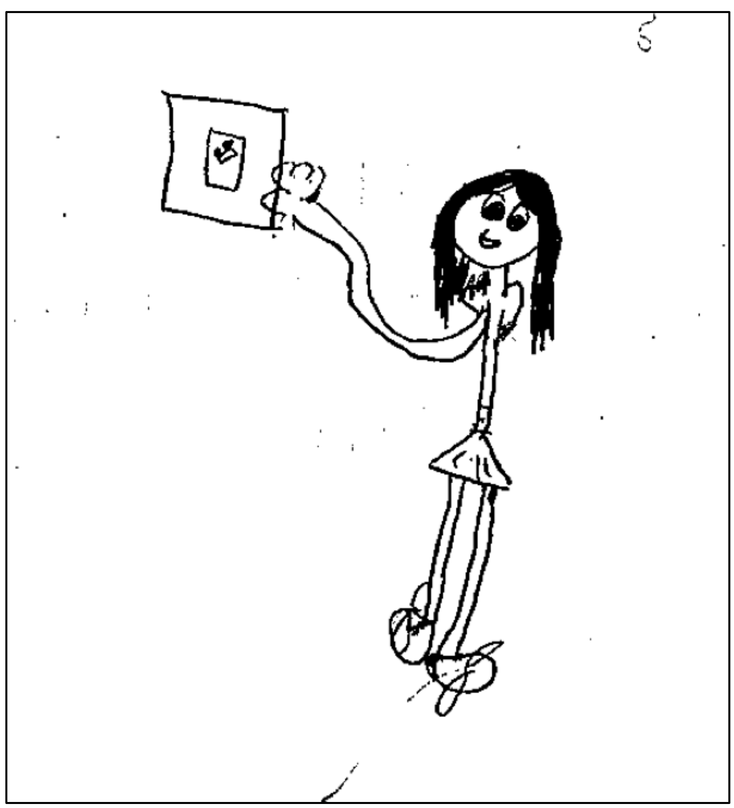
Participants generally shared the view that "we" (everyone, all humans) can all do something to help address climate change.

As members of groups, such as the Fairview Middle School student body, some participants saw themselves as having the potential to be *Everyday Heroes* when they changed personal behaviors like leaving the classroom lights on, using electronics excessively, or commuting to school by car. Some participants also cast themselves as members of families that could play the role of *Everyday Heroes* by driving places less as a family, recycling at home, and considering switching to renewable energy sources in the home. For example, Richie spoke about his family's decision to install solar panels on their house, casting his family (including himself) as *Everyday Heroes* (Richie, interview).

Finally, nearly all of the participants gave examples in which they cast themselves individually as *Everyday Heroes*. They referenced personal behaviors such as saving energy, saving water, recycling, not littering, carpooling, planting trees, and walking or biking. In some cases, these were behaviors in which participants said they were already engaged. In other cases, these were behaviors in which participants believed they *could* engage in order to help address climate change. For example, Sophia drew herself conserving electricity by turning off a light switch (Figure 23).

Figure 23

Sophia Depicting Herself Conserving Energy



Social Influencers. *Social Influencer* characters were people who encouraged others to make personal changes to address climate change, or to take on the role of *Everyday Heroes*. Nearly all participants cast themselves individually as *Social Influencers*, but did not generally see themselves as members of groups who played this role. Inconsistently, participants described others in the roles of *Social Influencers*. When participants cast others as *Social Influencers*, they gave examples such as scientists telling people what they can do to help mitigate climate change, parents influencing their children's actions, family members encouraging each other to drive less, and neighbors inspiring neighbors to move to renewable energy.

Most participants described themselves personally as *Social Influencers*. For example, Sophia spoke about encouraging her future children to engage in responsible behaviors, just as her mother was now encouraging her. Sophia said, "It doesn't matter if it's like one person… 'Cuz [my mom] encourages *me* to do it, to maybe think I'll encourage my kids to do it, and it will go on and on. So it'll be like thousands of people" (Sophia, interview). Other participants who cast themselves as *Social Influencer* characters spoke about persuading family members or peers to change their behaviors, such as conserving energy, driving less, and recycling.

I interpreted only one instance in which a participant cast herself as a member of a group that played the role of *Social Influencer*. In this singular instance during one of the focus groups, I interpreted Isabelle casting the youth generation – including herself – as having the capacity to take the role of *Social Influencer* among their peers. She said,

> I mean people will think 'Oh, I'm just one person, what can I do?' But if you change and you have friends, you'll influence your friends, who will influence

> their friends. And it's like a domino effect. So by you doing one thing, you're going to affect multiple other people. But if you don't do anything, somebody else who might think you're like cool and fun to hang out with, won't do anything either. (Isabelle, focus group).

Aside from this instance, participants did not see themselves as members of groups taking on the role of *Social Influencer*. However, most participants did cast themselves individually, as well as others, in this role.

Group Shifters. In the role of *Group Shifters,* characters move beyond individual behavior change, and seek to change the behaviors of large groups of people or engage them in collective action. Participants cast others within the roles of *Group Shifters* – much more often than they cast themselves in these roles. Often, participants cast lawmakers as *Group Shifters*, suggesting that they could impose top-down regulations that everyone would be required to follow. For example, during the focus group, James described that governments could impose limits on personal energy use: "I think they could limit people to the amount of energy they can use. A household, like, not like time-based, but like lock them off when they reach too much energy" (James, focus group). Participants also cast as *Group Shifters* those who work to stop deforestation practices, businesses that switch to renewable energy, cities that improve their municipal waste storage, companies making products more energy-efficient, people engaging in community gardening to reduce food mileage, and companies reducing their carbon footprints.

While participants did not cast themselves individually as *Group Shifters* –I noted that participants sometimes cast themselves as members of groups that could take on this role. For example, some participants cast themselves as members of the youth generation, a group that may have the capacity to shift the collective behaviors of others. For example, during one of the focus groups, James suggested that one way young people might disrupt climate change-exacerbating deforestation practices would be by engaging in a protest. Bobby suggested that as a member of his local community, he could engage with neighbors in campaigns to address local environmental problems. Richie suggested that as a member of the student body of Fairview Middle School, he and his classmates could raise funds to contribute groups working to address climate change. Although participants did not specifically intend to engage in such behaviors as members of these groups, they saw these actions as possible.

Self and others as Those Who Cannot Help: "It's very hard to do - to convince somebody that you need to make a difference". *Those Who Cannot Help* are characters who participants described as *Powerless* in their stories of climate change. Participants were more likely to cast themselves as individuals as *Powerless* characters in their narratives of climate change than as group members. They very rarely cast others in the role of *The Powerless*. Even though participants saw themselves as capable of changing their individual behaviors in the roles of *Everyday Heroes*, and sometimes those of other individuals in the roles of *Social Influencers*, participants saw limits to their spheres of influence and their capacities to incite change. Bobby believed he would be dismissed by others, predicting that, "They'll all be like, 'What are you talking about?'" (Bobby, interview). Sophia stated, "Well, I don't run any power plants" (Sophia, interview), when talking about her personal lack of power to incite change.

A few participants cast themselves as members of groups that were *Powerless*, particularly when they considered themselves as members of the youth generation. Bobby believed there was "nothing much" he could do about climate change because "basically nobody would listen to a kid and be like, 'Oh, let's learn from this kid'" (Bobby, interview). Similarly, Sophia said, "I think it'll be hard to say something, like, someone our age… to get [others] to start to make a difference… I just feel that it's very hard to do, to convince somebody that you need to make a difference" (Sophia, focus group). Finally, in casting herself as a member of humankind, Aliyah described herself as *Powerless* to some extent. She stated, "Even if we [humans] slow it down, it's still gonna continue to happen" (Aliyah, interview), suggesting the actions of *Everyday Heroes* may be futile in the face of a major global problem like climate change.

Participants very rarely cast others as *Powerless*. Rather, participants generally held onto the narrative that everyone could do their part to help address climate change. There was only one instance in which I noted a participant casting someone else as *Powerless*. This occurred when James and his peers were discussing what government could do about climate change. During this exchange, James initiated a discussion in which participants discussed the limits of President Obama's power in addressing climate change.

James: The government's more in power than him [President Obama]. He just signs…

Bobby: All Obama does is he signs.

Aliyah: He does more, but he just can't really do too much with the laws part.

James: Yeah, he can't change as much. (James, Bobby, and Aliyah, focus group)

Though participants saw the government as having the potential to address climate change by imposing rules, participants saw the President's power within this process as limited. Beyond this example, participants did not cast others as *Powerless* characters.

Self and others as Those Who Interpret: "We're younger, we have an eye for that sort of thing". Within the character type, *Those Who Interpret*, participants cast themselves and others within the roles of climate change *Witnesses*, *Learners*, and *Communicators*.

The Witnesses. Within participants' climate change stories, those in the roles of climate change *Witnesses* noticed changes in the world around them associated with climate change. All participants cast themselves as climate change *Witnesses*. In particular, participants were noticing hotter temperatures and changes in precipitation that they associated with climate change. For example, Sarah explained:

> I mean it's quite obvious… Summers here used to be, I guess, nice… I think it was like 2013 and I had to go to an all-day lacrosse camp. It was just really hot. And summertime used to be not so hot, and I'd spend a lot of time outside. And now it's just like, it's too hot. (Sarah, interview).

Individual participants varied in the other types of changes they were noticing. For example, Isabelle spoke about her annual visits to the beach with her family during summer vacation, and changes in the landscape that she was noticing and associating with climate change. These examples suggest how participants, as individuals, observed changes in their surroundings and began to identify as climate change *Witnesses*.

Additionally, some participants cast themselves as members of groups that were *Witnesses* to climate change. For example, Isabelle as cast herself as a member of the youth generation, when she spoke about young people as more perceptive *Witnesses* of environmental degradation than adults. Isabelle said,

> I feel like because when we're younger, we have an eye for that sort of thing more often… I feel like kids are able to, like, look at it and be like, "That's gross". More than adults because adults have been looking at it more. They've become oblivious to the fact that it's actually there. But kids, you know, we're younger, so it's all very new for us (Isabelle, interview).

It was rare for participants to cast others in the roles of climate change *Witnesses*. It may have simply have been too challenging for participants to recognize whether others were witnessing climate change. In one of the few instances in which a participant cast others in the role of *Witnesses*, Isabelle spoke about the changes her father had noticed in the landscape at the beach he had visited every summer since childhood. She explained,

> My dad's been going [to the same beach] since he was 5. His dad, you know, it's been a family tradition to bring your kids… When he was younger there were lots of pictures. The beach and the dunes were super far apart. Like to get from the dunes to the beach you'd have to walk a good ten-minute walk. Now, you can kind of jog down, take two minutes to get to the beach (Isabelle, interview).

In cases such as these, where participants were aware of others' experiences, they sometimes cast others in the role of *Witnesses*. However, they typically reserved this role for themselves.

The Learners. *The Learners* were a group of characters in participants' stories of climate change that were sought out or interacted with information, and came to a greater understanding of climate change. Nearly all participants cast themselves as individuals in the role of climate change *Learners*. Those who did not cast themselves as individuals in this role *did* cast themselves as members of groups enacting the role of *Learners*. For example, Bobby, who did not specifically cast himself individually as a climate change *Learner*, did so when he considered his group membership as a student at Fairview Middle School. Bobby said,

> We're doing the sustainability projects. So I think about it more and more because like, climate change and global warming has to do with the sustainability project of not using electricity and all that. So we have to come up with a way that helps us with saving electricity and not using gases and all that (Bobby, interview).

Some participants cast themselves both as individuals and as group members in the role of *Learners*. One example was evident to me in a statement from Isabelle, when she spoke about the value of learning about climate change in school with her classmates. She said,

> I feel like we could actually, like, learn about it. Because if you educate yourself on it, or somebody comes and talks to you, and talks about it like you guys [the research team] are for us. I feel like what you're doing is really gonna help us because we're the younger generation (Isabelle, interview)

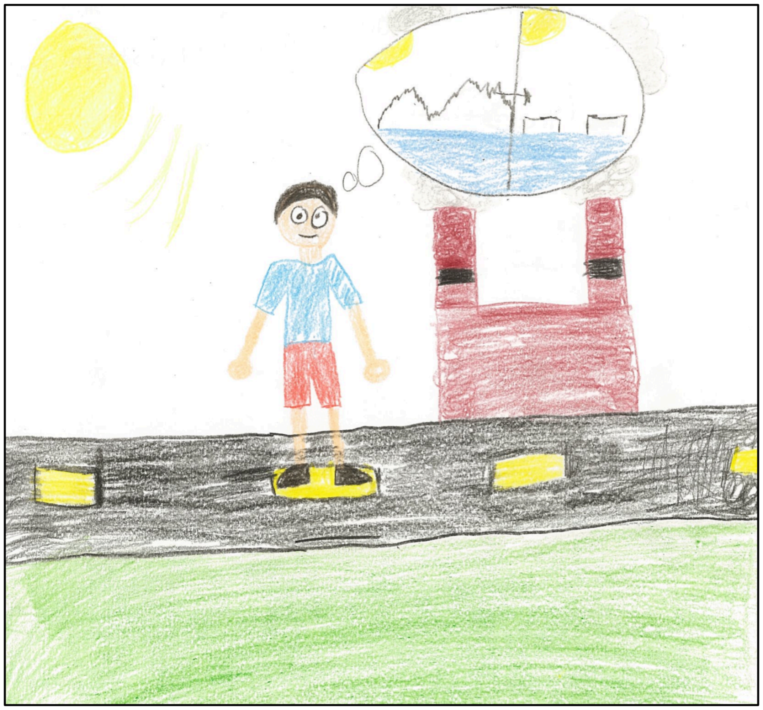
These examples show how when participants considered themselves as members of the group of Fairview Middle School students, they sometimes cast themselves collectively as *Learners*. Learning about climate change in school appeared to be making climate change more salient to participants. For example, Sophia stated, "I'm learning about it in school. And like… before I was learning about it… I rarely heard the word.

Now that I'm talking about it [in school], I seem to hear [about climate change]. Like when I'm walking, maybe I'll hear it somewhere" (Sophia interview). In addition to making climate change more salient to participants, learning about climate change in school generally made participants feel more knowledgeable about climate change and its scale. Some participants, such as Richie, referenced specific in-class activities that had impacted them in their roles as *Learners*. Richie stated, "When we did the project where we went around the room, there was a map that showed us how the white, or the ice, was big in a year and then it came down a few years after…. [Before] I thought it was just a little change but, it was actually a huge change" (Richie, interview). In his initial drawing (Figure 24), Richie drew a picture of himself with a thought bubble coming from his head to show him thinking about ice melt.

In addition to referencing their learning from in-school activities, some participants appeared to identify as climate change *Learners* as a result of their activities outside of school. Isabelle spoke about seeking out information about climate change on YouTube, and watching a documentary she encountered. As these examples suggest, participants' in school and out-of-school activities appeared to play a role in shaping their visions of themselves as *Learners* of climate change.

Figure 24

Richie Depicting Himself as a Climate Change Learner



It was rare for participants to cast others in the role of *Learners*, possibly because others' learning was challenging for participants to observe. In the few instances in which participants cast others as *Learners*, they spoke about how scientists were learning more about climate change through their research.

The Communicators. Participants referred to others, and sometimes themselves, as climate change *Communicators*, who disseminate information about climate change. When referring to others as *Communicators*, participants sometimes cast other individuals or groups of people. At other times, participants cast other types climate change information sources, such as the media, within the *Communicator* role. Often, these were sources from which participants themselves had obtained information about climate change. For example, participants cast others with whom they interacted directly in the roles of climate change *Communicators*, such as their parents, grandparents, siblings, science teacher, and researchers (including myself) that had visited their class. They occasionally cast as *Communicators* other people with whom they did not interact directly, such as scientists who disseminate their research findings about climate change.

Participants also cast media sources in the roles of *Communicators*, including media presented to them by others, and media that they encountered on their own. For example, Richie spoke about initially learning about climate change by reading a news article in school from *Time for Kids*. Isabelle, Sarah, Sophia, and Autumn all gave examples of coming across climate change information while using the Internet. At times, participants' parents shared information they had seen on social media about climate change. Aside from online media, participants also cast as *Communicators* media sources such as television news, cable programs (e.g., *Discovery Channel*, *The Disney Channel*), and sometimes, print media.

Participants sometimes identified themselves as climate change *Communicators*. Outside of school, much of this communication came in the form of raising family members' awareness of climate change. For example, Autumn described telling her mother about climate change, which led her mother to share a climate change learning experience of her own. Autumn stated,

> I was in there telling [my mom] that… the carbon dioxide has been rising, and… she said she'd heard about it at her job. She was on the Internet and she started hearing about it, how we can stop waste from carbon dioxide from going into the air, or ways that like, how, climate change is rising because of what humans are doing. (Autumn, interview).

Within school, participants generally appeared to see themselves in the role of climate change *Communicators* only when they were required to discuss the topic of climate change with their peers. This suggested that participants identified as *Communicators* both through the communication in which they opted to engage (e.g., with their families) and through the communication they were required to engage as students in school.

When considering themselves as members of the Fairview Middle School student body or as members of the youth generation, participants sometimes cast themselves in collective roles of climate change *Communicators*. During the focus group, James suggested that 6th graders could address climate change by: “Educating people maybe. Some people don’t even know about it” (James, focus group). Here, I interpreted James as identifying his own potential to communicate to others about climate change, because he was a member of a group that was becoming more knowledgeable about climate change. Similarly, Isabelle described how members of the youth generation, including herself, could educate their peers. She said,

> Because if you think about it, are all the adults gonna be around for another 20, 30 years? Sure. But are they gonna be around for another 50, 60 years? That’s the question. Like, you never know, because the older you get, the closer you are to dying. So I think the more you educate the younger people, the more they can educate the younger people, the more they can educate the younger people (Isabelle, interview)

As these examples suggest, some participants cast themselves as members of groups that could take up the roles of climate change *Communicators* for the varied purposes of educating other groups, educating their own group, or reinforcing group ideas.

Character web summary. In this section, I have used the storytelling notion of *character* to examine the ways in which participants appeared to cast themselves and others in relation to climate change. I described a character web, comprised of five character types (*Those Who Harm*, *Those Who Suffer*, *Those Who Help*, *Those Who Cannot Help*, and *Those Who Interpret*), that participants employed as they articulated their stories of climate change to me through the data sources. I interpret this character web as providing information about the enacted roles, or identities, within participants' figured worlds of climate change. I described how participants cast themselves – both individually and as members of groups – as enacting certain roles within their stories of climate change. I also described how participants cast others within certain roles, sometimes alongside themselves and sometimes in opposition.

I interpreted that participants were personally noticing changes in the world around them (role: *The Witnesses*), which they associated with climate change. This was a role they generally reserved for themselves, because they could not necessarily speak to whether others were noticing changes too. Participants saw themselves as individuals and group members (i.e., members of the 6th grade class) who were learning about climate change (role: *The Learners*), more than they saw others in this role. However, they sometimes referred to scientists as others who were *Learners*. Though some participants saw themselves as developing the capacity to communicate about climate change as they learned more (role: *The Communicators*), they saw others as more important climate change communicators than themselves.

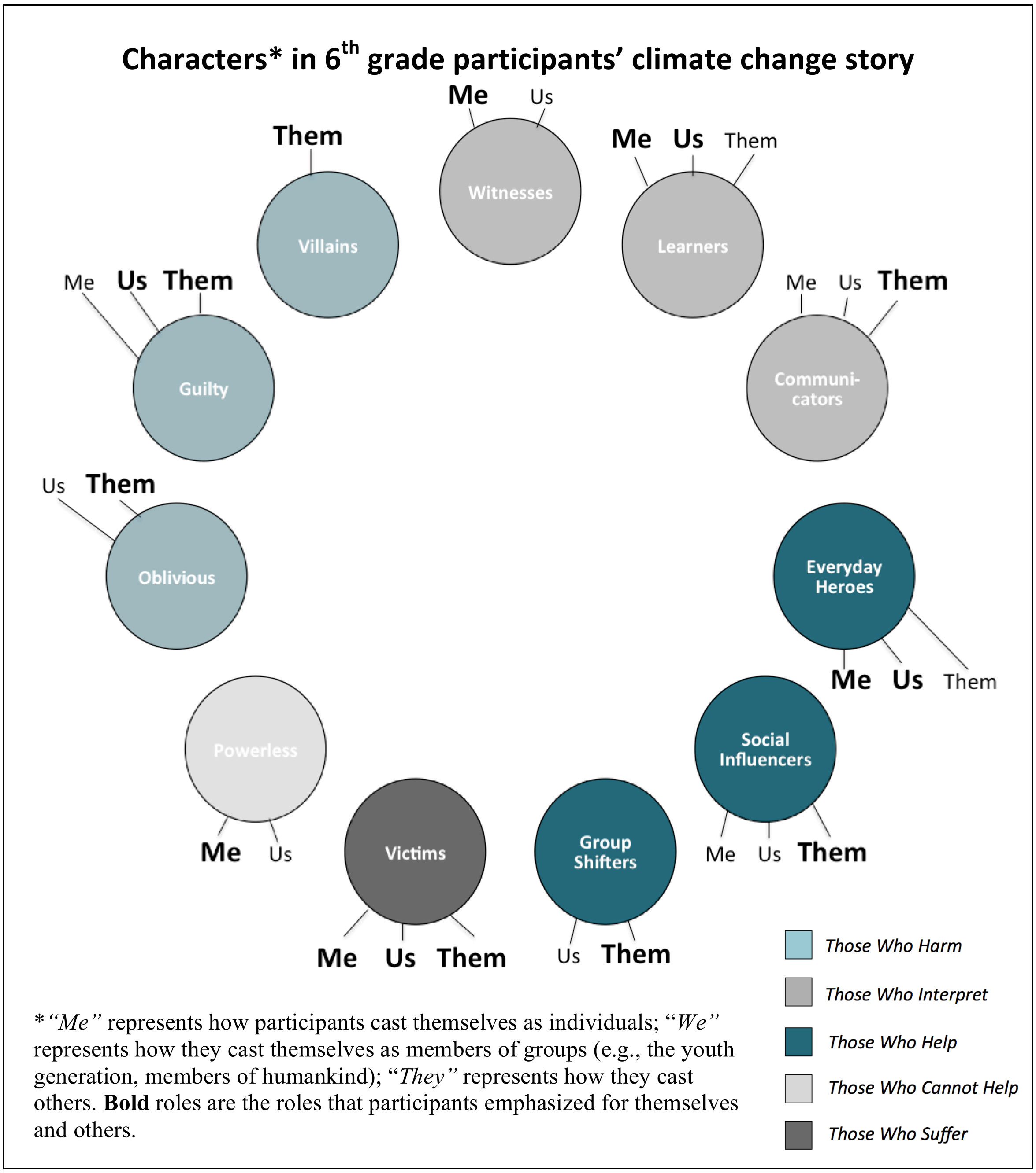
Participants saw themselves and all others—including non-human living things—as vulnerable to negative impacts of climate change, both now and in the future (role: *The*

Victims). They interpreted these negative impacts as caused more by others than themselves. In the past, participants saw themselves as possibly being amongst those who lacked climate change awareness (role: *The Oblivious*). They noted that others still engage in harmful actions because they lack awareness. Sometimes, participants still engaged in harmful actions, individually and collectively, because they were unable to change them (role: *The Guilty*). However, they saw themselves as personally less guilty than the larger groups to which they belonged (e.g., humankind as a whole). They also saw themselves as less guilty than others, who very often knowingly engaged in harmful actions but did not or could not change them. Participants would never knowingly engage in harmful actions because they did not care about climate change (role: *The Villains*), but they saw others as doing this all the time.

Participants saw everyone, including themselves, as capable of changing their personal behaviors to address climate change (role: *Everyday Heroes*). They highlighted this role for themselves, both individually and collectively, than they did for others. Likewise, participants saw themselves as having the ability to convince others to change personal behaviors (role: *Social Influencers*). However, they saw others as having a greater capacity for influencing others' personal behavior. Participants saw themselves individually as unable to change the behavior of groups of people (role: *Group Shifters*), but possibly able to do this as a member of the groups to which they belonged (e.g., members of the student body, the youth generation, members of the local community). Primarily, they saw others (e.g., lawmakers, cities, companies) as capable of changing the behaviors of groups of people. Personally, participants saw themselves as having less power than others to address climate change (role: *The Powerless*). However, when they considered themselves as members of larger groups, they saw themselves as having greater capacity to enact change. In Figure 25, I represent how participants cast themselves and others as characters in their stories of climate change.

Figure 25

Emergent Characters in Participants' Story of Climate Change from the Application of the "Identity" Analytic Lens



Moral Argument: Figured Worlds of Climate Change as Reflecting Values

Stories are "sequences of actions, with moral implications and effects" (Truby, 2007, p. 108). Like stories, actions within figured worlds have moral implications, which may be weighed against *what is valued* by those enacting them. What is valued within figured worlds is relevant to issues of identity, as people may be more apt to position themselves in roles they see as engaged in *right action*, or as protecting what is valued. To gain insight into participants' identities as certain characters that move the *plot* of climate change forward through certain (right and wrong) actions, it is worthwhile to examine the underlying values embedded in the climate change story participants are telling.

Truby (2007) suggested that whenever a storyteller presents a character using means to reach an end, the storyteller is "presenting a moral predicament, exploring the question of right action, and making a moral argument about how best to live" (p. 108). The moral argument of the story, then, is expressed through characters' actions in the plot – including how their actions may impact others, and what, if anything, characters do to make things right (Truby). With this in mind, I analyzed participant data through a values lens, seeking to identify what participants appeared to depict as *right* or *wrong* (good or bad) actions in relation to climate change. In Table 14, I represent how I connected the Truby's notion of "moral argument" with the analytic lens of "values". Where participants depicted actions as right, or good, I considered what was being valued – or protected – by the actions. Where they depicted actions were wrong, or bad, I considered what was being threatened by the actions.

Table 14

Alignment of the Moral Argument Framework Element with the "Values" Analytic Lens

Storytelling framework element	Analytic lens and related data collection question(s)	Structural coding questions	Data sources coded
Moral argument (Truby, 2007)	e) Climate change values [Relevant data collection question: *What is the nature of learners' ideas (i.e., their* ***values****...) in relation to climate change?*]	*What did participants appear to uphold as the good (or right) and the bad (or wrong) as they communicated about climate change?* Parent codes: ▪ Good or right ▪ Bad or wrong	• Participant-generated drawings and accompanying written reflections • Individual interviews (learners) • Focus group interview

Protecting what is valued in figured worlds of climate change. I identified a collection of ideals that appeared to be mutually valued by the participants, though variably emphasized amongst individuals. The protection of these ideals motivated any *right actions* that participants described in relation to climate change. Participants appeared to judge any threats to these ideals as *wrong actions* in relation to climate change. In total, I noted nine ideals that participants appeared to value, as indicated by the ways they communicated about climate change. I describe each of these ideals, and how they presented themselves in the data, in the following section. I suggest that the moral argument of participants' climate change stories is one that urges the upholding of this specific set of ideals.

Aesthetics, beauty of the natural world: "It was just beautiful… untouched by people who just wanna destroy it". Data from some of the drawings, interviews, and focus groups suggested that participants valued the natural beauty of the Earth, and saw this beauty as something that should be preserved. Conversely, they appeared to view actions that jeopardized the beauty of the natural world (e.g., pollution creating a “dirty” or “smelly” environment) as bad or wrong. This theme often came up when participants were discussing land and air pollution. An example is evident in Isabelle’s drawing (Figure 26), in which she included an image of a polluted pond, bags of trash, and herself saying: “It stinks” and coughing. In her written description, Isabelle explains that this part of her drawing shows “the effect of all the trash and CO_2. It is dirty and smelly” (Isabelle, drawing).

Figure 26

Isabelle Depicting Threats to Aesthetics of the Natural World

Though several participants did find coherent ways to connect trash or litter and climate change, I generally interpreted participants’ comments about trash or litter to serve as a concrete way to talk about environmental damage. An example was evident during the focus group when Sophia described noticing environmental degradation on a trip to visit family in Egypt. She explained, “I went to Egypt when I was four, and it was very beautiful, I saw a lot of rivers and stuff. There was no signs of pollution. No litter whatsoever. But now when I went when I was 11, I see all this litter. [It’s] not just piled up in one place… it's everywhere" (Sophia, focus group). In her interview, Isabelle talked about visiting an environmental education center and noticing its beauty. She said, "They had acres of land. It was just beautiful... because it was untouched by people who just wanna destroy it." (Isabelle, interview). This suggests a view of nature as separate from humans, unspoiled nature as beautiful, and human activity as a threat to the aesthetics of the natural world.

Altruism, consideration for others: "People don't do anything until something happens to them". Participants were particularly critical of environmentally detrimental actions they interpreted as motivated by greed or selfishness. This suggested that they valued altruism, selflessness, and consideration for others. Most discussion of greed or selfishness occurred when participants were speaking about corporations or people acting out of an interest in their own economic gain. This theme emerged, for example, during one of the focus group discussions in which participants' conversation turned to the topic of corporate responsibility. Here, Isabelle brought up *The Lorax* movie, describing how the factory owner in the movie destroyed the environment out of selfishness and greed. This prompted Sarah to talk about a documentary she had watched with her parents about Walmart, and how the company was engaged in environmentally damaging practices, prioritizing its own economic gain. Later, Sarah suggested that companies should prioritize the environment – benefiting everyone – rather than their own self-interest. She explained:

> I think I was in 3rd grade… I heard about how trash incineration really hurts the environment because of all the carbon dioxide released. And I heard that you could get these filters that would take out all the harmful gases… But I heard that

> they're really expensive. So maybe they could have, like, an initiative, so these big budget companies, like the family that owns the company, rather than spending all their money on a vacation, or a couple cars, or a mansion, how about you think of the environment first, and put in some filters in your factories? You could really make a difference. (Sarah, Focus group)

Other participants reiterated the criticism of prioritizing personal economic gain over the well-being of others or the environment. Autumn stated, "Sometimes, like business, industries, sometimes like power plants, they burn fossil fuels for energy because like, some people just don't care, they just want money. So, it's causing damage to the Earth…" (Autumn, interview). And during a focus group, Aliyah and Bobby had an exchange on this topic, in relation to development in their suburban community:

Aliyah:	Yeah, like where I live they're building this whole new neighborhood. But I've seen a bunch of houses that no one lives in.
Emily:	Okay, so to build that new neighborhood…
Aliyah:	…It's deforestation. Cuz people are…
Bobby:	Cuz they want the money, it's all about the money
Emily:	So, development is what you're thinking about?
All:	Yeah
Bobby:	Cuz all they want is the money." (Aliyah and Bobby, Focus Group)

In some cases, participants took the view that money was associated with not having to worry about the consequences of one's actions. For example, Isabelle, in talking about consumption and the production of commercial products stated: "If you have the money to make it, you really don't care like what it does to the planet because how's that gonna affect you? You've got money, you'll just buy your way through life kind of" (Isabelle, focus group). This theme also came up when participants talked about the consequence of climate change for developing countries.

Aliyah: In a first world country, there's other people in other countries that are being affected even more. They have less resources to go around.

Emily: Okay, so people should be thinking beyond their own personal experience.

James: Yeah, and not be selfish...

Bobby: Aren't countries like Vietnam, and like, small island counties

Richie: Like Haiti, other places.

James: I really agree with Aliyah…

Emily: James, you said you really agree. Why do you really agree with that?

James: Because that's true because… I believe that the reason that some people don't take a stand about climate change, some people actually know but the reason some people don't take a stand is because it's not happening around them. Just like most things in life. The people don't do anything until something happens to them. So when something does happen to them, when it starts happening around them, it's gonna be too late. So, that's why people should stand up and make a change. Stand up and take a stand now." (Aliyah, James, Bobby, and Richie, Focus group)

As these examples illustrate, participants appeared to share the view that consideration for others was an ideal to be upheld, and that it could be applied to actions in relation to the environment, including in relation to climate change.

Environmental stewardship behaviors and attitudes: "You could do all these things to save the Earth". Overwhelmingly, participants saw climate change – and environmental damage in general - as negative or wrong. Therefore, they tended to frame human actions that would exacerbate climate change as bad, negative, or wrong. Conversely, participants framed actions that mitigated climate change, as good, positive, or right. For example, many participants criticized wasting energy, an activity they saw as exacerbating climate change. As James said in his interview:

> I told [my brother]… we should conserve electricity, like turn off the lights after yourself when you leave the room… Because that's what he does, he leaves the lights on. I told him if we don't stand up and make a change, we're gonna die soon. (James, interview)

The stewardship behaviors that participants described were not always so specific. They also generally appeared to value "going green" or "saving the Earth". This was reflected in statements like the following excerpt from my interview with Sophia:

> Emily: So how would recycling… how would that help with climate change?
>
> Sophia: Saving the Earth I guess… All these like, "saving the Earth" things, they all relate to each other because they're all part of saving the Earth. Like you could do all these things to save the Earth." (Sophia, interview)

Aside from stewardship behaviors, participants also valued attitudes of environmental stewardship, and were particularly critical about people who simply do not care about the environment. In her interview, Isabelle explained her view that adults care less about climate change than kids:

> The adults and the older people really don't, like, teenagers and stuff don't care because it's not gonna affect them at all. It's gonna affect the younger kids. And like, we're the younger kids. If you compare this school, the older kids probably don't put as much thought into it as we do, because we're going to be going through it longer than them…. We're younger so we're going to have to put up with it longer, and it's gonna like fall on us more than it's gonna fall on them. (Isabelle, interview)

Here, Isabelle also connected with the previous theme of greed and self-interest, suggesting that it is wrong for people to only care about things that affect them personally. Autumn more directly stated her view that it was wrong not to care about climate change, when she said:

> My friends, I think in 5th grade (I already knew about climate change back then). And when I told them that I thought it was getting [to be] a serious problem… they just shrugged it off and said that it wasn't happening. Like they don't really care. I'm just like, "Do you know how rude that is? It's like, it's actually happening. Like it's scientificially being proven, so how can you not know about it? It's pretty much everywhere. Don't you see the rise in temperatures? How the summers are getting hotter?" (Autumn, focus group)

Participants generally appeared to agree that it was right to care about the environment, including climate change, and to act consistently with the same care.

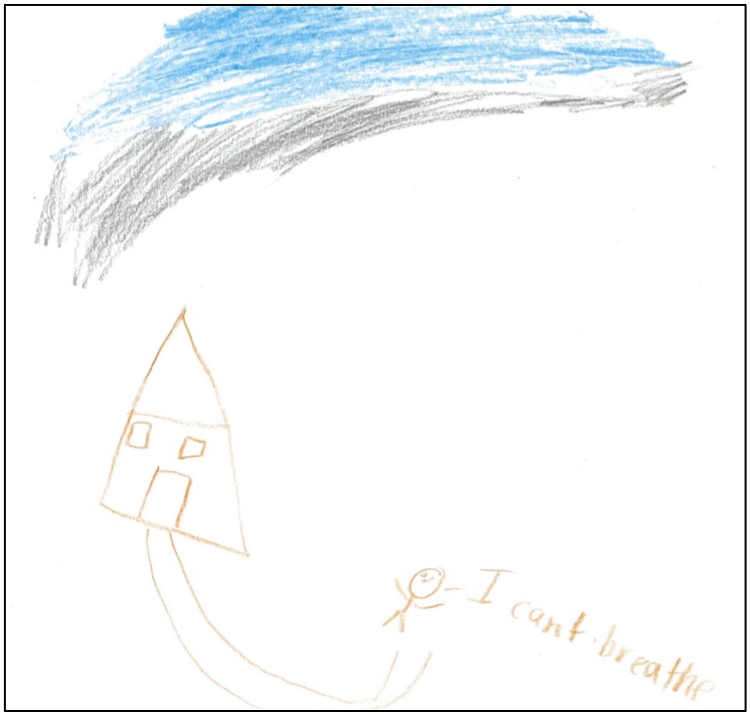
Health: "Maybe the first breath that a child takes when they're born, it could be… pollution". Human health appeared to be highly valued among participants. Participants described the threats to health they associated with climate change as particularly bad or problematic. Most of the health problems that participants associated with climate change stemmed from a view that increased carbon dioxide (or air pollution) would lead to breathing problems or asthma. While all participants appeared to value human health, it seemed to be a more important theme for those participants who did not generally think about climate change in terms of the carbon cycle. That is, some participants thought about carbon dioxide as air pollution that gets filtered out by trees. In the presence of deforestation and increased use of fossil fuels, the pollution would accumulate, make the Earth hotter, and make people sick. Along these lines, Sophia described during a focus group:

> This also may affect babies being born. Maybe the first breath that a child takes when they're born, it could be, like, pollution, and then… they'll be breathing bad air, and they'll die. And that might affect us. It might make us… make people extinct." (Sophia, Focus group)

This sentiment also showed up in one of James's drawings (Figure 27), which he described by writing, "The carbon dioxide in the atmosphere is making it harder to breathe" (James, drawing). Participants also brought up asthma, skin cancer, and lack of oxygen as problems associated with climate change that posed threats to human health.

Figure 27

James Depicting Threats to Human Health



Honesty: "I don't trust these off-brand, random people". The politicized nature of climate change in the U.S. did not appear highly salient to these 6th grade participants. However, participants were skeptical of corporate interests, as seen above in the category related to altruism and consideration for others. Participants were aware of the possibility that companies could try to mislead, particularly through advertising or false promises. In her interview, Isabelle brought up the issue of corporations seeking to mislead for financial gain:

> They're making commercials for like, new cars, and stuff that are supposed to be better for the environment, but they're not… And recently I heard a commercial, it was just like the government is putting too much effort into [climate change] because it's perfect as it is right now. (Isabelle, interview)

Isabelle also talked about trusting information on the Internet, a topic that had been emphasized to students in the blended learning school context. When talking about the Internet sources she trusted, Isabelle stated: "I don't trust these off-brand, random people [saying] 'This is happening'. I trust Discovery and them because they're scientists who are doing this for a living and they are getting paid for it. Not just some bored bum who is doing it as a hobby…" (Isabelle, interview). Along these lines, Richie stated that he wouldn't trust "websites that have dot.com" (Richie, interview).

Learners also upheld honesty in talking with young people as important, including not withholding information from young people about climate change. When talking about learning about climate change at Fairview Middle School, Isabelle stated:

> Originally I thought, "Well, it's just happening and we're doing the best we can to fix it", you know? I had been told by multiple people that it's getting a lot better and that we're gonna make it. We're doing great. And then I learned here that it's getting worse. (Isabelle, interview)

Later when I asked her about whether she'd discussed climate change with friends, she stated:

"No, cuz they're like me. They didn't really learn about it. Cuz my elementary school babied us. They had the place baby-proofed. Literally" (Isabelle, interview). In these statements, I interpreted that Isabelle saw it as wrong to withhold information from young people, or to mislead them to think that everything is okay in order to avoid scaring them.

Learning and knowledge: "I think by educating us, we're able to make a difference". Participants appeared to value – for themselves and others – gaining more information about climate change. This value emerged when participants spoke positively about scientists engaging in research to learn about climate change, people spreading the word to the public about climate change so that they can make responsible decisions about their actions, and themselves gaining a better personal understanding of climate change through their science education experiences.

In this category, participants raised concerns about the ethics of technology use – particularly the fact that the technologies people use are largely reliant on fossil fuels. Participants were aware that technology was helping scientists – and the public – to gain information about climate change, which they appeared to see as beneficial. As Autumn stated in her interview: "[Technology is] telling people ways to prevent [climate change]…Technology is showing what's happening all over the globe. And showing the changes and causes of global warming" (Autumn, interview). However, participants also noted that technology use – even when used for something they saw as positive, like learning about climate change – was still exacerbating the problem of climate change. Isabelle summarized this point when she said:

> On one hand it's good, because you can [use technology] to study the environment. Take pictures, take it back to a lab, develop them, look at like: "This is happening to this area. And this is happening to another". But to do that, you have to use coal and use oil. So on one hand, it's great that we have technology to look at this. On the other, it's part of the reason that [climate change] is happening. (Isabelle, interview)

Participants spoke positively of actions like "spreading the word" and promoting awareness of climate change to others, and saw this as something that people should do to address the problem of climate change. One example of this occurred in James's interview, when I asked if he thought there was anything he could do about climate change:

James: I could spread the word… I could turn off the lights after myself and other
stuff like that…

Emily: When you talked about like spreading the word, tell me more about what you were thinking with that?

James: Like, tell [people] to stop using as much electricity and to plant more trees, and make a banner or something. (James, interview)

Participants generally appeared to take the view that educating people about climate change might lead them to take action. Isabelle applied this thinking to her own learning when she said:

> I think by educating us, we're able to make a difference. We're able to realize this is what's happening. And this is when it's happening. So we can, you know, build less buildings. We can cut down less trees. Because if you think about it, are all the adults gonna be around for another 20, 30 years? Sure. But are they gonna be around for another 50, 60 years? That's the question. Like you never know, like because the older you get, the closer you are to dying. So I think the more you educate the younger people, the more they can educate the younger people, the more they can educate the younger people. And in the end I think that'll really help because people will realize "Oh, so when I do this, it affects this" and it'll you know, help global warming. (Isabelle, interview)

However, at times, participants noted that behavior change is not a given, just because a person has become aware of climate change. During the focus group interview, Sophia stated: "If you would just teach someone about [climate change], how it affects them and the way they live. They will make a change, most likely they will. Or, sometimes people just don't care whatsoever, which is, they'll just ignore it" (Sophia, Focus group). With this statement, Sophia upheld learning as valuable, and criticized others whose attitudes were not oriented to environmental stewardship, another value upheld by the participants.

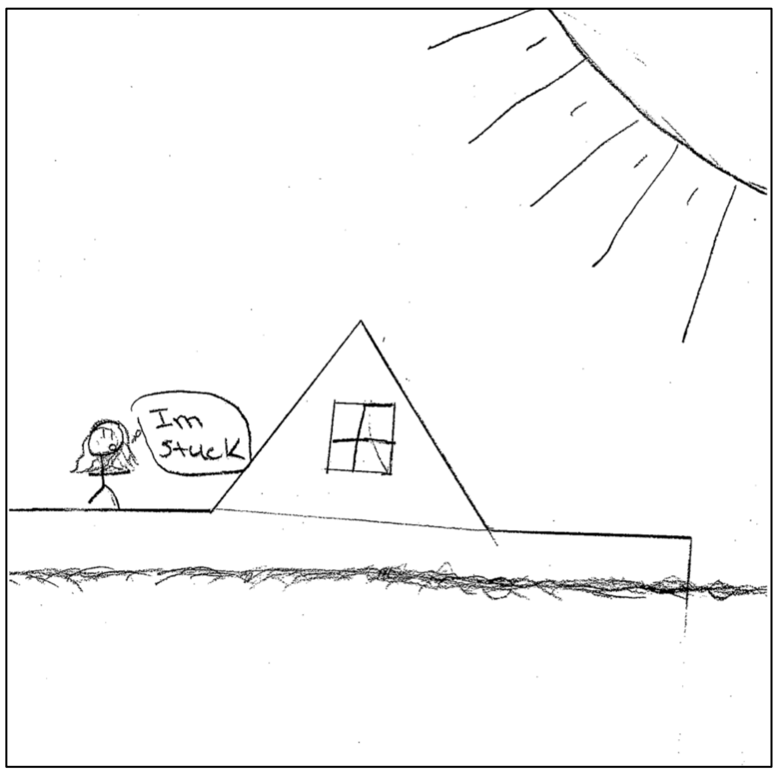
Life: "If you don't do anything, you could die". When participants spoke about the negative consequences of climate change, they spoke about the possibility of death of living things (humans, animal life, and plant life). Otherwise stated, they appeared to value life and see it as something that ought to be preserved. Their ideas were akin to Wilson's (1984) notion of *biophilia*, or the idea that humans have positive feelings toward life or living systems. Frequently, participants lamented the threats that climate change posed to the survival of animals, particularly those living in Arctic environments.

Similarly, participants lamented that climate change could be a threat to human survival or wellbeing, though not as frequently as they talked about threats to animal survival. In some cases, they spoke about threats to particular human populations, such as agricultural communities, Arctic dwellers, coastal communities, desert dwellers, developing nations, and island nations. In other cases, they talked about climate change as *affecting us all*. Most severely, participants talked about unmitigated climate change as potentially leading to human deaths. For example, in one of the focus groups, James responded to my question regarding what people should know about climate change by saying: “[People should know that] if you don’t do anything, you could die” (James, focus group).

In other cases, participants saw climate change as posing threats to human health and safety. This was evident, for example, in Isabelle’s drawing of herself becoming stranded on a rooftop as a result of flooding (Figure 28).

Figure 28

Isabelle Depicting Threats to Human Safety



Finally, in a few cases participants spoke about plant death as a consequence of climate change. For example, in Autumn’s drawing (Figure 29), she describes how global warming caused “flowers to lose their colors, and flowers dying”. In this example, Autumn appears to combine the ideal of preserving life with the ideal of preserving aesthetics.

Figure 29

Autumn Depicting the Loss of Plant Life

Maintaining what we have: "I would have to move further inland… away from home". Throughout the data, participants expressed a desire to maintain (and not threaten) the life that exists now. This came up especially when participants drew "before and after" images of climate change, in which the *before* appeared to represent the present, and the *after* to represent a future of negative climate change consequences. Figure 30 shows examples of drawings that included "before and after" scenes. The theme of maintaining, or not losing, what we have, also emerged when learners expressed concern about the possibility of displacement, and having to leave a familiar home. This was vividly present in Aliyah's drawing, which she described by stating,

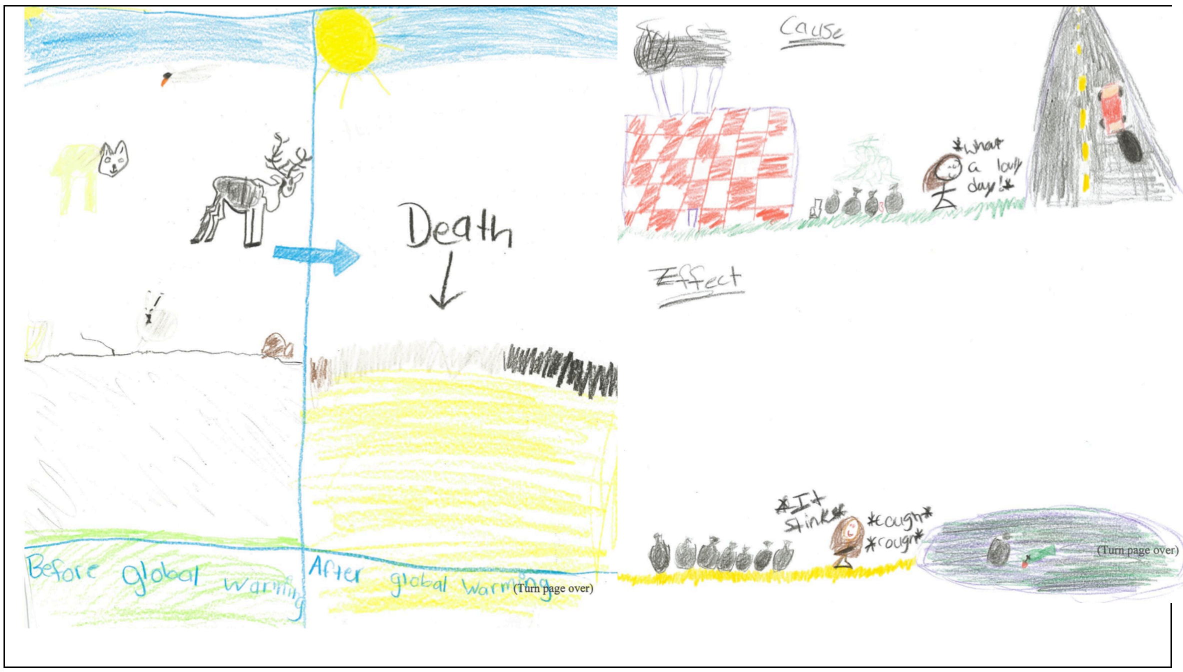
> What I'm showing is when it gets warmer, and water, the sea level rises, since we live in an area that's low… I would have to move to higher ground. I would have

to move further inland. So this is a picture of me moving away from home" (Aliyah, interview).

Here, the notion of maintaining something we have (i.e., our homes) was evident.

Figure 30

Sophia's (left) and Isabelle's (right) Depictions of "Before and After" Climate Change Scenes



Rules and regulations: "This is what you have to do. It's the law". Finally, participants' ideas related to what should be done to mitigate climate change suggested that they valued rules and regulations for maintaining order and for preventing wrong behavior. This was especially evident during the interviews when I asked participants about what governments or communities might do to deal with climate change. Participants often suggested imposing restrictions or limits on what people or businesses were allowed to do, and enforcing these restrictions with consequences. For example, James suggested: "I think [government] could limit people to the amount of energy they can use. A household… not like time-based, but… lock them off when they reach too much energy" (James, interview). Isabelle also spoke about government-regulated energy consumption as an effective means of getting people to actually reduce their energy use. Like James, she suggested:

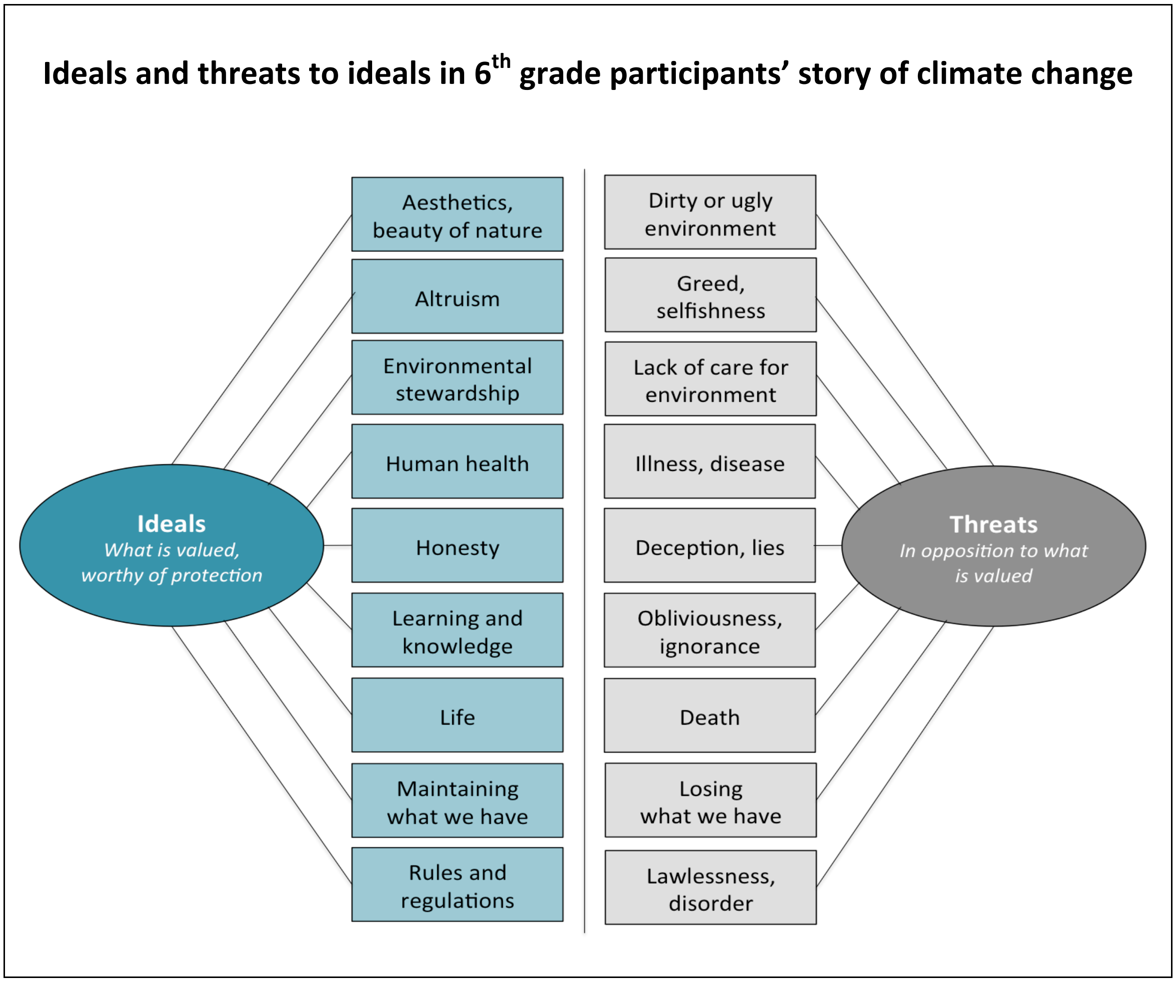
> [Government] could be like, "You are legally allowed to use this much energy in this area. This 100 miles is only allowed to use this much energy". It's not gonna be an itsy bitsy amount, but at the same time, they're gonna be given a regulation. Because when you patrol people, and you're able to say like, "This is what you have to do, it's the law", they'll most likely listen more than when you're just like "Hey, could you use a little less energy?" (Isabelle, interview).

Isabelle and others appeared to view government as playing an important role in getting people to act in ways they saw as responsible, creating rules that everyone would follow in order to protect what they saw as valuable.

Moral argument summary. As participants expressed their ideas about climate change, they described actions they saw as good or bad, or right or wrong. They framed right action as action that upheld a certain set of ideals they saw as valuable and worthy of protection. They framed wrong action as actions the threatened these ideals. The ideals that emerged in the data, and the threats to the ideals, are listed in Figure 31. Returning to Truby's (2007) view of moral argument as expressed through characters' actions in the plot, moral argument can provide another layer for understanding the character roles (identities) in which participants cast themselves and others. It can also provide another layer for understanding how story world (context) may be relate to what participants come to see as valuable, or worthy of protection. Finally, it provides a lens for interpreting the plot, or participants' knowledge about the sequence of events – good or bad – that play out within participants' stories of climate change.

Figure 31

Emergent Ideals and Threats in the Story of Climate Change from the Application of the "Values" Analytic Lens



Critical Responses: Sense of Agency within Figured Worlds of Climate Change

The final analytic lens that I applied to the data examined participants' responses to the story of climate change as they conveyed it. I consider participants' responses to climate change as providing evidence of their senses of *agency* – or, their views of their own capacities to act (Holland et al., 1998) - in relation to climate change. In figured worlds terms, these responses represent participants' *spaces of authoring* (Holland et al.), or the ways in which participants' enactment of their figured worlds may serve to reinforce or change their conditions.

Truby's (2007) storytelling framework does not provide an analogue for the notion of response. Therefore, I added my own notion of *critical response* to the storytelling framework. I conceptualized participants' critical response to their climate change stories as similar to the work of a book or movie critic. In stepping back from the story and reflecting upon it, I considered how participants themselves were changed by the climate change story they synthesized through their varied learning experiences. Table 15 shows how I aligned my analytic lens of "agency" with the notion of participants' "critical response" to the story of climate change. I also represent how these were connected with my data collection questions and structural coding questions, and the data sources that I analyzed.

I acknowledged that participants' *responses* could be: 1) outward responses manifested in observable behaviors, or 2) inward responses - not necessarily manifested in behaviors, but expressed through what participants communicated about their emotional reactions to climate change. Within the former category of *outward responses*, the participants' behaviors could be *actual* (i.e., participants were already engaged in certain actions), or *imagined* (i.e., participants saw themselves as having the capacity to engage in certain actions). I regarded data related to participants' *critical responses* to the story of climate change as providing potential insight into how climate change had *come to matter* (Callison, 2014) to participants.

Table 15

Alignment of the Critical Response Framework Element with the "Agency" Analytic Lens

Storytelling framework element	Analytic lens and related data collection question(s)	Structural coding questions	Data sources coded
Critical response (my framework addition)	f) Climate change agency, or responses [Relevant data collection questions: *What is the nature of learners' ideas (i.e., their… **responses**) in relation to climate change?* *To what extent, if any, might learners' ideas about climate change shape (reinforce or change) the conditions in which they are embedded?*]	*How do participants respond to climate change?* Parent codes: ▪ *Emotional responses* ▪ *Behavioral responses (imagined)* ▪ *Behavioral responses (enacted)*	• Individual interviews • Participant-generated drawings • Focus group interviews

Inward responses to climate change. Learners' emotional responses to climate change were generally rooted in the perceived loss or violation of valued ideals (see *Moral argument*, e.g., life, aesthetics, maintaining what we have). Learners very often depicted their emotional responses when they responded to the prompt*: Draw what comes to your mind when you think about climate change*, suggesting that drawing was a potentially useful means of students' emotional expression. The emotions that participants explicitly expressed through the data included sadness, frustration, and fear.

Sadness – "Why wouldn't you take care of your home?". Participants' emotional responses to climate change were predominantly feelings of sadness. For example, several participants expressed sadness over the possible death of living things as a result of climate change. Here, participants connected to their views of themselves and others as climate change *Victims* in the story of climate change. For example, when I asked Sophia how she felt about climate change, she responded, “It’s sad for the animals” (Sophia, interview) – a view reflected in her drawing of animals dying. Similarly, James depicted death in his drawing (Figure 32) and explained, “It’s sad. Because if we keep like we’re behaving with this stuff, we’re all gonna die.” (James, interview). In both of these examples, the participants appeared to be responding emotionally to the loss of life, which they saw as valuable (see Moral argument, above).

Figure 32

Participant Drawings Depicting Sadness Related to Loss of Life

Sophia’s drawing depicting animal death	*James’s drawing depicting animal death*

Others, such as Autumn, expressed sadness at the loss of Earth’s beauty, particularly when related to greed (violating the ideals of *beauty of the natural world* and *altruism*). She explained:

I feel kind of sad because we're just hurting this beautiful Earth. Like, if you go out into the scenery. I went to North Carolina and the scenery was so beautiful there… People should take care of the Earth, because that's where we're born. Why wouldn't you take care of your home? It's just like it's your own house. So you would clean it and make sure it's beautiful and sparkling. So I think [people] should do the same for the Earth and stop being greedy, for businesses to get more money." (Autumn, interview)

Finally, participants expressed sadness at the potential of losing what they have (*Moral argument: Maintaining what we have*). For example, Aliyah, in drawing herself being displaced from home by sea level rise (Figure 33), explained: "I think it's sad, because soon you won't be able to live here anymore. But the Earth's been here a long time. Soon, if it's not, if people aren't able to live here then it's just sad" (Aliyah, interview).

Figure 33

Aliyah's Depiction of Sadness Related to the Loss of Home

Frustration: "People know they're doing really bad things, but they keep on doing it". Where participants expressed feelings of frustration, it was related to their self-understandings as *Powerless* characters in the story of climate change. Participants expressed frustration in particular when powerful people (those who they cast as *Villain* characters) knowingly engaged in actions that were exacerbating climate change, but did not care and did not change their actions. Here, participants had an emotional response when they understood the ideals of *environmental stewardship* and *altruism* as being violated. For example, Isabelle stated, "It irritates me that people, like, don't really like seem to care about it. Like people just think 'Oh, the younger generation should take care of it'. So I think that irritates me." (Isabelle, interview). Similarly, Bobby explained, "I feel like it's really bad for the world because people know that they're doing really bad things but they keep on doing it, so… I really don't like it" (Bobby, interview). These statements exemplify the view that participants sometimes saw others as engaged in destructive behaviors, and themselves as lacking the power to intervene, which cultivated a sense of frustration for participants.

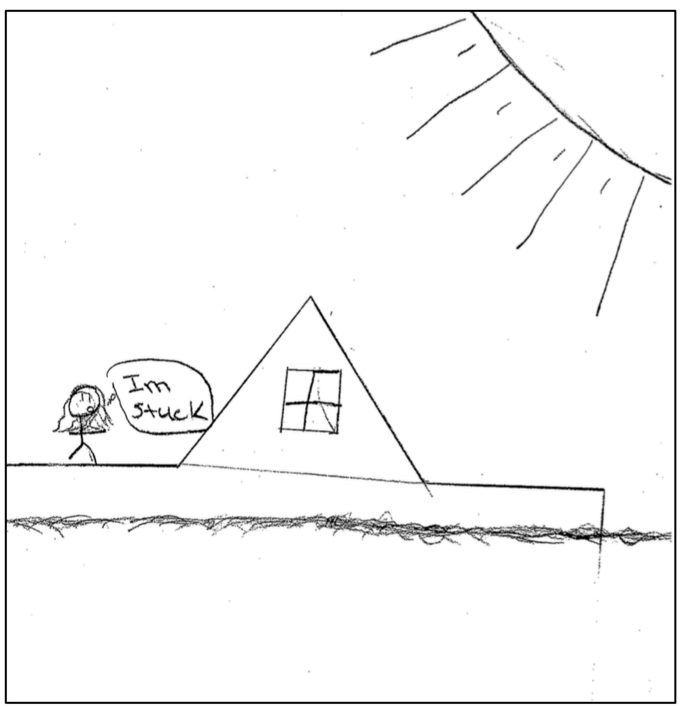
Fear: "I'm left there alone as the water rises". A final emotional response that emerged among the participants was fear or anxiety. Like the emotions of sadness and frustration, participants expressed fear when they interpreted threats to what they valued. For example, participants expressed fear over loss of life and lose of home (Moral argument, values: *Life*, *Maintaining what we have*). The most explicit example of fear that I interpreted came in the form of Isabelle's description of her fear of being caught in a flood, which she depicted in her drawing (Figure 34). Isabelle explained:

> I have family down by the beach and stuff. And one of the scariest things, like this is a silly fear, but I'm down there and it starts to pour, and there's a horrible flash flood, and things get ripped away and I'm left there alone sitting on a roof, scared in the freezing cold rain, with water slowly rising closer and closer… Like, it's silly, but I'm like really scared that'll happen. Like my parents aren't anywhere to be found, my sister, nothing. And I'm left there alone as the water rises (Isabelle, interview).

As this example suggests, fearful responses to the story of climate change were connected with participants' self-understandings as characters who were *Victims* or *Powerless* in the story of climate change.

Figure 34

Isabelle's Depiction of Fear of Flooding



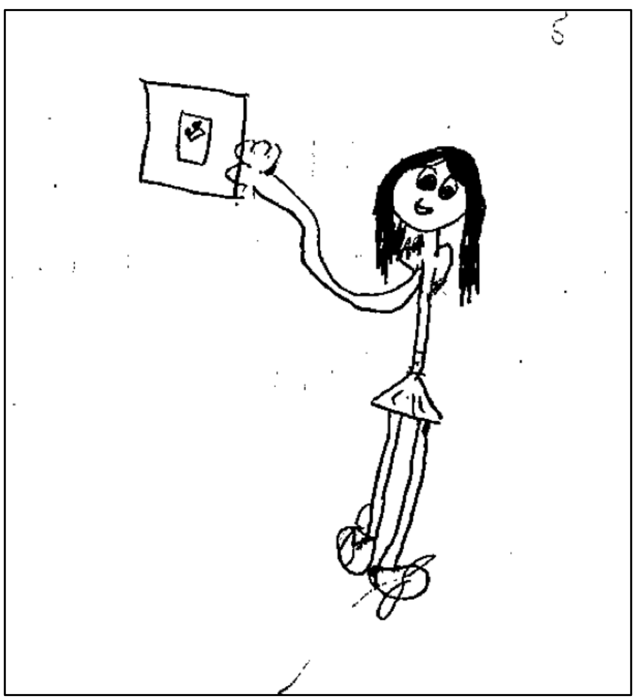
Outward responses to climate change. Although participants' emotional responses of sadness, frustration, and fear often suggested that they saw themselves as *Powerless* characters and as *Victims* in the story of climate change, they simultaneously expressed what I interpreted as some sense of empowerment in relation to climate change. This is consistent with Truby's (2007) notion of characters as expressions of selves, which may have conflicting needs or desires, and may play a variety of roles. Despite feeling disempowered at times, I interpreted participants as expressing a sense of empowerment as they made statements about what they were already doing (actual behaviors), or what they could do (imagined behaviors), in response to climate change.

Enacting stewardship behaviors: "I'm turning off the lights to save energy." Participants described their own engagement in behaviors they believed would help address climate change, such as conserving resources (water, energy) and recycling. With these statements, participants cast themselves in roles of *Everyday Hero* characters (engaged in positive personal actions to address climate change). For example, Sophia explained, "When I get home, I come and go around the whole house turning off lights and stuff" (Sophia, interview). She drew herself enacting this role (Figure 35), and explained her drawing by stating, "I'm turning off the lights to save energy because I'm scared that there might not be any energy when I grow up if I don't save energy" (Sophia, drawing).

Much more frequently than discussing what they were *already* doing to address climate change, participants described what they *could* do in response to climate change (imagined behaviors). Participants suggested, for example, that they could engage in behaviors such as conserving resources, describing their capacity to monitor their own consumption, and to change their consumptive activities. For example, Aliyah suggested that she and her peers could play outside more, instead of staying inside to watch TV and play video games[4]. Participants also stated that they could change their modes of transportation. However, they often cited reasons why this would be challenging (e.g., living too far away to walk or bike to school; not being allowed to walk or bike for safety reasons). Finally, participants sometimes suggested that they could pick up litter, though they rarely connected this specifically with climate change. In these instances, I interpreted participants as adopting the view that any action that helps the environment is helpful for addressing climate change.

Figure 35

Sophia's Depiction of Herself Conserving Energy



[4] In addition to upholding the value of environmental stewardship, I also interpreted this particular example as possibly reflecting the modern cultural narrative in America that adolescents should limit their screen time

Communicating and modeling responsible behavior: "If you don't do anything, somebody else who might think you're cool and fun to hang out with won't do anything either". As with changing their own personal behaviors, participants described their potential to change the personal behaviors of others, casting themselves in the role of *Social Influencers*. For example, James explained, "I told [my brother] we should conserve electricity, like turn off the lights after yourself when you leave the room… because that's what he does, he leaves the lights on. And I told him if we don't stand up and make a change, we're gonna die soon" (James, interview). This example also illustrates how participants' emotional responses to climate change (in this case, fear) may have motivated the behavioral responses in which they chose to engage.

Participants said they could do more to *spread the word* to others about climate change, taking the role of *Communicators* in the story of climate change. They were more oriented toward individuals influencing individuals, than toward individuals (or groups) influencing groups. As Sophia explained, "It doesn't matter if it's one person… [My mom] encourages me to do it, to maybe think I'll encourage my kids to do it, and it will go on and on. So it'll be like thousands of people" (Sophia, interview). Similarly, Isabelle explained:

> People will think "Oh, I'm just one person, what can I do?" But if you change and you have friends, you'll influence your friends, who will influence their friends. And it's like a domino effect. So by you doing one thing, you're going to affect multiple other people. But if you don't do anything, somebody else who might think you're cool and fun to hang out with, won't do anything either. (Isabelle, Focus group)

As these examples suggest, participants generally imagined themselves as able to communicate with, and possibly influence, those around them through one-to-one interactions. Participants described spreading the word to people in their immediate circles, but not typically though outreach to larger circles, such as through social media. They generally perceived their sphere of influence as limited, as evidenced by statements in which participants cast themselves as *Powerless*. As Bobby explained in describing his limited influence among those beyond his immediate circle, "Basically nobody would listen to a kid and be like, 'Oh, let's learn from this kid'" (Bobby, interview).

Learning: "When we're educated on it, we can make a difference". Participants also described themselves as engaged in ongoing learning about climate change, placing themselves in the role of *Learner* characters, and taking the view that climate change knowledge would enable them to make a difference. Taken this way, learning (or seeking knowledge) might be construed as a behavior that participants saw as something positive they could do in response to climate change. For example, when I asked Isabelle what, if anything, she thought people could do about climate change, she replied,

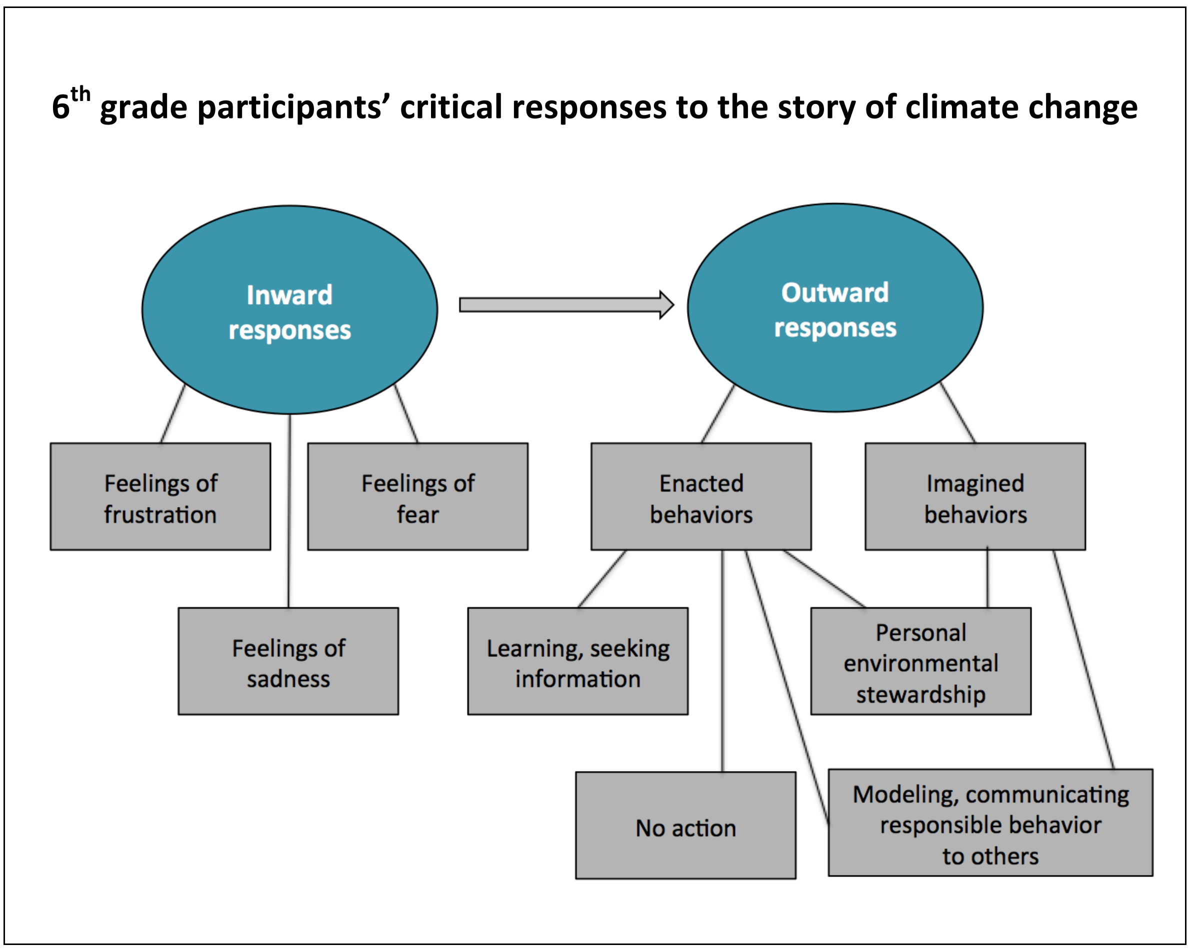
> If you educate yourself on it, or somebody comes and talks to you and talks about it like you guys are for us. Like I feel like what you're doing is really gonna help us because we're the younger generation… So I feel like when we're educated on it, we can make a difference. (Isabelle, interview)

By being actively engaged in climate change learning, then, participants saw themselves as having the potential to become more aware about what they could do to make a difference, and possibly less likely to commit the infractions of the *Oblivious*, or those who unknowingly exacerbate climate change. By engaging in climate change learning, participants appeared to see themselves as upholding the ideals of learning and knowledge.

In Figure 36, I represent the internal and external responses that participants described through the data. I also represent how I saw them as possibly connected, with participants' emotions having potential to motivate their action or inaction (e.g., feelings of fear may motivate energy conservation behaviors; feelings of frustration around a personal lack of power may motivate inaction).

Figure 36

Participants' Emergent Critical Responses to the Story of Climate Change



Data Analysis Summary

I now summarize the insights provided by each analytic lens described thus far, representing the disparate elements of the 6th grade participants' climate change story. Then, I will weave together the elements of the story into a more "integrated whole" (Truby, 2007, p. 109). Thus far, I have presented - with supporting evidence - the themes that emerged from my application of six varied analytic lenses to my collected data. I used a storytelling framework (Truby, 2007) to guide my data analysis and reporting. I presented how I aligned the storytelling framework elements with my analytic lenses and their related data collection questions, structural coding questions, and relevant case study data sources (see Table 8, above).

"Sources of Information" analytic lens. In applying the *Sources of Information* analytic lens, my coding was guided by the question: "*What were the apparent sources of learners' climate change information?"* The application of this lens provided potential insight into the forces shaping participants' views of the world in which climate change was (and is) occurring. I framed this as the *story world* (Truby, 2007) in which participants' climate change stories were set. Through my data analysis, I noted three modes by which participants gleaned new information about climate change: 1) attending to information communicated by others (e.g., teachers, parents, media); 2) observing human behavior (perceived as) contributing to climate change; and 3) observing changes in the natural world (perceived as) related to climate change.

In their school contexts, participants described interactions with educators, educational media, and peers that contributed to their ideas about climate change. They also described behaviors they observed in school, such as personal electronics use and commuting to school by car, which had informed their ideas about climate change. Outside of school, participants described ways in which their interactions parents and other family members, their television and movie viewing, and their Internet use had contributed to their ideas about climate change. They also described their observations of home and community energy use, environmental stewardship behaviors, and changes in the natural environment that had informed their climate change ideas.

"Perceptions" analytic lens. Using the analytic lens of *Perceptions*, my coding was guided by the question: *"How did participants show evidence of their perceptions of the world in relation to climate change?"* Here, I organized evidence using Truby's (2007) *story world* elements of 1) natural setting, 2) human-made (social) setting, 3) technology, and 4) time.

I interpreted participants' collective stories of climate change as taking place in a warming world in which weather was becoming extreme and unpredictable; polar ice was melting; Arctic animals were losing their habitats; coastal areas were experiencing floods and rising seas; and air, land, and water were becoming polluted. Within this world, people were conveying messages about climate change (e.g., through curriculum materials, Internet images, television, websites, social media), talking about changes they were noticing in the natural world, and being impacted by climate change consequences. People were engaged in behaviors that both served to exacerbate (e.g., using personal electronics, cars, home appliances) and mitigate (e.g., using renewable energy) climate change. In this world, environmental conditions had declined over time, and participants viewed human behaviors of the past and present as having ramifications for the future.

That is, without a change in human behavior, future conditions on Earth would be undesirable and possibly inhospitable for living things.

"Knowledge" analytic lens. In applying the *"Knowledge"* analytic lens to my data, my coding was guided by the question: *How did participants provide evidence of their sense-making of information about climate change (i.e., communicate knowledge about climate change as a sequence of causally-connected events)?* Here, I connected with Truby's (2007) notion of "plot" as a series of causally-connected events unfolding within the story world,

I interpreted four key causally-connected events within the plot of participants' climate change stories. The plot began with human activities already disrupting the normal functioning of Earth's systems, resulting in warmer temperatures on Earth (first causal event, representing the past and present). These warmer temperatures were beginning to have consequences for life on Earth (second causal event, representing the present and near future). Ultimately, the future would hinge on how or whether humans changed their activities. If they changed their behaviors in ways that reduced the disruption of the normal functioning of Earth's systems, then life on Earth might improve – or at least continue (third causal event, representing one possibility for Earth's eventual future). Conversely, if humans failed to change their behaviors, or failed to change them sufficiently, observed negative consequences would be exacerbated, resulting in declining conditions and the suffering or death of living things (fourth causal event, representing another possibility for Earth's eventual future). Participants variably described these causal events in ways that aligned with scientific explanations, and in ways that, at times, did not.

"Identity" analytic lens. I used *"Identity"* as an analytic lens to examine the data, guided by the structural coding question: *What characters emerged in participants' stories of climate change, and in what roles did participants cast themselves and others?* Here, I connected the notion of *"Identity"* with Truby's (2007) notion of story characters who enact the plot of a story – in this case, the 6th grade participants' story of climate change.

The causal events comprising the plot were carried out by five types of characters: *Those Who Harm*, *Those Who Suffer*, *Those Who Help*, *Those Who Cannot Help*, and *Those Who Interpret*. Participants saw themselves as variably enacting the roles of all of these types of characters. Within the group, *Those Who Harm*, participants generally cast others. However, to a lesser degree, they sometimes cast themselves. They saw others – and sometimes themselves as individuals and members of groups – as *The Guilty.* These were characters who knowingly engaged in some actions they associated with climate change exacerbation, such as technology use or car use, but could not easily change their behaviors. Participants did not often cast themselves as *The Oblivious*, since they saw themselves as having climate change awareness. They cast others, but not themselves, as *Villains*, or those who make major contributions to climate change, but do not care.

Within the group, *Those Who Suffer*, participants cast themselves (individually and collectively) and others – including animals – as *Victims* of climate change. They saw climate change as *affecting us all*. Participants' own roles as climate change *Victims* appeared particularly salient to them when they were asked to draw how they saw climate change relating to their lives.

Within the group, *Those Who Help*, participants cast both themselves and others. Most prominently, participants cast themselves (individually and collectively) as *Everyday Heroes* who tried to – or had the potential to – limit their contributions to climate change though individual actions such as using less electricity. To a lesser extent, participants sometimes cast others in this role. They sometimes also cast themselves as *Social Influencers*, who encouraged others to take these individual actions, though they saw their potential influence as limited to those in their immediate social sphere. They generally saw others (e.g., older people) as having a greater capacity for influence. Likewise, they saw others as more likely to take the role of *Group Shifters*, who sought to catalyze behavior change at the group level. Only when they considered their identities as members of groups (e.g., the youth generation), rather than as individuals, did participants see themselves as possibly enacting this role.

Participants were also highly aware of the limits to their ability to enact change, often casting themselves as *Those Who Cannot Help*. As individuals and as members of groups (e.g., the youth generation), participants sometimes saw themselves – but not others - as *Powerless* characters, who would like to change their conditions but lack the power to act.

Finally, within the group, *Those Who Interpret*, participants cast both themselves and others. Overwhelmingly, participants saw themselves as *Witnesses* to climate change, who were noticing changes in the world around them. They did not generally place others in this role. They also identified strongly as *Learners*, or characters that were interacting with information about climate change and coming to a greater understanding. They sometimes also placed others (e.g., research scientists) in this role. At times, participants cast themselves as *The Communicators*, who were disseminating information about climate change. However, some believed that they needed to learn more before feeling confident to engage in this role, reserving it primarily for others (e.g., teachers, media).

"Values" analytic lens. In applying the analytic lens of *"Values",* I examined the data using the structural coding question: "*What did participants appear to uphold as the good (or right) and the bad (or wrong) as they communicated about climate change?"*. Using this lens, I made connections with Truby's (2007) notion of a story's moral argument.

As the characters that participants described carried out the plot of their climate change stories, participants described a set of underlying values or ideals being upheld and violated. This set of values represents the moral argument embedded within participants' climate change stories. Participants spoke about climate change in ways that communicated their valuing of the beauty of the natural world, altruism, environmental stewardship, health, life, learning and knowledge, honesty, maintaining what we have, and upholding rules and regulations. They referred positively to character actions in the plot that upheld these ideals. Conversely, participants referred to actions that violated these ideals, such as acting out of greed or selfishness, deception, or environmentally destructive behaviors, as negative – or wrong – actions in the story of climate change. In general, participants cast themselves as characters in the story of climate change that upheld the ideals they valued, to the extent they saw themselves as having power to do so.

"Agency" analytic lens. With my final analytic lens of "agency", I approached the data using the structural coding question: "*How do participants respond to climate* *change?"*. Here, I added an element to Truby's storytelling framework, which I termed *critical response*. I conceptualized participants' *critical responses* to encompass the ways in which participants – in reflecting on the story of climate change – were changed by what they had come to understand. I considered these changes, or responses, to take inward (emotional) and outward (behavioral – either enacted or imagined) forms.

When participants described their emotional responses to climate change, they described feeling sadness, frustration, and fear. When participants described their behavioral responses to climate change, they spoke about what they were already doing or what they *could* do in response to climate change. These included behaviors such as personally conserving resources, encouraging others to change their personal behaviors, and learning about climate change. At times, participants expressed the view that there was little or nothing they could do in response to climate change. I interpreted participants' inward responses as sometimes motivating their external responses. For example, sometimes participants described environmental stewardship behaviors in which they were engaged (e.g., energy conservation) as being motivated by a fear of what could happen if they failed to enact these behaviors. In other cases, they described emotions of frustration in witnessing other people exacerbating climate change in ways they could not prevent or stop.

Synthesis of Insights

With the aim of addressing my overarching research question – "*How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded?"* - I have framed the 6th grade participants' climate change stories as "entrances" (Kitchell et al., 2000) into their figured worlds of climate change. I described how participants' interactions with varied dimensions of their conditions (i.e., their sources of information) appeared to inform their climate change stories. I then described how participants communicated their sense-making of climate change by rendering a climate change *story world*, *plot*, a cast of *characters*, and a *moral argument*. Finally, I described how participants' responses to their story of climate change could have potential implications for reshaping or reinforcing the conditions in which they are embedded. As a next step to my data analysis, I now synthesize these disparate elements to create a more "integrated whole" (Truby, 2007, p. 109) from the insights the data have provided.

First, I focus on the *figured worlds* aspect of my research question, synthesizing my interpretation of the nature of participants' figured worlds of climate change through a process of "restorying" (Leavy, 2009, p. 7). To do so, I revisit and unpack the climate change *plot* that emerged from my analysis of the data. I weave each causal event in the plot into the climate change *story world* that participants described. I then describe the *characters* – enacted by the 6th grade participants and others – that participants described as carrying out the causal events through their actions, and the *moral arguments* participants made about these actions.

Second, I focus on the *conditions* aspect of my research question. I identify the potential connections between participants' conditions and their figured worlds of climate change. To do so, I examine each causal event in participants' climate change story. I describe the ways in which participants' conditions appeared to shape their ideas about how these causal events play out. And conversely, I describe the ways in which participants' own engagement in these causal events (i.e., their actions within figured worlds of climate change) had the potential to reshape or reinforce their conditions.

Describing 6th grade participants' *figured world of climate change.* In participants' figured world of climate change, I interpreted climate change as beginning with human activities disrupting the normal functioning of Earth's systems, causing Earth to become warmer. This action is set on a planet where temperatures are increasing and where people, including the 6th grade participants themselves, are noticing and beginning to suffer from hotter temperatures. People, including the 6th grade participants and their families, are discussing their observations of change. People, including teachers, scientists, and those in the media, are disseminating information about the causes of warming temperatures. As a result of hotter temperatures, people's physical health and wellbeing and their formerly comfortable surroundings are at risk.

- *Causal event* (Plot)
- *Natural setting* (Story World)
- *Witnesses* (Characters)
- *Victims* (Characters)
- *Human-made (social) setting* (Story World)
- *Communicators* (Characters)
- *Violated value: Health* (Moral Argument)
- *Violated value: Maintaining what we have* (Moral Argument)

Human activities that produce carbon dioxide and other forms of pollution are causing the increase in temperature. There is more carbon dioxide than trees are able to remove from the air through photosynthesis. Some people unknowingly engage in actions that contribute to climate change, such as using personal technologies powered by fossil fuels. Since they do not know they are causing harm, they do not change their behavior. This group may have included the 6th grade participants themselves in the past, before they had been taught

- *Violated value: Environmental stewardship* (Moral Argument)
- *Natural setting* (Story World)
- *Oblivious* (Characters)
- *Technology* (Story World)
- *Violated value: Learning and knowledge* (Moral Argument)
- *Learners* (Characters)

about climate change. Some people, including the 6th grade participants and their families, know and are concerned that their actions are contributing to climate change (e.g., driving, using electricity at home and school). However, changing these actions is inconvenient or infeasible. Finally, some people, such as those who operate factories powered by fossil fuels, knowingly contribute to climate change, but do not care about their impact. This is often the case for those who stand to suffer economically by changing their actions. At times, they may lie about their environmental impact. Together, these environmentally disruptive actions are making temperatures on Earth warmer than in the past. They also create pollution, harming the beauty of the natural world.

Warmer temperatures and pollution are causing physical changes on Earth including extreme and unpredictable weather (e.g., storms, hurricanes, droughts, earlier spring), melting polar ice, and flooding and rising seas in coastal areas. As a result, Earth is becoming less hospitable for living things, threatening their physical wellbeing and possibly their survival. Living conditions on Earth have declined in recent times, and may continue to decline in the future without a change in human behavior. Arctic animals are at risk of habitat loss. Coastal residents, possibly including the 6th grade participants themselves, face potential safety hazards from natural disasters and displacement from their homes.

Guilty (Characters)

Violated value: Maintaining what we have (Moral Argument)

Villains (Characters)

Violated value: Altruism (greed) (Moral Argument)

Violated value: Honesty (Moral Argument)

Time (Story World)

Violated value: Aesthetics (Moral Argument)

Natural setting (Story World)

Causal event (Plot)

Violated value: Health (Moral Argument)

Violated value: Life (Moral Argument)

Time (Story World)

Victims (Characters)

Victims (Characters)

Violated value: Maintaining what we have (Moral Argument)

Witnesses (Characters)

Communicators (Characters)

Learners (Characters)

Value: Learning (Moral Argument)

Technology (Story World)

People are noticing changes on Earth locally and globally, including the 6th grade participants themselves, who are noticing altered timing of the seasons and more frequent heavy storms. People, including teachers, scientists, those in the media, and sometimes the 6th grade participants and their families, are communicating about environmental changes being observed. Some are seeking to learn more about how and why these changes are occurring. This learning and communication is often made possible through the use of technology for conducting research and disseminating information.

Causal Event (Plot)

Time (Story World)

Value: Life (Moral Argument)

Value: Environmental Stewardship (Moral Argument)

Natural setting (Story World)

The 6th grade participants' figured world of climate change included two alternate visions of the future, depending on the actions people take. In the first vision, people change their actions in ways that reduce disruption to the normal functioning of Earth's systems, leading to improved conditions for life on Earth. In this future, Earth is equally or more habitable for living things than it is today. Damage to the environment (e.g., air pollution, negative impacts of warming temperatures) would be remediated, and human and animal habitats would be conserved.

Human-made (social) setting (Moral Argument)

Everyday Heroes (Characters)

Value: Environmental Stewardship (Moral Argument)

Social Influencers (Characters)

Humans can make this world possible through their actions. People, including the 6th grade participants and their families, reduce their personal fossil fuel use. They may use renewable energy sources, reduce their use of energy-consuming technologies, use energy-efficient products, and reduce their car use. They encourage others to do the

Group Shifters (Characters)

Value: Rules and Regulations (Moral Argument)

Communicators (Characters)

Value: Learning (Moral Argument)

same. Others, though not typically the 6th grade participants themselves, catalyze larger-scale action, such as stopping deforestation. Government imposes limits on energy use for companies, and possibly individual families, fining those who exceed limits. People, primarily others, are expanding human understanding of climate change through education. As a result, people are able to make more informed choices about their actions in relation to climate change.

Causal event (Plot)

Time (Story World)

Violated value: Life (Moral Argument)

Natural setting (Story World)

Human-made setting (Story World)

Violated value: Altruism (Moral Argument)

Violated value: Environmental stewardship (Moral Argument)

Violated value: Learning (Moral Argument)

Victims (Characters)

Violated value: Aesthetics (Moral Argument)

Violated value: Health (Moral Argument)

In the 6th grade participants' alternate vision of the future, people fail to change the actions that are causing climate change, leading to greater suffering and death for life on Earth. In this future, destruction of the environment has led to a planet that is dramatically less hospitable or completely inhospitable for life In this imagined future, the planet is plagued by droughts, extreme weather, extreme heat, melted Arctic regions, sea level rise, and polluted air. People continue actions that pollute the air and exacerbate negative impacts of climate change because of their greed, lack of care, and obliviousness. Living things, including the 6th grade participants and others, suffer as a result of the negative consequences of climate change. Damage to the planet has negatively impacted the Earth's beauty. The inhospitable living conditions on Earth are causing people physical health problems (e.g., lack of food, lack of clean air to breathe).

Violated value: Life
(Moral Argument)

Violated value: Maintaining what we have
(Moral Argument)

Powerless
(Characters)

Possibly these conditions are causing people, animals, and plants to die. Life on Earth is altered, and human populations – particularly those living on coasts - may be displaced, including the 6th grade participants and their families. Though some people, including the 6th grade participants themselves, would have hoped to change their conditions, they lacked sufficient power to enact the necessary changes.

Interpreting the Relationship Between Conditions and Figured Worlds

Having just synthesized and described my interpretations of the actions unfolding within the 6th grade participants' figured world of climate change, I turn now to an examination of the connections between participants' conditions and their figured worlds of climate change. This includes consideration of both the ways in which participants' conditions appeared to shape their figured world of climate change (the *conditions-to-figured-world* connection), as well as consideration of the ways in which participants' figured world of climate change – when enacted – has the potential to reshape or reinforce their conditions (the *figured-world-to-conditions* connection).

Interpretations of the conditions-to-figured-world connection. Through my analysis of the data, I interpreted three means by which the 6th grade participants' interactions with/(in) their conditions appeared to inform their figured world of climate change. These included attending to information communicated by others, observing human behavior (perceived as) relevant to climate change, and observing changes in the natural world (perceived as) evidence of climate change. Although many aspects of participants' conditions were shared – that is, participants received many of the same messages about climate change at school, and observed many of the same human activities and environmental shifts in their local surroundings – their lives outside of school were unique. Participants cited their recreational media use, family practices and traditions, and interests when they communicated about their climate change ideas. I noted that participants' unique experiences played a role in what they highlighted in communicating about climate change (e.g., information shared by family members, scenes from television programs, concerns shared by their parents). While acknowledging these differences, I focused my synthesis on the views that were shared amongst participants, and patterns I interpreted across the group regarding conditional influences.

Story world. Through everyday experiences within their particular set of multifaceted and multilayered conditions, participants developed a view of the world they inhabited as a world in which climate change was occurring (their climate change *story world* described above). In relating their understanding of climate change, the 6th grade participants portrayed a world in which: the world was getting warmer causing physical changes on Earth with repercussions for living things (natural setting); climate change was gaining attention and becoming a topic of conversation among people around them (social setting); people's use of modern technologies was exacerbating climate change (technology setting); and conditions on Earth were declining – and would continue to decline into the future – without a change in human behavior (time setting).

I interpreted participants' views of the natural setting in which climate change was occurring as potentially informed by a combination of: information communicated at school (e.g., graphs of temperature increase), information communicated to through media (e.g., Internet images of dying Arctic animals), and participants' interpretations[5] of

[5] These interpretations may have been reinforced by participants' conversations with parents and other family members about "strange weather" they were experiencing.

personal experiences in the natural world (e.g., felt experiences of hot temperatures) as evidence of climate change. I interpreted their views of climate change as a socially salient topic (social setting) as potentially related to its inclusion in their 6th grade science curriculum (e.g., Ms. Kane and online curriculum addressing the topic); their engagement in a school-wide sustainability initiative that emphasized climate change; and the presence of climate change education research ongoing in their classroom. Additionally, participants may have viewed climate change as socially salient as a result of hearing about it in the media. I interpreted participants' views of the technological setting in which climate change was occurring as primarily related to their observations of everyday technology use in the world around them (e.g., cars in their suburban community, laptops and personal electronics use in their blended learning school) and media images of pollution (e.g., factory smokestacks emitting clouds of pollutants, as sometimes appeared in their drawings). Finally, I interpreted the their visions of the past and future in relation to climate change as a product of idealized visions of the past (i.e., nature untouched by humans) and their worst-case scenario imaginings of the future based upon their understandings of current environmental problems.

Plot. Through everyday experiences within their particular set of multifaceted and multilayered conditions, 6th grade participants also developed a generally shared climate change *plot* – or ideas about the causal events that were playing out as climate change occurred. Although individual learners varied in their explanations of the details – and the extent to which their explanations were scientifically supported – the main events in the story were held in common. I considered participants' explanations of these causal events as evidence of their sense-making of information from varied sources, or otherwise stated, their climate change knowledge. The causal events included: 1) (past and present) Human activities disrupting the normal functioning of Earth's systems, causing Earth to become warmer; 2) (present and near future) Warmer temperatures cause physical changes on Earth, making Earth less hospitable for living things; 3) (possible future scenario) People change their actions in ways that reduce the disruption to the normal functioning of Earth's systems, improving (or maintaining current) conditions for life on Earth; 4) (alternate possible future scenario) People fail to change their actions, leading to greater suffering or death for life on Earth. Overall, I noted that school and media appeared to be the most important informants of participants' climate change knowledge.

I interpreted this storyline – or, participants' climate change knowledge – as shaped primarily by their sense-making of information communicated at school regarding the causes and effects of climate change. For the first causal event – *human activities cause disruptions that warm the Earth* – information at school (e.g., regarding fossil fuels and carbon dioxide) appeared to help participants make the connection between human activities and climate change. However, some considered climate change-related disruptions to encompass any kind of pollution, possibly a result of broader cultural messages about *going green* or *saving the Earth*. Once aware of climate change, participants' experiences in the natural world let them to interpret experiences of warm temperatures as evidence of climate change.

For the second causal event – *warmer temperatures make Earth less hospitable* – participants cited information from school (e.g., images of polar ice melt) and the media (e.g., news stories about displacement of coastal residents) as informing their understanding of observed climate change consequences. For the third causal event –

people change their actions and improve life on Earth – participants cited information from school (e.g., reducing fossil fuel use) and their lives at home (e.g., recycling) as examples of mitigation actions. Their ideas were generally focused on individual, not collective, actions. They did not generally associate climate change mitigation with the realm of politics, other than responding to my question about what governments could do - agreeing that government should impose limits and regulations on energy use. Here, I interpreted the political salience of climate change in the U.S. as *not* particularly informative for participants' ideas. However, I posit that their focus on individual action, their ideas about authority, and their acceptance of rules and regulations may have been culturally-mediated.

Finally, I interpreted the fourth causal event – *people failing to change their actions, leading to suffering and death* – as related to participants' imaginings of the future based upon their current understandings of climate change consequences (i.e., from information sources at school, in the media). The apocalyptic scenarios depicted by some may have related to media images they have seen (e.g., associating extreme flooding or dying animals with climate change), or possibly images presented in their online curriculum (e.g., image of a polar bear alone on an iceberg). They may also have been rooted in participants' emotional reactions to climate change – particularly sadness and fear.

Moral argument. In communicating about climate change, participants stated or implied that certain human behaviors were right (or good) and wrong (or bad). I considered such statements to provide insight into participants' moral argument, or values, in relation to climate change. Right actions were those that upheld a certain set of ideals, namely: aesthetics, altruism, environmental stewardship, human health, honesty, learning, life, maintaining what we have, and rules and regulations. Participants conveyed wrong actions as actions that violated these ideals.

Unlike their discussions of their climate change knowledge, participants did not explicitly cite the sources of their values. However, I noted that the set of values they conveyed in speaking about climate change generally reflected dominant values in the world(s) around them. For example, participants' engagement in school-wide sustainability projects, as well as their families' sustainability practices at home (e.g., recycling) promoted the value of *environmental stewardship*. Media presented in the classroom – encouraging students that there were actions they could personally take to address climate change – also conveyed this message. In their daily lives as young people (11 and 12 years old), participants were accustomed to following rules (e.g., parents' rules at home; classroom rules), and saw *rules and regulations* as an effective means of ensuring right action. In addition, they lived in a state that generally favored stricter environmental laws and regulations (Pew Research Center, 2014).

When speaking about right and wrong in relation to the environment, they sometimes cited examples from media. For example, they saw impending animal extinction (e.g., suggested by images on the Internet) and air pollution as *wrong* (i.e., threats to life, health, aesthetics). At times, messages from children's media – such as *The Lorax* movie – appeared to inform participants' environmental values, particularly in relation to *greed* as wrong, and *honesty* and *environmental stewardship* as right. They sometimes extrapolated these messages to new situations in the world around them –

such as observing deforestation and development in their suburban community, and considering it to be problematic.

More broadly, I interpreted participants' values as potentially reflective of some broader cultural messages that emphasize ideas such as: *going green* through personal action (individual *environmental stewardship* as good); *knowledge is power* (*learning* as a necessary for informed action); and following *The Golden Rule* (*altruism* or concern for others (e.g., animals) as right). In general, I noted that participants' values generally reflected those of their parents – though the 6th graders often expressed greater concern for the environment – as well as the kinds of environmental values conveyed in school and in the media they consumed. Participants supported the values and concerns expressed by one another, suggesting they were in general agreement about what constituted right and wrong action.

Characters. As participants described how climate change was relevant to their own lives, they cast themselves in varied roles. They described varied, and sometimes conflicting, *climate change identities* for themselves, both individually and collectively. I interpreted these climate change identities as most directly related to participants' values (described above). That is, the 6th grade participants generally cast themselves as characters engaged in actions that agreed with their values. These included roles they saw as desirable, most often the roles of climate change *Learners* and *Everyday Heroes* and occasionally the roles of, climate change *Communicators*, *Social Influencers*, and *Group Shifters*. Participants also sometimes described themselves in less desirable roles, or roles in which they could not (or did not) uphold their ideals. These included instances in which participants described themselves as *Guilty,* (formerly) *Oblivious, Powerless,* or

Victims. Participants never cast themselves in the least desirable role of climate change *Villains*.

I interpreted the conditions that shaped participants climate change-related values (e.g., family, messages at school, messages in media, broader cultural messages) as likewise playing a key role in the *climate change identities* they saw for themselves. Secondarily, I saw participants' ideas about the climate change identities as informed by their climate change knowledge – particularly their knowledge of actions that could exacerbate or mitigate climate change. As with values, I interpreted participants' knowledge as informed by their conditions, particularly the messages conveyed to them at school and in the media. Further, I interpreted participants' existing views of themselves as members of groups as playing a role in how they saw themselves in relation to climate change. Participants considered their collective climate change identities (using "we" or "us" language) less frequently than they considered their individual climate change identities (using "I" or "me" language). However, when they did consider themselves as members of families, a student body, a local community, the youth generation, and humankind, they saw their relationship to climate change in new ways.

In general, participants saw their collective climate change identities as having *greater capacity* both to exacerbate and to mitigate climate change. For example, at times, participants considered themselves to be personally *Guilty*, because they engaged in actions such as using electronics and riding in their parents' cars. However, they also identified as *Guilty* when they considered themselves as members of humankind. Here, they viewed the collective actions of humankind as causing greater destruction than their individual actions did. They also saw themselves, at times, as both individually and collectively *Powerless*. However, they were *less likely* to see themselves as *Powerless* when they considered themselves as members of groups (e.g., members of families, members of the student body, or members of humankind). Similarly, when they considered themselves as members of groups, they sometimes saw themselves as having the capacity to change the behaviors of other groups in the role of *Group Shifters*. They did not see this role as possible for them to assume individually. However, I noted that it was rare for participants to see themselves – even collectively – as having the capacity to help incite any kind of large-scale change. This was a role they typically reserved for others. Overall, consideration of participants' views of their collective identities provided evidence that their understanding of their place within their conditions – globally (member of humankind), locally (member of local community), temporally (member of youth generation), at school (member of student body), and at home (member of family) – could matter for their shaping their climate change identities, or views of themselves in relation to climate change.

Interpretations of the *figured-world-to-conditions* connection. In describing participants' *critical responses* to their stories of climate change, that is – how participants reacted inwardly and outwardly to what they had learned about climate change, I provided preliminary information relevant to understanding how participants might *reshape or reinforce* the conditions in which they are embedded. That is, I described how participants' figured worlds of climate change might serve as *spaces of authoring* (Holland et al., 1998) in which participants have agency.

I described participants' *inward responses* as the emotions they communicated about climate change, which included sadness, fear, and frustration. I described participants' *outward responses* as the behaviors they enacted (or imagined) for themselves personally in relation to climate change. These behaviors included personal environmental stewardship, modeling or communicating responsible behavior to others, learning or seeking information, or sometimes, taking no action. I noted that sometimes participants' inward responses appeared to motivate their outward responses (e.g., frustration related to one's sense of powerlessness motivating inaction; fear of future consequences motivating personal energy conservation behaviors).

I interpreted participants' critical responses to climate change as providing evidence of their *climate change agency*. I saw participants' climate change agency as their (actual and imagined) enactment of their figured world of climate change. Thus, I interpreted their climate change agency – or their senses of their capacity to act in relation to climate change – as closely linked with their climate change identities, or the varied roles they saw for themselves within their figured world of climate change.

When casting themselves as *Powerless* characters or *Victims* of climate change, participants described emotions of sadness, frustration, and fear. In describing themselves as *Everyday Heroes*, *Communicators*, and *Social Influencers*, participants suggested actions they were capable of taking to incite positive change in relation to climate change. In all of these roles, participants rationalized their actions as upholding certain ideals (e.g., environmental stewardship; knowledge and learning), or lamented threats to these ideals (e.g., altruism, beauty of the natural world, life). Therefore, I posit that – as with climate change identity – participants' climate change agency was likely informed by conditionally-mediated values and knowledge related to climate change.

How or whether participants ultimately enact these roles in their in-school and out-of-school lives is yet unknown, and – I posit – subject to change as they learn more about climate change and evolve in their self-understandings in relation to it. At this point in their climate change learning, participants saw their *capacity to act* in response to climate change – their *climate change agency* – as having a relatively small sphere of influence and as based upon individual rather than collective action. At times, they also expressed their own *lack of* capacity to act in response to climate change. The ultimate enactment of these roles in the future may hinge on participants' continued learning and self-reflection in relation to climate change. As such, new questions arise regarding fruitful future directions for climate change education.

Chapter Summary

In this chapter, I described insights from the application of six analytic lenses to my case study data in relation to the research question: *How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded?* I considered the data to provide insight into the 6th grade participants' climate change *stories*, and regarded these stories as "entrances" (Kitchell et al., 2000) into participants' figured worlds of climate change. To organize my reporting, I aligned my analytic lenses with elements of Truby's (2007) *Anatomy of a Story*.

After describing my interpretations of the data through each analytic lens, I synthesized my insights by "restorying" (Leavy, 2009, p. 7) the data into a cohesive climate change story that I interpreted as shared amongst the participants. I considered this climate change story to represent the group's figured world of climate change. Key findings related to the 6th grade participants' collective figured world of climate change included:

- Participants shared a common general storyline regarding climate change, with some variation in the extent to which the details were scientifically supported.
- Participants consistently communicated that climate change was already underway and was caused by human activities, particularly technology use.
- Participants cited evidence of physical changes on Earth, and believed that Earth was becoming less hospitable for living things, including themselves.
- Participants saw climate change as relevant to their lives as individuals (primarily) and as members of groups (secondarily).
- When considering their *individual climate change identities*, participants held conflicting views of themselves, primarily foregrounding their simultaneous roles as: *Powerless*, *Victims*, *Witnesses*, *Learners*, and *Everyday Heroes*.
- When considering their *collective climate change identities* (e.g., as members of families, the youth generation, humankind), participants saw themselves as having greater capacity to exacerbate climate change (as collectively *Guilty*), but also to mitigate climate change (sometimes, though rarely, as *Group Shifters*).
- Participants experienced tensions where they saw human activities in relation to climate change—including, at times, their own activities— as threatening or violating their values or ideals.

After describing participants' collective climate change story, I then examined the relationship between participants' figured world of climate change and the multifaceted, multilayered conditions in which they were embedded. In doing so, I described the ways in which I interpreted participants' conditions as potentially informing their figured world of climate change. Key findings included that:

- Participants' climate change ideas appeared to be informed by communicated messages from others, observations of human behavior, and observations of the natural world.
- Participants cited school and media, especially visual information, as important sources of their climate change knowledge.
- Participants' values in relation to climate change consistently aligned with those of their parents, though the 6th grade students generally expressed greater concern.
- Cultural messages such as the importance of "going green" and "saving the Earth" were evident as participants communicated about climate change.

Finally, I described the ways in which I interpreted participants' figured worlds of climate change – particularly their descriptions of their own *climate change identities* and *climate change agency* – as having potential implications for reshaping or reinforcing the conditions in which the 6th grade participants were embedded.

- Like their *climate change identities*, participants' senses of *climate change agency*, or their own capacities to act in relation to climate change, were varied and sometimes conflicting.
- Participants often expressed emotions of sadness, frustration, and fear in responding to climate change.

- Participants reported being already engaged (or believing they could engage) in small-scale personal behaviors to help mitigate climate change (e.g., in line with their *Everyday Hero* identities). These behaviors often appeared to be motivated by their emotional responses to climate change (e.g., fear of consequences of inaction).
- At times, participants expressed that there was nothing they could do to address climate change (in line with their *Powerless* and *Victim* identities). However, they also expressed a view that "knowledge is power", and that they and others could gain power through learning (in line with their *Learner* identities).

I turn now to a discussion of the insights presented in this chapter, revisiting them in light of my theoretical model (articulated in Chapter Three) and prior research relevant to climate change learning (reviewed in Chapter Two). Finally, I discuss the potential relevance of the study for policy, research, and science teaching and learning.

CHAPTER FIVE: DISCUSSION, AND IMPLICATIONS

In this chapter, I synthesize and discuss the insights my case study provides with regard to my overarching research question: *How are middle school science learners' figured worlds of climate change related to the conditions in which they are embedded?* I revisit these insights in light of the figured worlds theoretical perspective, engaging in dialogue with relevant literature on learner identity and agency. I also compare the insights generated through the present case study with prior literature related to climate change learning and to cultural perspectives on climate change. Finally, I discuss the potential implications of the study for the realms of policy, science teaching and learning, and science education research, including suggested avenues for future investigation.

Theoretical Perspective

In adopting a sociocultural theoretical perspective on learning, I took the view that learning takes place through learners' interactions (e.g. with people, with cultural objects (Vygotsky, 1978)) within social environments. In doing so, I sought to examine "the nexus of relations between the mind at work and the world in which it works" (Lave, 1988, p. 1) in relation to climate change learning. Drawing on anthropological perspectives on culture and climate change (Roncoli et al., 2009), I considered climate change learning as a socioculturally-mediated process. I drew on Holland et al.'s (1998) notion of figured worlds to describe the "historically contingent, socially enacted, and culturally constructed worlds" (p. 7) in which climate change identity and agency are formed.

In Chapter 3, I presented a theoretical model of climate change learning (Figure 3). In the model, I sought to illustrate a relationship between learners' conditions and learners' figured world of climate change. Key elements examined included: 1) learners' figured world of climate change, 2) the influence of learners' conditions (or contexts) on their figured world of climate change; and 3) the (potential) influence of learners' figured world of climate change on their conditions (contexts). I highlight each of these elements in Figure 37 below.

Figure 37

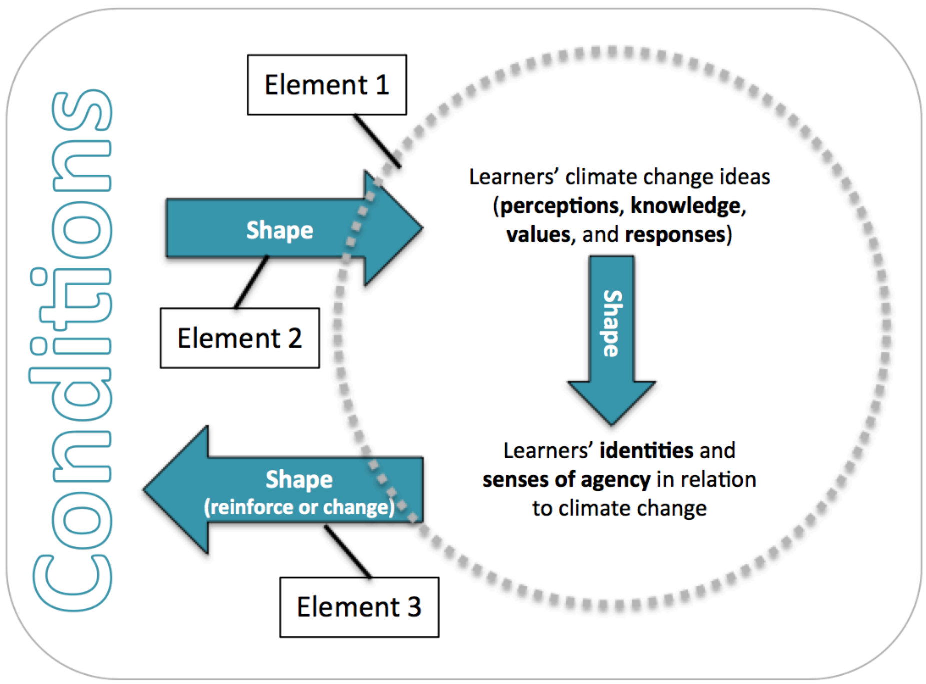
Elements of the Theoretical Model of Climate Change Learning

Elements examined:

1. Learners' figured worlds of climate change

2. Influence of learners' conditions on their figured worlds of climate change

3. Influence of learners' figured worlds of climate change on their conditions



Discussion

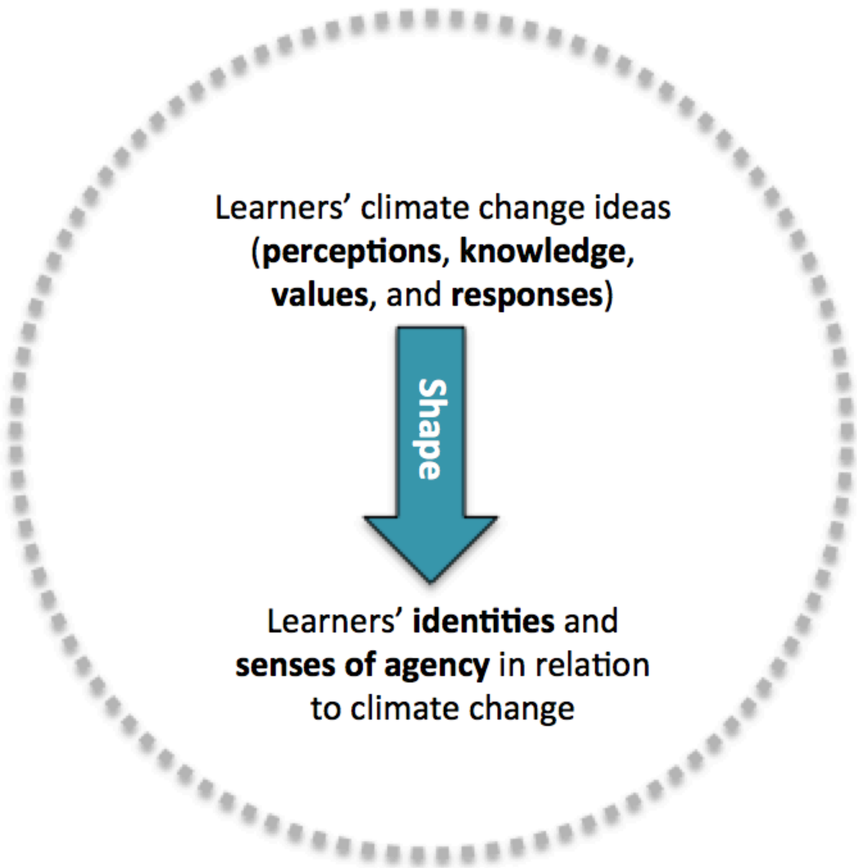
In the section that follows, I examine each element of my initial theoretical model, discussing it in light of insights from my collected data and in relation to prior literature on climate change learning.

Element 1: The "Figured world of climate change" dimension of the model. The first element of the initial model represents participants' figured world of climate change itself. Based on theoretical literature on figured worlds (Holland et al., 1998), I envisioned this element as the space in which participants' identities and agency in relation to climate change would be formed. Following the approach of other researchers adopting a figured worlds perspective (Holland et al., 1998b; Sfard & Prusak, 2000; Urrieta, 2007a), I became interested in *stories* a means of gaining insight into participants' understandings of climate change and of themselves. Using a storytelling heuristic (Truby, 2007), I described how participants expressed their perceptions of the *story world* in which climate change was taking place; the causal events comprising the climate change *plot*; the *characters* – including the participants themselves and others – enacting climate change; and participants' *moral argument* about these actions. These elements provided support for portions of two of my initial theoretical propositions: 1) *As learners engage in climate change learning, they develop perceptions, knowledge, and values… [in relation] to climate change*, and 2) *Climate change learning entails developing identity… with regard to climate change*.

In Figure 38 below, I isolate the figured world dimension of the model. Then, in Figures 39-42, I add detail to the initial model to illustrate how I now understand the figured world dimension. Because figured worlds are dynamic and enacted, I now depict the figured world element of my model in terms of the actions present in participants' collective story of climate change. I consider this story to be a representation of participants' figured world of climate change, in that participants considered their own roles (identities) and capacities to act (agency) in the world. To represent in more detail the action within the story and the characters involved in each, I now depict the figured world element of the model as a series of figures, rather than in a singular figure.

Figure 38

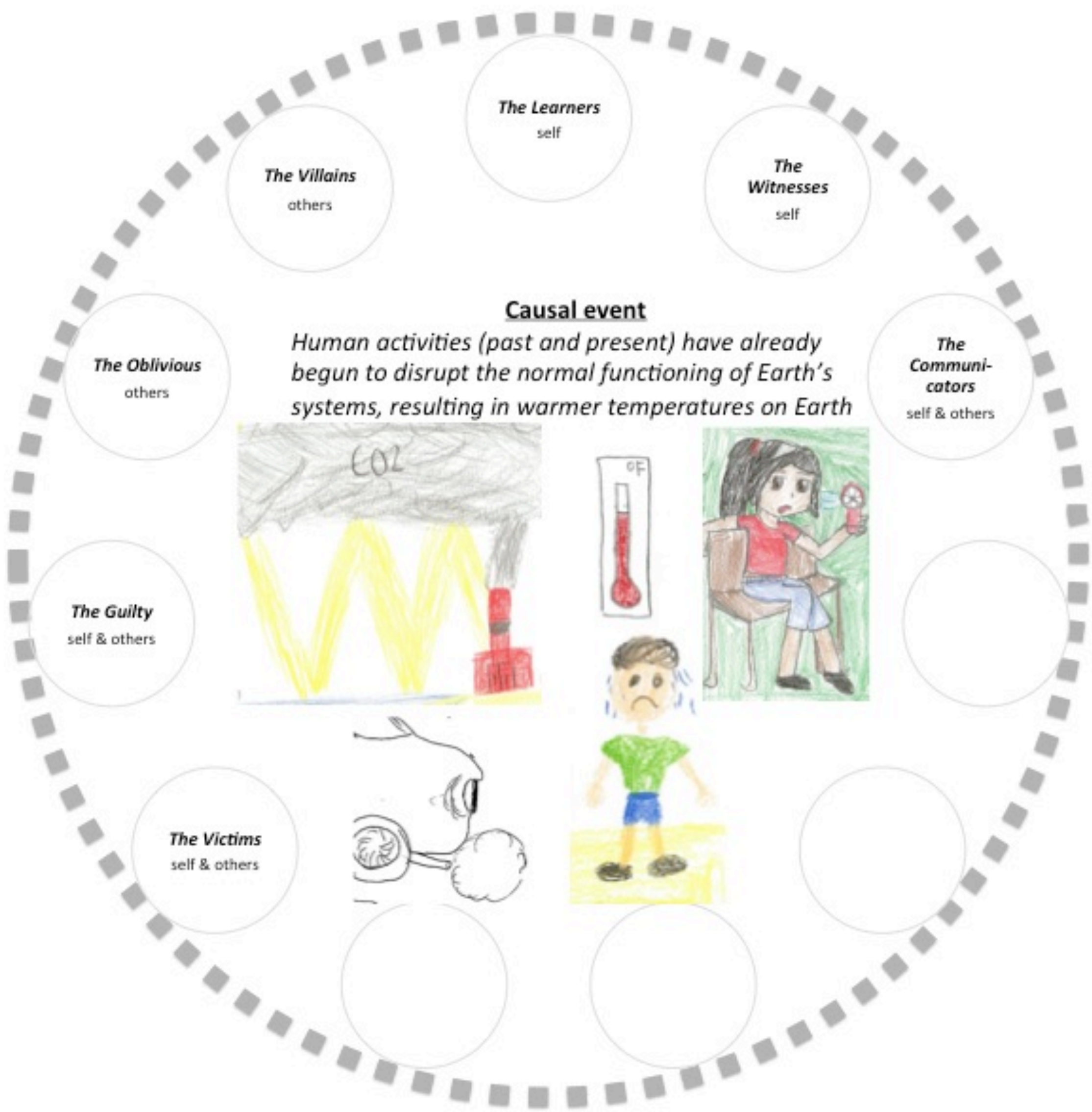
Isolating the "Figured World of Climate Change" Element of the Theoretical Model



Figures A-D.
Adding detail to the "figured worlds of climate change" element of my initial theoretical model. Here, I depict how I interpreted participants' figured world of climate change as humans (6th grade participants and others) enacting a series of events.

Figure 39

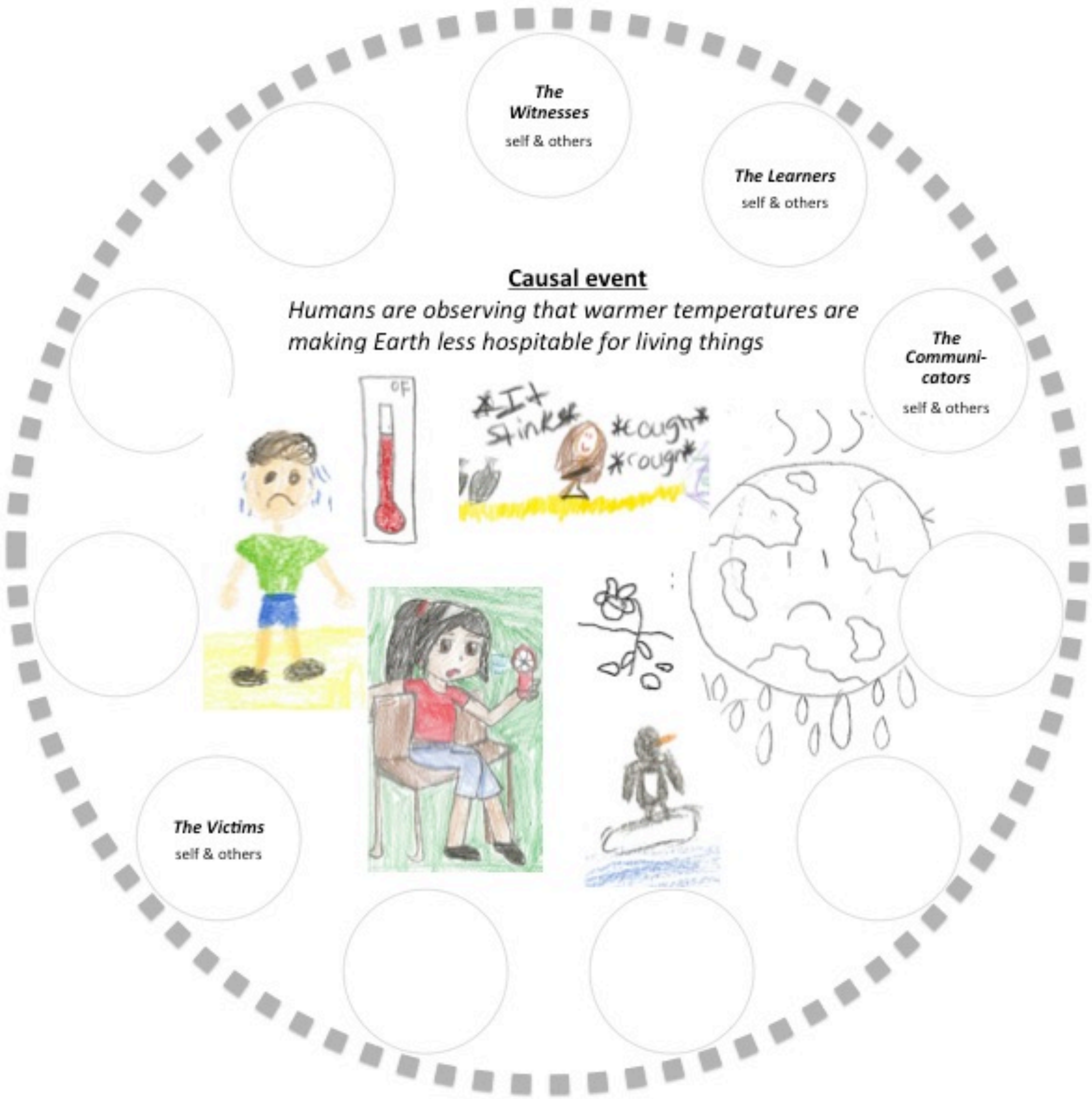
Depicting Action within Participants' Figured World of Climate Change: ***Human activities have already begun to disrupt the normal functioning of Earth's systems, resulting in warmer temperatures on Earth.***



*Here, the 6th grade participants saw themselves as **Guilty** characters who contributed to climate change through their daily actions; **Witnesses** who were noticing warmer temperatures; **Victims** who were suffering because of warmer temperatures; **Communicators** who were talking about the changes they were noticing; and **Learners** who were being taught about climate change. They depicted others – but not themselves - as **Villains** who contributed to climate change but did not care, and **Oblivious** characters who were unaware of their impact. Like themselves, others were also **Guilty**, **Victims**, and **Communicators**.

Figure 40

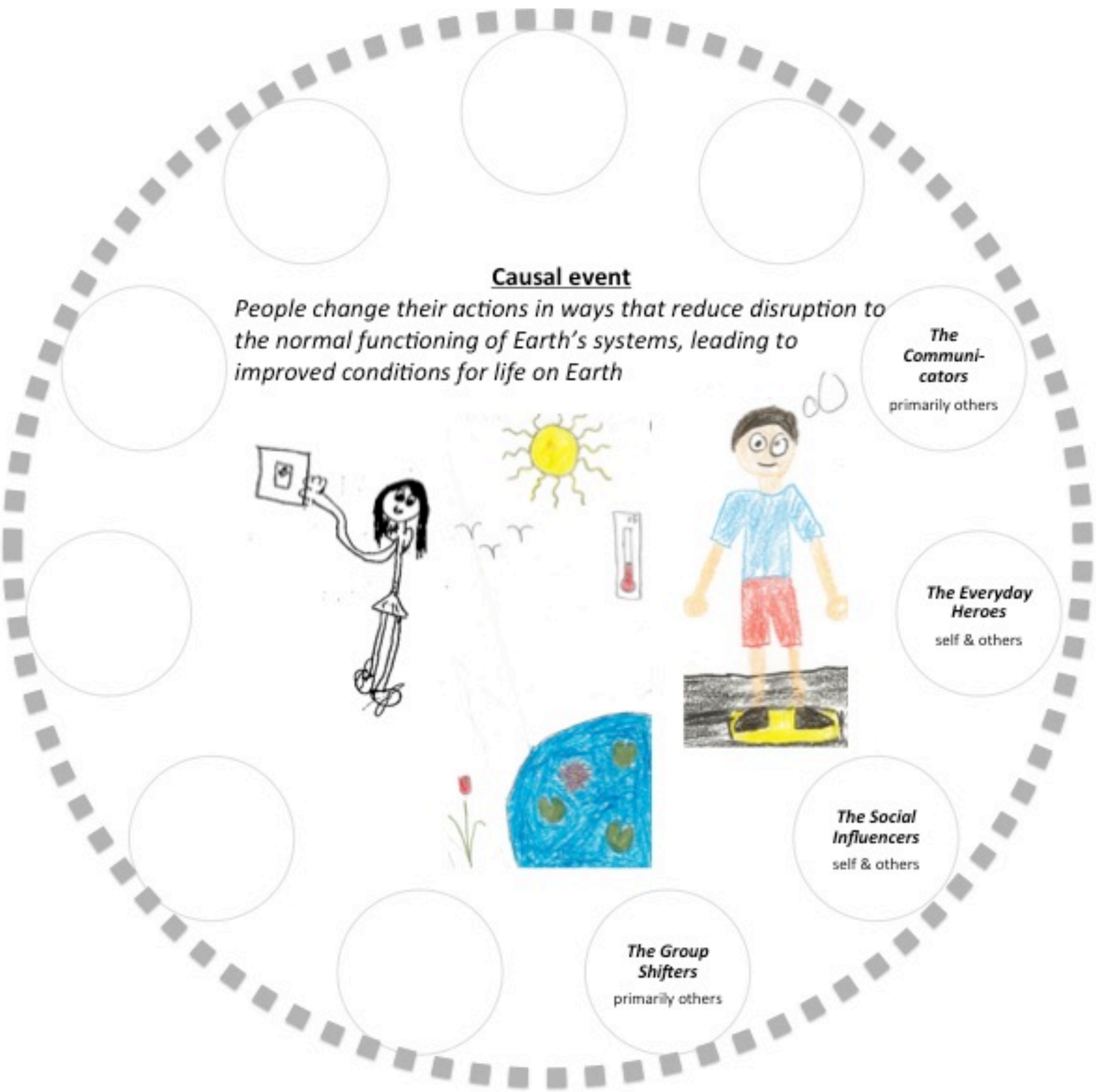
Depicting Action within Participants' Figured World of Climate Change: ***Humans are observing that warmer temperatures are making Earth less hospitable for living things.***



*Here, the 6th grade participants saw themselves and others as **Witnesses** who were observing physical changes on Earth; **Victims** (along with other living things, especially animals) who were suffering from physical changes; **Communicators** who were talking about observed changes; and **Learners** (along with scientists) who were studying changes on Earth.

Figure 41

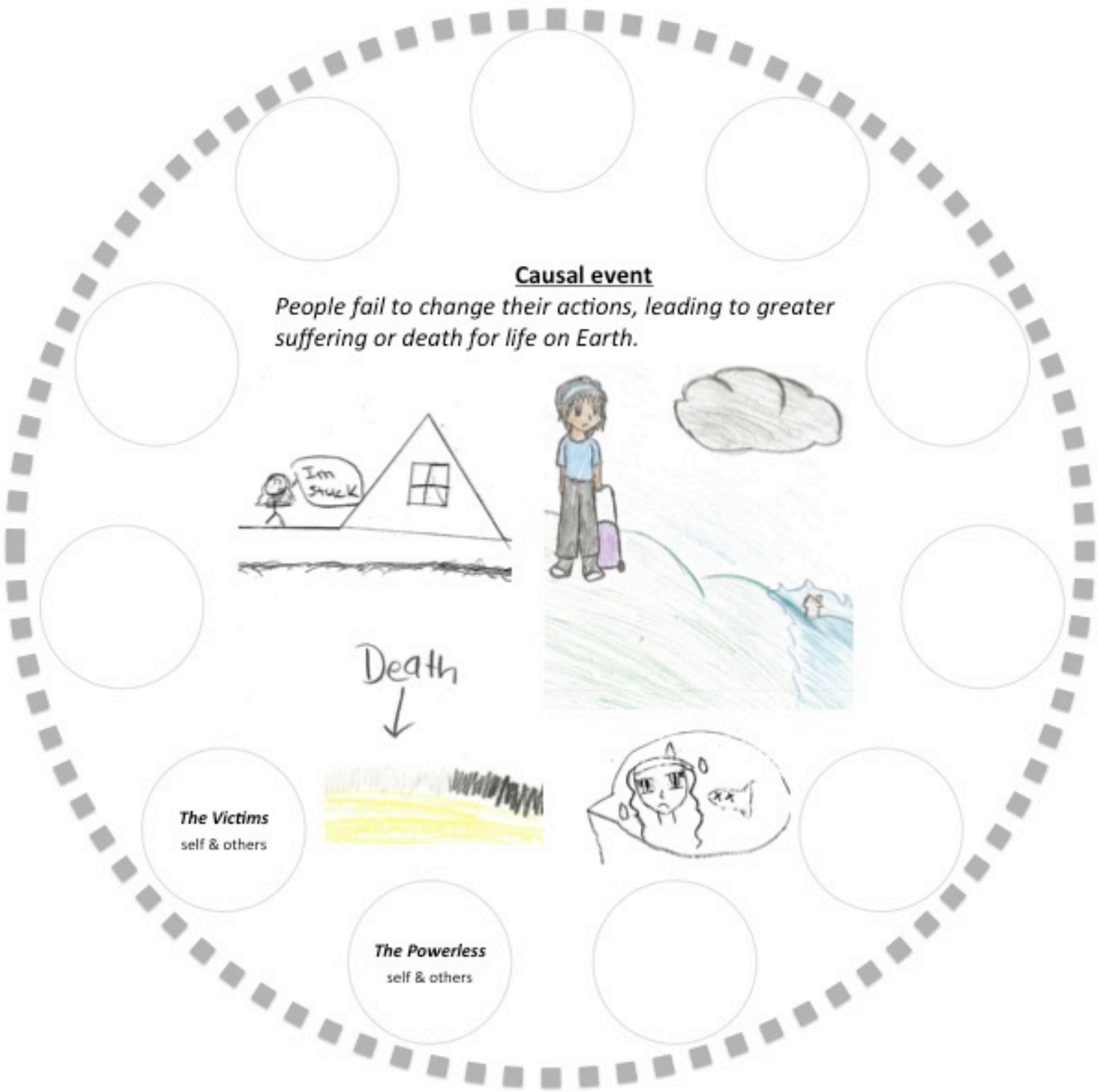
Depicting Action within Participants' Figured World of Climate Change: ***People change their actions in ways that reduce disruption to the normal functioning of Earth's systems, leading to improved conditions for life on Earth.***



*Here, the 6th grade participants saw themselves and others as **Everyday Heroes** who take personal action to address climate change. They influence others to change their personal actions in the role of **Social Influencers**. In the role of **Communicators**, others are expanding human understanding of climate change. Others are also catalyzing group-level climate change action in the role of **Group Shifters**.

Figure 42.

Depicting Action within Participants' Figured World of Climate Change: ***People fail to change their actions, leading to greater suffering and death for life on Earth.***



*Here, the 6th grade participants saw themselves and others as **Victims** who suffer the negative consequences of climate change, and as characters who are **Powerless**, unable to enact change.

Connections with prior literature regarding learners' climate change ideas. Prior studies have suggested that a majority of middle and high school respondents believed that climate change (or global warming) was occurring (Boyes et al., 2009; Boyes & Stanisstreet, 2012; Chhokar et al., 2012; Leiserowitz et al., 2011), though not always a large majority – particularly in the U.S. (Leiserowitz et al., 2011). In my case study, all eight of the 6th grade case study participants unanimously believed that climate change was occurring *and* that they were already personally witnessing its effects (e.g., personally felt hotter temperatures). Although participants expressed certainty that climate change was occurring, at ages 11 and 12, they were just beginning to learn about it. When I conducted my case study at the end of their 6th grade year, participants appeared to be piecing together new, disparate pieces of information about climate change, and were still developing their understandings of its causes, effects, and the roles of human activities.

Ideas about climate change cause and mechanism. When participants described the climate change event: *Human activities disrupt the normal functioning of Earth's systems, causing Earth to become warmer*, they provided varying explanations of the causes and mechanism behind rising temperatures on Earth. Participants generally understood that global temperatures were increasing as a result of changes in the amounts of gases in the atmosphere. However, they generally did not describe this phenomenon in ways that were fully aligned with scientifically-supported explanations of the greenhouse effect, and provided varying explanations of the relationship between atmosphere and global temperature. As commonly reported in prior literature, several participants expressed a view that air pollution was creating a hole in the ozone layer and causing global warming. As Francis et al. (1993) suggested, participants in this study may have *fused* ideas about discrepant environmental problems in providing explanations of climate change cause and mechanism. Several participants described gas building up and acting like the glass of a greenhouse (e.g., Reinfried & Tempelmann, 2014; Shepardson et al., 2009). Some appeared to hold a view that global warming was caused by air pollution in general (e.g., Boyes & Stannisstreet, 1997; Lee et al., 2007). Participants often connected this with deforestation, drawing on prior understandings of the roles of the biosphere (but generally not the atmosphere) in the carbon cycle. Such information supports research suggesting that learners may have incomplete understandings of carbon transforming processes (Jin et al., 2013). I conjecture that the explanations provided may be a reflection of both an emphasis on life science topics (e.g., photosynthesis) in the elementary grades, as well as of cultural messages about the harms associated with pollution.

Ideas about climate change effects or consequences. As reported in prior literature (e.g., Liarakou et al., 2011; Punter et al., 2011), 6th grade participants in this case study had greater awareness of climate change effects than of causes and mechanism. Participants' awareness of climate change effects was evident both as they described the causal event: *Warmer temperatures make Earth less hospitable for living things*; and the causal event: *People fail to change their actions, leading to greater suffering or death for life on Earth.*

Participants' discussion of climate change effects included many of the scientifically-supported physical changes on Earth discussed in prior literature, including precipitation changes, sea level rise, ice and snow melt, and flooding (e.g. Boyes &

Stanisstreet, 1993; Shepardson et al., 2009). I also noted evidence that supported Shepardson et al.'s (2009) finding that learners often considered changes in local temperature and precipitation, rather than thinking in terms of long-term global patterns. This could signal participants' conflation the concepts of weather and climate. I observed that participants were particularly attentive to impacts that affected human or animal life. These included threats to plant and animal survival (also documented by Koulaidis & Christiadou, 1999; Lee et al., 2007); threats to human health, safety, and survival; and disruptions to humans' lives. This could be, in part, a product of my drawing and interview protocols, in which I specifically asked participants about how they saw climate change as relevant to their own lives. It may also relate to interest in and empathy with animals, as has been documented with learners of similar ages (Nevers, Gebhard, & Billman-Mahecha, 1997).

Although participants were generally more knowledgeable about climate change consequences than other dimensions of climate change, they sometimes described climate change consequences in ways that were not scientifically supported. For example, as reported in prior literature (e.g., Kılınç et al., 2008; Punter et al., 2011), some participants, such as Isabelle and Autumn, associated climate change with the death of aquatic animals as a result of pollution (e.g., trash or litter) entering waterways. Others, such as Bobby and Richie, associated climate change with increased risk of skin cancer (e.g., Rye & Rubba, 1998). I did not detect among the 6th grade participants a number of other scientifically unsupported views, such as the association of the greenhouse effect with food poisoning, heart attacks, or unsafe drinking water.

Ideas about the role of human activities in climate change. Participants provided evidence of their ideas about the roles of human activities, including their own, in climate change through their descriptions of the causal events: *Human activities disrupt the normal functioning of Earth's systems causing Earth to become warmer; People change their actions in ways that reduce disruption to the normal functioning of Earth's systems, leading to improved conditions for life on Earth*; and *People fail to change their actions, leading to greater suffering or death for life on Earth.*

In describing activities participants understood as exacerbating climate change, a number of activities emerged that supported insights from prior literature. For example, participants in this study widely cited fossil fuel use (including from electricity use, driving cars, and factory production); deforestation; and pollution in general as exacerbating climate change, all of which have been reported in prior literature. Many participants associated land-based pollution (i.e., litter or trash) with climate change (also reported in prior literature), but generally did not provide coherent cause-effect explanations of the relationship. This suggested that participants, when in doubt, held the view that any activity they understood as bad for the environment was likely to contribute in some way to climate change.

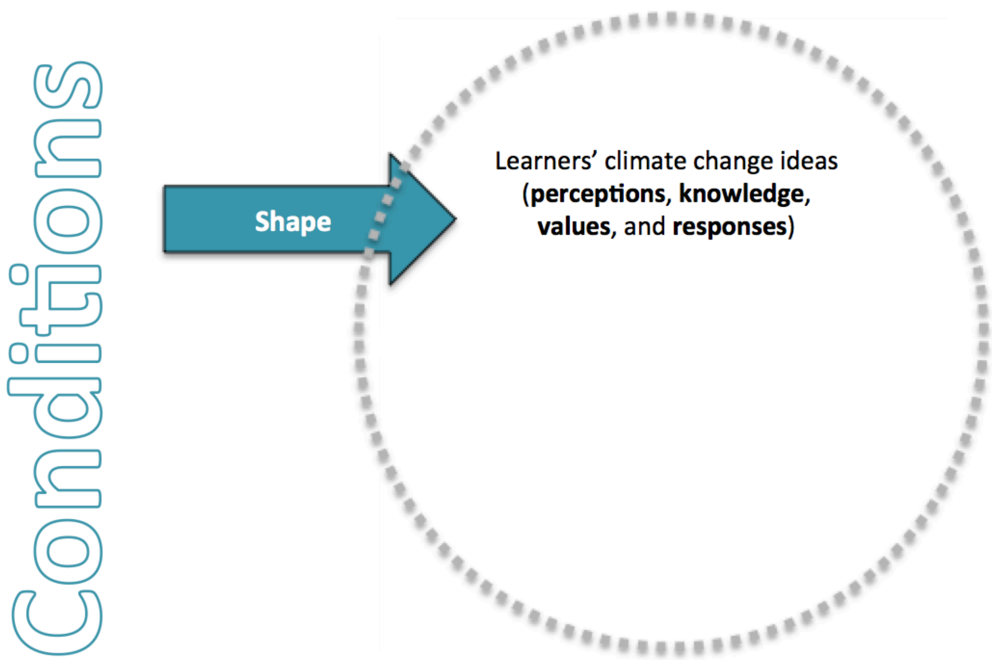
In describing activities they understood as mitigating climate change, participants likewise cited a number of activities previously reported in the literature. These included reducing fossil fuel use (including driving less, using public transportation, using less electricity, using renewable energy sources), reducing deforestation, and reducing pollution (e.g., by recycling). Additionally, I noted that participants generally held the view that education was crucial for mitigating climate change, and that greater understanding of climate change would empower people to make sustainable choices in their everyday lives. They also held the view that imposing rules and regulations that limited people's use of fossil fuels would be an effective way to mitigate climate change. These types of actions – located more centrally in the realm of the social sciences – are less frequently discussed science education, but were an important part of participants' thinking about actions that could mitigate climate change.

I noted that it was less common for participants to talk about climate change mitigation as a collective (possibly political) activity. Participants' ideas about climate change mitigation focused primarily on the kinds of individual actions (e.g., recycling, turning out lights) communicated to them as positive actions to take in their homes and schools. It appeared that parents, Ms. Kane, and the science curriculum resources presented to participants sought to empower them to make a difference with regard to climate change, rather than to become overwhelmed or hopeless. These efforts were generally channeled into messages about simple actions young people could take as individuals, and did not delve into messier, more complex, and more potentially political notions of collective action.

Element 2: The "Influence of learners' conditions" dimension of the model. The second element of my theoretical model that warrants exploration in light of my findings is the *influence of learners' conditions* element (Element 2 in Figure 37, above). I isolate this aspect of the model in Figure 43. I identified three modes by which participants perceived information about climate change: 1) by attending to information communicated by others; 2) by observing human behavior (perceived as) impacting climate change; and 3) by observing changes in the natural environment (perceived as) evidence of climate change. Examples in the data that suggested that as participants interacted within their conditions in these ways, they formed new ideas about climate change. This observation provided support for my theoretical proposition that: *Learners' ideas about climate change are formed through social interaction and are thus shaped by aspects of their conditions.*

Figure 43

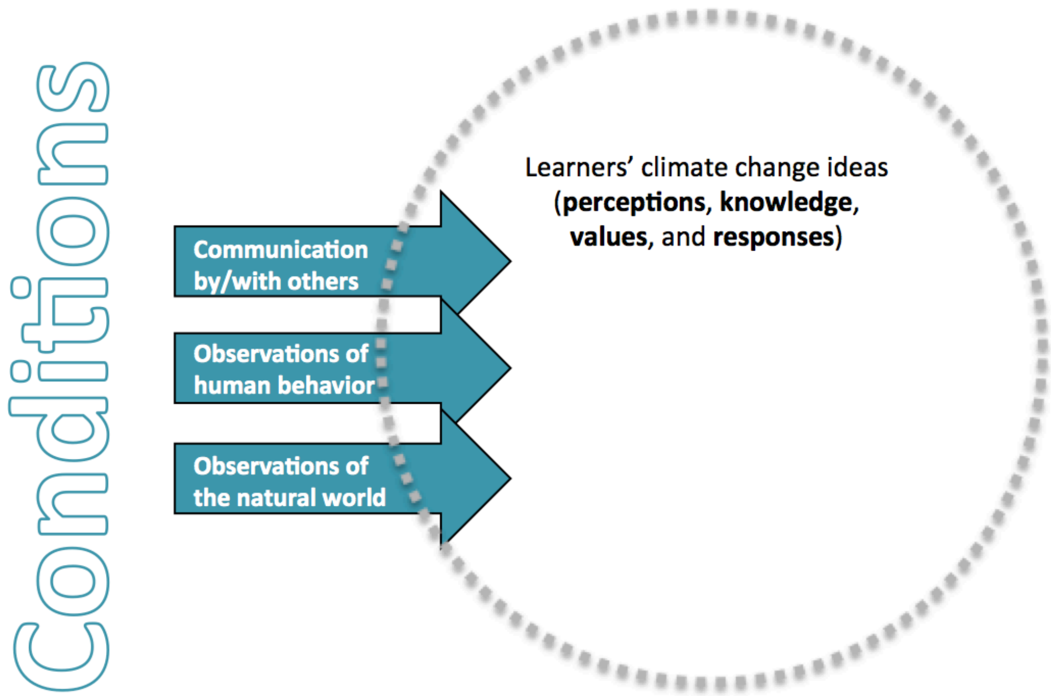
Isolating the "Influence of Learners' Conditions" Element of the Theoretical Model



In Figure 44, I modify my representation of the *influence of context (conditions)* element of my initial theoretical model. Here, I represent three modes by which participants' interactions with their conditions appeared to shape their figured worlds of climate change. I note that participants' interactions with people or cultural objects within their immediate surroundings (e.g., home or school) had the potential to connect them to more remote aspects of their conditions (e.g. a TV news report viewed at home may show distant island nations affected by sea level rise; a website viewed at school may show images of Arctic animals impacted by climate change). Thus, I suggest that participants' figured worlds of climate change were directly and indirectly shaped by their conditions from local to global scales.

Figure 44

Adding Detail to the "Influence of Learners' Conditions" Element of the Theoretical Model



Connections with prior literature regarding conditional influences on climate change learning. As reported in prior literature, participants in this case study described ways in which messages communicated at school (teachers, curriculum, peers) (Bodzin & Fu, 2014; Boon, 2010; Kılınç et al., 2008; Varma & Linn, 2012); in the media (Boon, 2010; Boyes et al. 2008; Hansen, 2010); and by family (Mead et al., 2012) had influenced their ideas about climate change.

Influence of messages in school. As reported in previous studies, 6th grade participants in this case study cited messages communicated in school as important influences on their climate change ideas (Boon, 2010; Kılınç et al., 2008). They provided more scientifically supported explanations of climate change after engaging with school-based instruction on the topic (Bodzin & Fu, 2014; Varma & Linn, 2012). However, even after instruction, some aspects of participants' explanations of climate change – particularly related to cause and mechanism - were not scientifically supported (Jin et al., 2013). When speaking about climate change, I noted that participants often referenced visual media presented in class, as well as interactive learning activities in which they had engaged. I rarely noted any participants referencing climate change messages communicated to them through their individual engagement with the *Innovate* online curriculum. This suggested to me that although participants may have gained some ideas about climate change through their individual work, opportunities to interact with others around the topic of climate change were most memorable.

Influence of messages from peers. Although I interpreted social interaction as important for shaping participants' climate change ideas, I had few opportunities during my classroom observations to observe participants and their peers engaged in discussion about climate change. When I inquired during individual interviews, most said that climate change was *not* something that 6th grade participants discussed much with their peers. Aliyah explained that her peers did little to shape her thinking about climate change because "We all [have] similar ideas" (Aliyah, interview), and Bobby agreed that he only talked to his peers about climate change when directed to do so in school (Bobby, interview). I created a situation like this in setting up the focus group discussions, so that

I could observe how participants interacted with their peers around climate change. I observed that, in general, participants supported and agreed with one another's ideas. This may provide further support for the finding that friends may influence learners' thinking about climate change (Kılınç et al., 2013; Leiserowitz et al., 2011), but perhaps through reinforcing one another's ideas more than changing their ideas.

Influence of messages from media. Also as reported in prior studies (Boyes et al. 2008; Hansen, 2010; Svilha & Linn, 2011), participants cited media as a source of their information on climate change, particularly television and Internet. Media sources, both in school and out-of-school, appeared to increase participants' awareness of climate change in some ways, particularly with regard to its impacts (Andersson & Wallin, 2000; Hansen, 2010). However, as previously reported, media sources could also become sources of participants' climate change explanations that were not scientifically supported (Boyes & Stanisstreet, 2001; Gowda et al. 1997). For example, Autumn's use of the NASA website led her to the scientifically unsupported conclusion that the ozone hole was the cause of global warming. I further noted evidence that brief reports in the media, such as on the television news, provided participants with incomplete information about climate change (Boon, 2010; Varma & Linn, 2012). This was evident in Isabelle's statement that "The news just kind of skims over it and then goes on to like, 'Oh, these people escaped from jail'" (Isabelle, interview). Finally, as Kılınç et al. (2013) reported, I noted evidence that media reports about climate change sometimes incited feelings of fear. For example, Aliyah became fearful of being displaced from home after seeing a news report about climate change refugees in island nations. As these examples suggest, messages communicated through media appeared to have an important influence on participants' climate change ideas.

Influence of messages from family. Like all of their parents, all of the 6th grade participants were worried or concerned about the risks posed by climate change. This finding aligns with prior research suggesting that adolescents were likely to perceive climate change risk in the same way as their parents (Mead et al., 2012). A number of parents talked about being careful in their conversations with their children about climate change, so as not to incite worry. However, I noted that some of the potential climate change risks that the 6th grade participants described were more extreme than those potential risks that concerned their parents.

Influence of broader cultural messages. Looking beyond the realm of what participants cited as directly influencing their climate change ideas – that is, the influences of which they were aware and about which they communicated to me – I interpreted other ways in which broader cultural messages could be indirectly shaping participants' climate change ideas.

Public discourse. The 11- and 12-year-old participants in my study rarely appeared to be influenced by, nor generally aware, of political conversations around climate change. For example, they were not aware of political rhetoric calling scientific evidence to question as Boon (2010) reported. They did not express distrust in politicians as Boyes and Stanisstreet (2012) observed amongst students in their study. I interpret this general lack of awareness of public discourse around climate change – particularly its politicization in the U.S. - as potentially a matter of parents' caution when discussing climate change, care taken in school science to avoid politicizing climate change, and the types of media that these 11- and 12-year-old students consumed.

Although participants were not highly aware of broader public (adult) discourse around climate change, it may have had indirect influence on their climate change learning and ideas. For example, it is possible that participants' parents – who were all generally aware of the politicization of climate change – shared messages with their children that were aligned with their political views on climate change. For example, James's father told me, "Oh yeah, I believe the hype!" (James's father, interview) and described his desire to instill in James the importance of working to protect the environment, for example, by purchasing from companies that are environmentally conscious. Even though participants lived in a county where there was some disagreement about climate change – although less disagreement than at the national scale (Yale Project on Climate Change Communication, 2014) – these arguments generally did not appear to touch the 6th grade participants' everyday lives. The people (e.g., parents, teachers) and cultural objects (e.g., curriculum, media) with which they interacted did not appear to cast doubt on whether or not climate change was a real phenomenon. This suggests that, possibly, learners' immediate contexts (e.g., everyday life in school and out-of-school) may have had greater power to shape their ideas than their less immediate contexts (e.g., national level conversations about climate change). However, it is likely that participants will come into greater contact with alternate views in the future.

The politicized nature of climate change in the U.S. may have also shaped how climate change was presented to students in school. For example, the Next Generation

Science Standards, with which the *Innovate* online curriculum was aligned, state that middle school students should be able to "Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century" (MS-ESS3-5, NGSS Lead States, 2013). This language may suggest to some that climate change evidence is unclear, and *needs* clarification – a message sometimes promoted in U.S. political discourse on climate change, but not necessarily in scientific discourse. It also may point to the care that science educators are tacitly expected to take in presenting climate change as a potentially politically sensitive topic. Accordingly, none of the messages communicated to participants about climate change at school addressed the presence of political debate around climate change. Normative questions addressing climate change mitigation strategies were focused on positive actions participants could take as individuals (e.g., monitoring their personal carbon footprint) – avoiding notions of collective action that might be construed as promoting environmental activism.

Cultural values related to environment, science, and technology. I noticed some trends in the case study data that were similar to trends reported by other researchers related to the role of cultural views of environment, science, and technology in shaping people's ideas about climate change. For example, Kılınç et al. (2011) argued that aspects of national culture led students to self-identify as *environmentally friendly*. Similarly, in my case study, I noted that the school (Fairview Middle School) and the local community in which the school was located took pride in sustainability efforts, and that all of the 6th grade case study participants spoke positively about environmental stewardship behaviors, including their own. Byrne et al. (2014) identified a set of *interpretive repertoires* that 9 and 10-year-old students employed when speaking about climate change, which aligned with cultural values instilled in children at a young age. These included values such as *saving the planet*, *staying healthy*, and *being fair* (Byrne et al.). I noted very similar trends in analyzing data related to the climate change values of the 11 and 12-year-old participants in my case study. I identified *environmental stewardship*, *human health*, *altruism*, *honesty*, and *rules and regulations* as some of the ideals that participants saw as worthy of protecting when they spoke about climate change.

However, I also noted evidence that some widely shared cultural values did *not* shape learners' ideas about climate change in anticipated ways. For example, several researchers have reported that adolescent learners often hold the view that climate change can be resolved by technological fixes (Byrne et al., 2014; Stanisstreet et al., 2008). Skamp et al. (2013) posited that this was particularly likely among youth in Western cultures, who may often associate technology with progress. I noted this view amongst participants' parents (but not among participants themselves), particularly when they believed that their children's generation would generate innovative technological solutions to address climate change. Such a view would align with the current cultural interest in STEM education in the United States, including the infusion of engineering into the Next Generation Science Standards.

Influence of participants' observations of human behavior. Participants' observations of human behavior appeared to shape their ideas about the scope and severity of climate change, and to inform their levels of concern with regard to climate change. These observations often related to people's personal technology use at home and school, as well as to people's modes of transportation. Participants often described technology as creating more problems than solutions. They tended to associate *technology* with personal technology products, such as the laptops participants used every day in their blended learning school, which they had learned were powered by fossil fuel energy. Participants expressed concern about the prevalence of activities in their immediate surroundings they understood to exacerbate climate change, but saw these behaviors as largely infeasible to change. An exception was evident with Richie, whose family had recently installed solar panels on their house, who expressed a view of technology as having the potential to help mitigate climate change. Both of these examples suggest that participants' observations of human behavior in the world around them may have played a role in their climate change ideas.

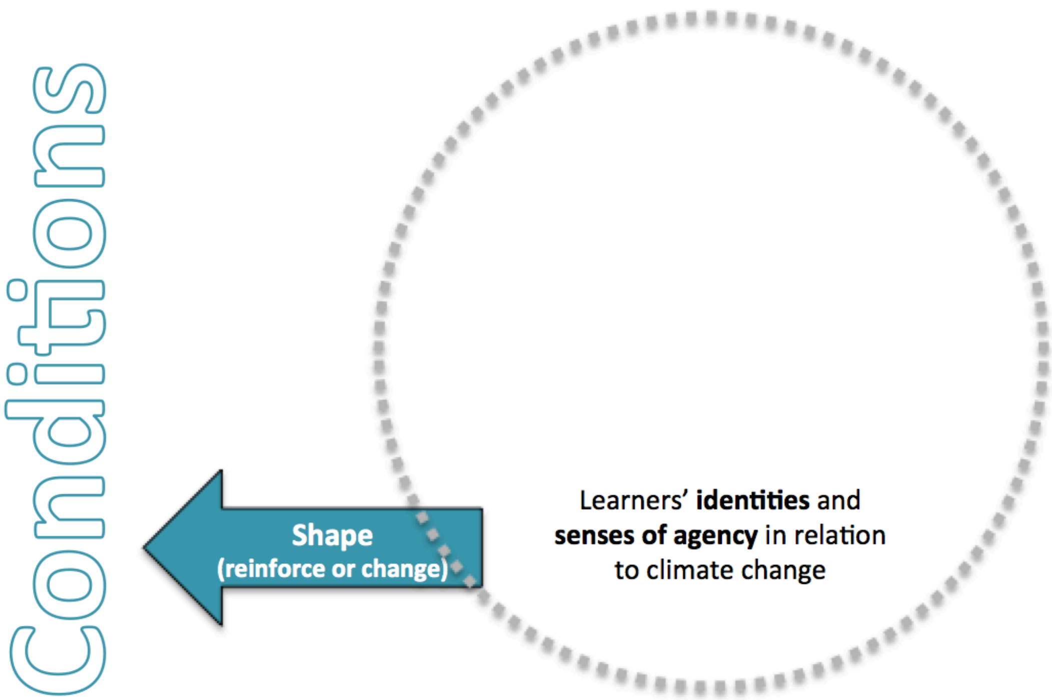
Influence of participants' observations of the natural world. I noted evidence that participants' observations of the natural world may have played a role in shaping their climate change ideas. Once aware of climate change as a phenomenon, participants often interpreted phenomena such as hot temperatures, extreme weather events as evidence of climate change. Participants often interpreted events through conversation with others, such as their family members. Anthropologists have described how people's observations of the physical environment, such as thinning sea ice, arrival of unfamiliar insects, disappearance of familiar species, and changes in precipitation may shape understandings of climate change (Crate, 2009; Jacka, 2009; Marino & Schweitzer, 2009). In addition, people may interpret climate change through the lens of changes in cultural activities, for example, being no longer able to predict the weather (Crate, 2009), or experiencing new difficulties in hunting and producing food (Crate, 2009; Jacka, 2009), or in Autumn's family's case, no longer experiencing white Christmases.

In many of the instances in which the 6th grade case study participants and their family members associated observed changes in the natural environment with climate change, they described changes in local temperature and precipitation, rather than thinking in terms of long-term global patterns (see also Shepardson et al., 2009). Here, it is worthwhile to acknowledge Nuttall's (2009) warning to anthropologists that observations about unusual weather should not be automatically considered evidence of climate change. However, in some cases, in which participants' families had resided in Douglass County for many decades – such as Isabelle's father who had visited the same beach every year since childhood, participants' families may possess place-based knowledge related to climate change. Such knowledge may be similar to the kinds of traditional ecological knowledge – based on people's "locally developed knowledges and practices" (Leonard, Parsons, Olawsky, & Kofod, 2013, p. 263). While the 11- and 12-year-old participants themselves had not been alive long enough for such long-term climate observation and awareness, their ideas may have been informed by the interpretations of older members of their families and communities who had witnesses such long-term change.

Element 3: The "Influence of figured worlds" dimension of the model. The final element of the initial theoretical model (Figure 45) represents how participants' enactment of their figured worlds of climate change serves to reshape or reinforce their conditions. Figured worlds, then, become "sites of possibility" (Urrieta, 2007a, p. 109) for enacting social change. In applying this thinking to a sociocultural model of climate change learning, this would entail people acting according to, and in response to, their stories of climate change. This enactment would hinge on how people see themselves in relation to climate change (their *climate change identities*) and how they understand their capacities to act in relation to climate change (their *climate change agency*).

Figure 45

Isolating the "Influence of Figured Worlds" Element of the Theoretical Model



To examine this dimension of the model, I analyzed the data with attention to participants' critical responses to climate change. I interpreted these responses as providing evidence of participants' *climate change agency*, or their sense of their own capacities to act in relation to climate change. For each type of response, I interpreted how participants cast themselves as certain types of characters in the story of climate change, representing their varied *climate change identities*. These interpretations were relevant to my theoretical proposition that: *Learners' identity and agency development* *may reinforce or change the conditions in which they are embedded.* In Figures 46 and 47, I represent how participants' enactment of these identities may extend beyond the participants themselves, and have the potential to impact the conditions in which they are embedded.

Figure 46 illustrates that by enacting certain character roles, participants have the potential to reinforce the conditions in which they are embedded. In the role of *Communicators*, participants may "spread the word" about climate change by repeating climate change messages already prevalent in the world around them – reinforcing, but not changing, their conditions. As *Learners*, participants may become personally knowledgeable about climate change, but not alter their behaviors or those of others – reinforcing conditions in which people are aware of climate change, but still engage in behaviors that contribute to it. As *Everyday Heroes*, participants may engage in personal actions they perceive as beneficial to climate change mitigation (e.g., recycling), joining a larger community of people engaged in personal "green" actions, while climate change consequences persist. As *Guilty* characters, participants may continue daily personal behaviors that contribute to climate change, while climate change consequences also persist. As *Victims* or *Powerless* characters, participants may see themselves as unable to address climate change in any way, while climate change consequences persist or worsen.

Figure 46

Participants' Enactment of Climate Change Identities with Potential to Reinforce their Conditions

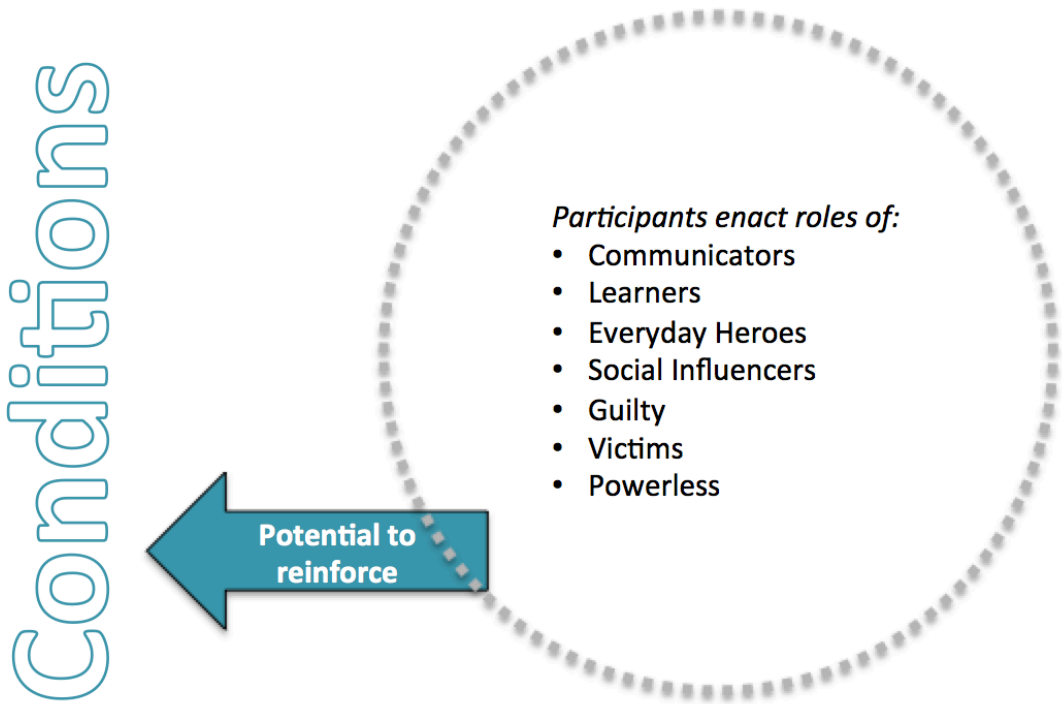
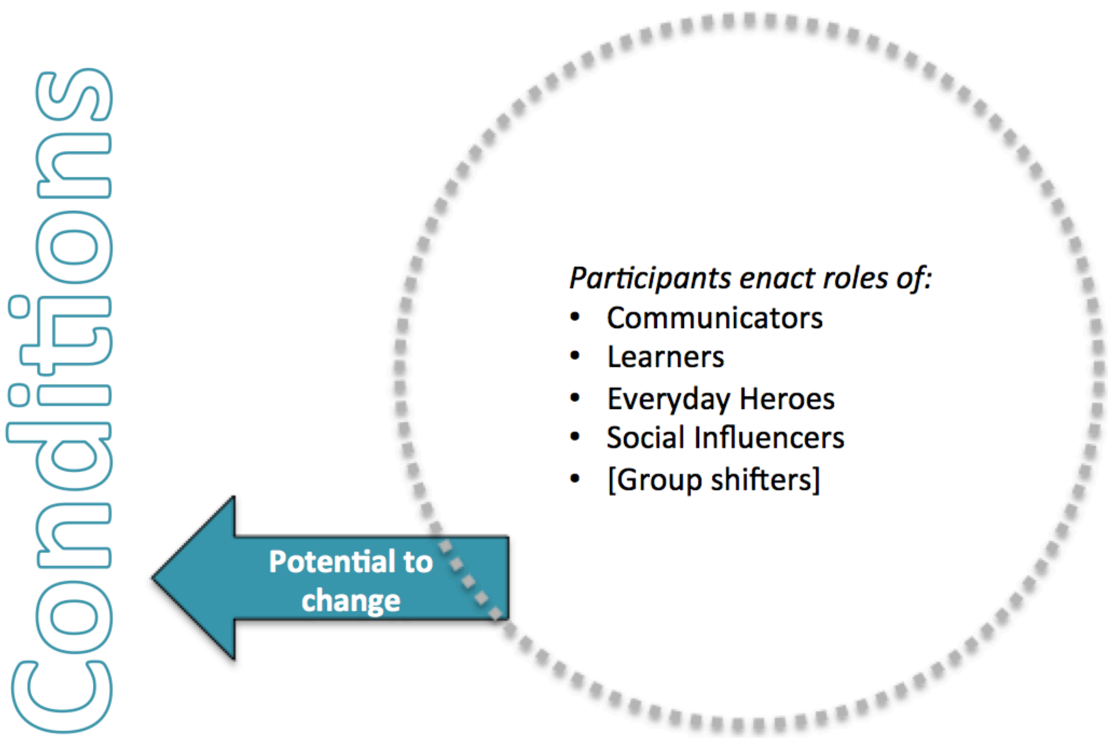


Figure 47 illustrates that by enacting some climate change identities, participants may have the potential to change the conditions in which they are embedded. In several of these roles (*Communicators*, *Learners*, *Everyday Heroes*, and *Social Influencers*), participants could also reinforce their conditions, depending on *how* the roles are enacted. By enacting the role of *Communicators*, participants could "spread the word" about climate change to others who do not know about climate change, creating conditions of greater climate change awareness. By enacting the role of *Learners*, participants could become more knowledgeable in ways that incite more informed decisions about climate change that impact their conditions. In the role of *Everyday Heroes* and *Social Influencers*, participants could engage in personal actions that help mitigate climate change and encourage others to do the same. In addition to potentially mitigating climate change, these actions could be significant for making climate change more salient to participants themselves and others. Finally, though the 6th grade participants rarely saw themselves in the role of *Group Shifters*, if they could be supported in developing these identities, participants could be a part of larger-scale climate change mitigation actions with greater potential to mitigate climate change than individual actions alone.

Figure 47

Participants' Enactment of Climate Change Identities with Potential to Change their Conditions



Connections with prior literature regarding learner identity and agency in relation to environment and climate change. In describing the various character roles in which participants cast themselves and others in their stories of climate change, I described 6th grade participants' varied and sometimes conflicting climate change identities and actions. The notion of inhabiting multiple identities in relation to environment was also described in Blatt's[6] (2013, 2014) work on environmental identity among U.S. high school students. Blatt described a variety of possible views of one's own relation to the natural environment. I noted that some of these views resonated with a number of the climate change character roles I interpreted among the 6th grade case study participants, including the view of oneself as damaging to nature (similar to *The Guilty* character role), the view of oneself as dependent upon nature (similar to *The Victim* character role); and the view of oneself as a protector of nature (similar to the *Everyday Hero* character role).

In connecting identity with emotion, Blatt described the work of Hitlin (2003), who saw values as bridging the two. I noted a similar kind of connection between 6th grade participants' climate change identities, values, and emotions. In particular, when participants described themselves and others as enacting the roles of *Those Who Harm* (*The Guilty*, *The Oblivious*, and *The Villains*), they expressed emotions of sadness and frustration. They described these emotions in relation to the violation of certain values or ideals, such as the violation of their *environmental stewardship* value, or threats to ideals such as *health* and *life.* This was evident, for example, when James stated, "It's sad [emotion]. Because if we keep like we're behaving with this stuff [*Those Who Harm* collective character role], we're gonna all die [threat to the value: *life*]" (James, interview).

Because of the relatively short-term nature of this study, I did not frame it as a study of participants' identity *development*, but rather as a *snapshot* of the climate change

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[6] Blatt drew on the work of Thomashow (1995) and Clayton (2003), both of whom described a connection between environmental identity and behavior, just as figured worlds theory would assume in its focus on identity and agency in particular cultural realms.

identities participants had developed up to (and during) the time of the study. However, I note certain connections between findings related to participants' climate change identities and Kempton and Holland's (2003) the process of environmental identity development, which moves from *salience*, to *empowerment*, to *activism*. Evidence from participants suggested that all had at least entered the *salience* stage of their climate change identity development, particularly in casting themselves in the character roles of climate change *Learners*. Where participants described their individual roles as *Everyday Heroes* and *Social Influencers*, and rarely, their collective roles as *Group Shifters*, it may have been the case that they were entering the *empowerment* stage of their climate change identity development. Conversely, however, when they cast themselves as *Powerless* characters or *Victims* in the story of climate change, participants did not show evidence of a sense of empowerment. The third and final stage that Kempton and Holland described for environmental identity development is the *activism* stage. Because I was unable to observe participants engaged in climate change activism practices firsthand, I relied on their reporting of their actual and intended actions in response to climate change. In describing their climate change actions - or possibly, their inability to act on climate change - participants may have provided initial evidence related to the *activism* stage of their environmental identity development.

Blatt (2013) suggested that, "through an understanding of the different levels of salience of various identities within an individual, one can gain a better understanding of the actions of that individual" (p. 469). In applying this idea to my case study, many questions arise: Which of their multiplicity of climate change identities will become most salient to the 6th grade participants as they engage in further climate change learning?

Under what conditions might participants enact those identities in the world to reshape or reinforce their conditions? For example, it may be possible that participants' enactment of their already strong *Everyday Hero* identities (people who consciously limit their contribution to climate change through individual actions) may serve to reinforce their current conditions, in which many people are already engaged in such individual actions, yet climate change consequences persist. However, it may also be possible that if participants further develop in their nascent collective *Group Shifter* identities (those who catalyze group-level action to address climate change), enactment of these identities might better serve to reshape participants' conditions in line with participants' desired vision of the future – or, "where [we would] prefer to go" (Hicks and Holden, 2007)

I posit that through the enactment of their figured worlds of climate change, participants have the potential to change or reinforce the multifaceted, multilayered conditions in which they are embedded. I also posit that through future climate change learning experiences, participants have the possibility of taking up new kinds of climate change identities, developing new self-understandings in relation to climate change. In doing so, they may also gain new senses of agency, or views of their own capacities to act in relation to climate change. In addition, future learning experiences might serve to strengthen or reinforce particular elements of participants' currently varied climate change identities. Climate change education itself, then, becomes a site of possibility. Questions for the policy, education, and research communities thus arise around the goals of climate change education, and how these might be realized for today's science learners.

Implications

While I do not make the claim that insights from this study of eight particular learners may be generalized to draw conclusions about other student populations, I believe that they highlight a number of key issues with broader implications for climate change education. I now turn to implications of the study for the areas of policy, curriculum and instruction, teacher education, and research.

Policy. This study has potential implications for policymaking on varied levels. In the broadest sense, it raises questions about the kinds of climate change identities and agency we would desire for today's young people to adopt and enact in the world. At the global level, the Sustainable Development Goals of the United Nations' 2030 Agenda describe a future requiring "solutions…coordinated at the international level and… international cooperation to help developing countries move toward a low-carbon economy" (UN.org, 2016, para 4). At the Paris Climate Conference (COP-21), which occurred several months after the completion of my data collection, world leaders set the goal of keeping global temperatures from rising more than 2°C by the year 2100, with an ideal target of keeping temperature rise below 1.5°C. Considering these global-level aspirations, young people – along with older generations – must presumably develop certain capacities to act in relation to climate change if they are expected to take part in realizing them.

In the U.S., the Federal government's take on the desired capacities to act are reflected in the *Essential Principles for Climate Literacy* (U.S. Global Change Research Program, 2009). They state that a climate literate person should be able to: assess scientifically credible information, understand Earth's climate system, communicate about climate and climate change, and make informed, responsible decisions about actions that may affect climate. I interpret these as focusing primarily on developing people's individual identities as climate change *Learners* and *Communicators.* Promisingly, this case study has suggested that climate change learning experiences, both in and out of school, may help adolescents to develop such climate change identities. However, it also suggests that adolescents may develop other kinds of identities and senses of agency when they consider themselves as members of groups.

Beyond the decision-making ability of individuals, collaborative action will likely be required realize global and national climate change goals (i.e., enactment of *Group Shifter* identities). Thus, a notion of collaboration – through an added focus on collective identities, or *individual <u>and</u> collective senses of competence* (Chawla and Cushing, 2007) – may be beneficial. In support of this view, the White House Office of Science and Technology Policy (OSTP) stated, "Ensuring that the outcomes of COP-21 are lasting and effective will require the support of a public that understands the fundamentals of the changing climate and *what can be done through collective action* to mitigate and prepare for climate change" (White House OSTP, Climate Education and Literacy Initiative, 2015, para. 3). Chawla and Cushing acknowledged that such educational efforts could run the risk of being perceived as advocating a certain political position, which is generally deemed unacceptable in U.S. educational systems. In response, they argued that:

> Engaging young people in democratic processes… means enabling them to come to their own decisions based on the information they gather and the discussions they share. It means helping them to seek the common good despite gaps in

> knowledge and diversity in perspectives, acknowledging that their decisions need to be responsive to consequences and open to revision. Defending young people's right to navigate these processes is equivalent to defending the role of schools to prepare students for authentic democratic citizenship. (p. 448)

In this view, educational efforts focused on the development of individual *and collective* competence in relation to climate change are warranted and necessary.

Insights from this case study support the view that values are embedded in seeing oneself and one's own capacity to act in relation to climate change. The *Essential Principles of Climate Literacy* allude to this in the notion of "responsible decisions about actions" (U.S. Global Change Research Program, 2009), though they do not address carrying out such actions. Thus, there may be a need for a set of climate *citizenship* principles to guide climate change education, that clarifies the kinds of responsible actions citizens should be prepared and able to take, both individually and collectively, in order to help realize collective climate goals. Such an approach would align with a view of science literacy as functional (Zeidler & Kahn, 2014), which contends that becoming "responsibly scientifically literate" is a matter of developing the ability to *act upon* what one knows. Promising examples were highlighted in the U.S. Center's "Our Time To Lead: Youth Engagement on Climate Change" panel during COP-21, which included youth engaged in place-based climate solutions (NOAA Climate.gov, 2015).

At U.S. state levels, many states are in the process of shaping their approaches to climate change education, particularly as they consider adoption of the Next Generation Science Standards (NGSS), which would bring climate change into the science curriculum. In some states, where climate change is more politically contentious, the inclusion of climate change in the NGSS has become a reason to *avoid* adopting the NGSS. Insights from this study suggested that participants saw school-based science instruction and media use as highly important influences on their climate change understanding. Since media may not provide learners with the kinds of scientifically-supported information about climate change included in the NGSS, students in states avoiding the inclusion of climate change in state-level science standards may have less access to scientifically-supported climate change information, and less opportunity to become *climate literate* (U.S. Global Change Research Program, 2009).

States opting against adopting the NGSS might consider the other state-level efforts to promote climate literacy. This may also benefit states that *do* choose to adopt the NGSS, supplementing students' climate change learning beyond what is included in the NGSS. This may be important for preparing students to make "responsible decisions about actions" (U.S. Global Change Research Program, 2009), since the NGSS are clear in separating science from societal decision-making, stating that: "The consequences of… consumption of natural resources are described by science, but science does not make the decisions for the actions society takes" (e.g., MS-ESS3-4, NGSS Lead States, 2013). One example of such state-level efforts, which could be built upon to more explicitly include climate literacy, can be found in the Environmental Literacy graduation requirement in the state of Maryland, which includes an action component. Such efforts could promote interaction at local levels between formal and informal science education around climate change, and may find support under Title IV of the Every Student Succeeds Act (ESSA) that makes environmental education and environmental literacy programs eligible for federal funding.

Curriculum and instruction. This study also has implications for the areas of curriculum and instruction. First, if learners develop ideas about climate change both in school and out-of-school, it may be helpful for climate change educators to find out what learners already know about climate change, including concerns they may have. Roncoli et al.'s (2009) notion of climate change understanding as a matter of perceptions, knowledge, values, and responses might provide a more holistic way of envisioning climate change learning – moving beyond a singularly knowledge-focused approach. This may provide opportunity to use learners' interests and concerns as a basis for instruction, creating greater engagement with the topic of climate change.

I noted that the standard science curriculum in which students were engaged (e.g. assignments, assessments) did not provide me with information about students' concerns in relation to climate change. However, I was able to gain insight into these dimensions of learners' thinking through engaging them in a drawing activity *("Draw what comes to your mind when you think about climate change")* and in facilitated focus groups. Participants reported that they enjoyed discussing a science topic like climate change with their peers in the focus group setting, but had not engaged in this type of activity before in science. Since findings suggested that interactions with people in their immediate contexts were important for shaping learners' ideas about climate change, it would follow that curriculum and instruction should provide opportunities for such social interaction. This may be particularly valuable for interpreting and discussing visual information related to climate change, which was particularly compelling to learners in this study.

Another dimension of this study that may have implications for teaching and learning relates to issues of technology integration for climate change education. This study suggested that learners could connect to broader aspects of their conditions through technology (e.g., seeing video evidence on the news of climate change impacts in other parts of the world). Thus, it may be beneficial for curriculum and instruction that guides student engagement in both online research and experiential learning about climate change from local to global scales, including by facilitating opportunities for learners to gain insight into others' experiences with climate change (e.g., Stapleton, 2015). The adolescent students in this case study enjoyed using technology, and it played a major role in their everyday lives, particularly as students in a blended learning school. However, participants were sometimes skeptical about online information, suggesting that educator guidance in assessing the trustworthiness of online information about climate change may benefit learners in developing the ability to eventually make such judgments on their own – an ability of a climate literate person (U.S. Global Change Research Program, 2009).

In general, I noted that learners had a negative view of technology in terms of its connection to climate change exacerbation. It appeared that students could benefit from approaches to curriculum and instruction that fostered their understanding of the role of fossil-fuel based technology in exacerbating climate change, including understanding of the production of the energy they use on a daily basis. I believe they could also benefit from curriculum and instruction efforts highlighting how renewable energy technologies work, and their potential role in mitigating climate change. The U.S. Global Change

Research Program's (2012) *Energy Literacy Principles* may provide helpful guidance in this area.

Beyond interpreting information about climate change through their observations of technology use in the world around them as evidence of climate change exacerbation, learners in this study also interpreted directly observed changes in the natural world (e.g. hot temperatures, unusual weather) as evidence of climate change. Such interpretations could be an example of motivated reasoning (Kahan, 2013), in which students were making interpretations that supported their prior beliefs (in this case, the belief that climate change was already underway). It may also provide evidence of some confusion amongst learners regarding the difference between weather and climate. Curriculum and instruction could address this area of potential confusion by providing learners with opportunities to compare observed events with long-term trends. One such approach could entail recording data about observed events as part of a citizen science initiative related to climate change (e.g., Celebrate Urban Birds, Project BudBurst, CoCoRaHS). However, a challenge that persists is the reality that climate change is creating less predictable weather patterns (U.S. Global Change Research Program, 2014), complicating definitions distinguishing weather from climate such as "Weather is what you get; climate is what you expect" (NASA, 2005). That is, what we come to expect in the "climate change era" (Sharma, 2012) may be the unexpected. Such complexities underscore the challenging nuances of teaching and learning about climate change.

As suggested in this study, participants expressed alternative conceptions in relation to climate change. For example, students were aware that pollution from human activities was causing warmer temperatures, but did not provide scientifically-supported explanations of the greenhouse effect. Instruction focused on known alternative conceptions may be helpful. However, as science education leaders have noted, many core ideas in science, such as climate change and others included in the NGSS "are complex or even counterintuitive…[and take] time (sometimes years) to fully understand" (Keller, 2010). Thus, is unreasonable that a single school science unit, addressing climate change as only one aspect (e.g., *Weather and Climate*), would lead students to develop completely scientifically-supported explanations of climate change. Partnerships between the science and education communities, such as through the Climate Voices Science Speakers Network (climatevoices.org), could support student and teacher learning around the more complex aspects of climate change.

It may also be possible to increase attention to climate change in the science curriculum by addressing the topic beyond the traditional *Weather and Climate* unit. This may be especially important to realize the recommendation that climate change education should address aspects of the problem that interest learners and about which they care most. For participants in this study, these aspects included the life science dimensions of climate change, such as impacts for animals and human health. Though the NGSS locates climate change in Earth Science and not Life Science, there are opportunities for connections to life science when teaching about climate change, even while aligning with the NGSS. For instance, McGinnis, Breslyn, McDonald & Hestness (2013) identified a collection of NGSS standards that are *proximally* related to climate change – that is, they are related to climate change, but do not mention it explicitly. These standards provide opportunity to connect to climate change in other science disciplines beyond Earth Science, including Life Science. They also provide opportunity to introduce climate change ideas at grade levels prior to middle school, where the NGSS first *explicitly* mention climate change.

Using a figured worlds (Holland et al., 1998) theoretical perspective in this study, I examined how learners saw themselves in relation to climate change. These participants took the view that humans, including themselves and others, could and should change their behaviors to address climate change, as reflected in the *Everyday Hero*, *Social Influencer*, and (rarely) *Group Shifter* roles participants described. However, they did not see themselves as major contributors to the problem (i.e., in the roles of climate change *Villains*). When considering their own capacities to act, or *climate change agency*, participants were generally only aware of small-scale individual actions they could take, such as using less energy at home and school, (foregrounding their individual *Everyday Hero* identities).

This finding suggests that students may benefit from curriculum and instruction that introduces case studies profiling climate change mitigation strategies of which students may not be aware. This could include the study of promising climate change mitigation or adaptation strategies happening on community, national, or international levels – especially those that have involved young people (e.g. *Young Voices for the Planet* (http://www.youngvoicesonclimatechange.com); *Our Time To Lead: Youth Engagement on Climate Change* (https://www.climate.gov/teaching/climate-youth-engagement/events/our-time-lead-youth-engagement-climate-change-0)). Such examples may also help move students away from *Powerless* or *Victim* climate change identities toward a more empowered self-understanding. This may be especially important for learners in this age group (early adolescence), as prior studies have suggested that adolescents may become increasingly pessimistic about environmental issues as they get older (Hicks and Holden, 2007)

Finally, if as the Climate Literacy Principles state, a goal of climate change education is for learners to develop capacities as climate change *Communicators*, curriculum and instruction should create opportunities for students to practice communicating about climate change. Such efforts could incorporate opportunities for direct communication (e.g., talking with others at home or school) or indirect communication (e.g., raising awareness among broader audiences, such as online). In this study, learners were somewhat engaged in the former, by communicating with their families about climate change, but communicated with their peers to a limited degree, and did not yet communicate with broader audiences about climate change. This could be a product of their positionality as younger adolescents (11- and 12-years-old), not yet involved in social media. However, older learners may benefit from opportunities for online communication around climate change, including opportunities that enable them to engage in forms of service-learning by raising others' awareness. Finally, learners may benefit from opportunities to develop and practice their climate change identity and agency through community-based service-learning (McNeill & Vaughn, 2012).

Teacher education and professional development. To realize the curriculum and instruction recommendations articulated above, there are corresponding implications for science teacher education and professional development. First, science educators will need strategies for accessing information about students' perceptions, knowledge, values, and responses (Roncoli et al., 2009) in relation to climate change. Through this case study, I build on research (e.g., Shepardson et al., 2009; McGinnis & Hestness, in press) that suggests that drawings may be a valuable means for students to express their ideas about climate change. Teacher education and professional development may provide teachers with guidance on incorporating drawing as a diagnostic, formative, and summative strategy for assessing student perspectives on climate change (e.g., www.drawntoscience.org). I also noted that providing opportunities for students to discuss drawings through facilitated focus groups provided additional insight into student perspectives. Teacher educators might model such approaches as a means of providing opportunities to peer-to-peer interaction around climate change while accessing students' potentially divergent views on climate change.

In this case study, none of the participating students or parents resisted the scientific consensus view of climate change. Therefore, it does not provide direct insight into the ways in which educators might navigate their interactions with such audiences. However, this study affirms the argument that today's science educators should be well-prepared to teach the scientific consensus view on climate change. Plutzer, McCaffrey, Hannah, Rosenau, Berbeco, & Reid (2016) emphasized the importance of attending to teacher knowledge *and* values for teaching about climate change, noting that teachers of science may lack understanding of certain dimensions of climate change (e.g., extent of scientific agreement) and may feel compelled to "teach both sides" of the issue. In this case study, the classroom teacher collaborated with university-based climate change educators to address climate change in the 6th grade science classrooms, avoiding a "teach both sides" approach and focusing on teaching the scientific perspective. Toward this end, teacher education and professional development related to climate change should increase science educators' awareness of resources to support the teaching of a scientific consensus view on climate change. Some examples may include age-appropriate resources available on the CLEAN Network's (Climate Literacy and Energy Awareness Network) collection of educational resources (cleanet.org).

This study suggested that learners were able to connect with broader aspects of their conditions through technology. Therefore, teacher education and professional development should also support teachers in integrating technology into curriculum and instruction around climate change. This could include the use of citizen science mobile apps and online platforms that engage learners in monitoring aspects of local conditions to contribute to larger datasets. Such activities could provide opportunity for discussion around how locally observed weather and phenological events compare with data extending over larger spatial and temporal scales. Teacher education and professional development efforts could provide opportunities for teachers to practice the use of such resources (see http://www.climateedresearch.org/citizen-science/), and also engage in discussion with learners about weather and climate. Though the teacher in this case study did not show confusion about the differences between these concepts, the 6th grade learners and their parents did – often attributing singular instances of locally observed "strange weather" to climate change. Teachers should be prepared to engage in conversation with students about the appropriateness of drawing such conclusions from singular events versus larger data sets over larger spatial and temporal scales.

Finally, learners in this case study expressed strong emotions about climate change, especially regarding the threats it posed to things they valued. Emotions of sadness, frustration, and fear were accompanied by a view of self as *Powerless*, or lacking the capacity to act meaningfully on climate change. Educators should be prepared to deal sensitively with emotions such as fear and anxiety that learners may express as they learn about climate change. Ojala (2012a) found that action appeared to be a coping mechanism for some learners in dealing with such emotions related to climate change. Likewise, learners in this case study described their engagement or intention to engage in actions such as personal energy conservation, particularly through the expression of *Everyday Hero* identities. Contrary to the view that such individual actions are insignificant in large-scale problems like climate change, Willis & Schor (2012) found that conscious consumers were also the individuals most likely to engage in broader actions. This view would suggest that educators should be prepared to support learners' in cultivating their *Everyday Hero* (i.e., responsible individual) identities, but also to help expand their view of self as having the capacity to engage in action reaching beyond themselves (e.g., *Group Shifter* identities) (Chawla and Cushing, 2007). Resources in the areas of youth and service-learning may provide support for educators in this domain.

Research. This case study has implications for climate change education research, and sheds light on avenues for future investigation. First, the application of an anthropological perspective on climate change learning, including an examination of learners' climate change perceptions, knowledge, values, and responses (Roncoli et al., 2009) offered a holistic view of learners' climate change ideas. In doing so, this case study builds upon previous studies that have focused primarily on learners' science content knowledge in relation to climate change, by additionally attending to values, emotions, and actions in response to climate change. The application of the figured worlds (Holland et al., 1998) theoretical perspective offered a means of examining learner identity and agency in relation to climate change, which may have important implications for the actions today's young people ultimately take in response to climate change. I argue that there is a need for further research examining young people's relationship to climate change from a sociocultural perspective. For example, science education research may benefit from applying learning from anthropological research approaches that have examined the intersections of climate change and culture (e.g., Crate & Nuttall, 2009; Crate, 2011).

Insights from this case study suggested a complex network of direct and indirect influences from learners' conditions on their climate change perspectives. Ethnographic studies of a longer duration could provide additional insight on the ways in which young people's contexts shape their figured worlds of climate change, and conversely, how enactment of young people's figured worlds may come to reshape their contexts. This study was set in a school context, but sought to gain initial insight into potential influence of out-of-school contexts by asking learners about varied influences on their climate change ideas, and by including parent perspectives. Future studies might examine learners' engagement with climate change through fieldwork outside of school contexts, such as in the home and in informal science education settings (e.g., McNeill & Vaughn, 2012; Devine-Wright et al., 2004). For example, in this study, learners mentioned various media sources (e.g., television news, *Discovery Channel* programs, *The Weather Channel*, *The Disney Channel*, *The Lorax Movie*) that informed their perspectives on climate change. Investigations focusing in-depth on learners' engagement with media as it pertains to their climate change ideas may be of particular interest. This could include investigation of learners' interactions with various types of educational media on climate change.

This case study examined the ideas of learners in one particular context. Future research should also examine learners embedded in different geographic and cultural conditions. Crate (2011) called for anthropological researchers to engage in multi-sited ethnography to advance understanding of human engagement with climate change. Such multi-sited work could also benefit the science education community in the "global climate change era" (Sharma, 2012), particularly as it seeks to integrate climate change education into diverse geographical, cultural, and ideological contexts. Learners in this case study expressed similar values related to climate change as their parents, though often higher levels of concern. Future studies might further investigate parent-child views of climate change, particularly with children and teens of different ages, and among those embedded in contexts in which climate change may be a divisive topic. Such work could help provide insight into ways in which climate change science may be communicated in diverse contexts, responding to calls for the science education community to incorporate ideas from the science communication research community.

Finally, in taking a figured worlds approach, this study was interested in learners' climate change identity and agency. Learners in this study saw themselves as having multiple kinds of climate change identities. However, due to the study's relatively short duration, I was unable to document how learners enact these identities as they encountered varied situations in their lives over time, and which identities become most salient to learners as they further developed in their climate change understanding. While I acknowledge this as a potential limitation of my case study, I view my time spent engaging with public school students around climate change as significant, both because of the sensitive nature of climate change in U.S. public schools, and because climate change is typically only briefly addressed in secondary science classrooms (Plutzer et al., 2016). Future ethnographic studies examining the ways in which learners may come to reinforce or change their conditions would be of interest. In particular, understanding the conditions in which learners feel sufficiently empowered to act, and which identities are at play, could provide valuable insights for climate change education research.

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APPENDIX A

Climate Change Content Knowledge Assessment Instrument

1. Which of the following would cause Earth's average global temperature to rise?
    a. Changes in the length of seasons
    b. Changes in the thickness of atmosphere
    c. Changes in the amounts of gases in the atmosphere
    d. Changes in the amount of heat from Earth's molten core

2. A warmer global climate will impact:
    a. The temperature at the center of the Earth
    b. The shape of Earth's orbit around the Sun
    c. The amount of fossil fuels available
    d. Humans and Earth's ecosystems

3. Over the past several decades, the Earth has warmed faster than any other time period. What best explains this increase?
    a. The sun is releasing more heat energy
    b. There's an increase in volcanic activity
    c. Humans are generating more pollution
    d. The Earth's orbit around the Sun is changing

4. If humans continue to release carbon dioxide (CO2) into the atmosphere at the current rate, ecosystems may be damaged or destroyed. Which of the following actions can reduce the amount of CO2 released by humans?
    a. Produce less nuclear power
    b. Drive cars less often
    c. Use more fossil fuel
    d. Decrease littering

Why is your choice the best answer?**

5. There is strong evidence that there is more carbon dioxide (CO2) in the atmosphere now than in the past several hundred years. What is most likely the cause of the current increase in carbon dioxide?
    a. There's more toxic chemicals in the oceans and rivers
    b. Plants are releasing more CO2 (carbon dioxide)
    c. Volcanoes are producing more ash and gases
    d. Humans are using more fossil fuels

Why is your choice the best answer?**

6. Likely outcomes of climate change are:
   a. Ice sheets will grow larger in Arctic areas
   b. The temperature will rise equally around the world
   c. Ocean levels will rise, impacting people who live on the coast
   d. Earth's atmosphere will thin, especially in the Southern Hemisphere

Why is your choice the best answer?*

7. Which method below do you think would be the most effective strategy to reduce future damage from climate change to coastal communities?
   a. Insulate houses and buildings less
   b. Switch form nuclear power to fossil fuels
   c. Preserve wetlands along rivers and shorelines to absorb storm surge.
   d. Do nothing since no idea will work because climate change is outside of our control.

8. Scientists believe that global temperatures are rising primarily because of:
   a. An increase in the use of toxic chemicals such as pesticides and aerosol sprays.
   b. Increases in the amount of carbon dioxide (CO_2) from burning fossil fuels
   c. A hole in the ozone layer allowing heat to enter the Earth's atmosphere
   d. Excess heat given off from energy generation in nuclear power plants

Why is your choice the best answer?*

9. Not every action taken by humans contributes to climate change. Which of the following human activities does NOT contribute to climate change?
   a. Greater use of chemicals that destroy the ozone layer
   b. Rises in the number of people driving cars
   c. Greater rates of deforestation
   d. Larger demand for electricity

10. How is CO_2 (carbon dioxide) removed from the atmosphere?
   a. Factories need carbon dioxide to run
   b. Carbon dioxide breaks down naturally
   c. Carbon dioxide escapes into space
   d. Plants absorb carbon dioxide for food

Why is your choice the best answer?*

11. Where can scientists see evidence of climate change?
   a. Evidence can be seen only in areas that experience droughts
   b. Evidence can be seen only in the polar areas like Antarctica
   c. Evidence can be seen only in coastal areas by the beach
   d. Evidence can be seen in all of these areas.

12. Energy can be obtained from different sources. Which of the following forms of energy production releases the most carbon dioxide (CO2) into the atmosphere?
    a. Nuclear plants
    b. Windmills
    c. Oil and coal
    d. Solar power

13. Data collected by scientists indicate that the average global temperature is rising and will continue to rise in the foreseeable future. What actions could people in your community take to reduce the negative impacts of climate change?
    a. Buy organic produce like fruits and vegetables
    b. Prevent litter and pollution from entering rivers and oceans
    c. Plant more trees or reduce the number of trees being cut down
    d. Ban chemicals that break down ozone in the Earth's ozone layer

Why is your choice the best answer?*

14. What is the relationship between temperature and the Earth's atmosphere? The Earth's atmosphere:
    a. Blocks light from the sun to make the Earth cooler
    b. Holds heat energy from the sun to warm the Earth
    c. Has no influence so Earth's temperature doesn't change
    d. Strengthens heat energy to increase Earth's temperature

Why is your choice the best answer?*

15. Human activities and technologies are being developed around the world to slow the increasing rate of global climate change. What is one direct benefit of changing human behavior and using technology to reduce the impacts of climate change worldwide?
    a. Coastal areas would be less likely to flood
    b. Society will become more dependent on fossil fuels
    c. Endangered species will be better protected by laws
    d. There would be fewer cases of skin cancer in humans

16. How does the rate that humans produce greenhouse gases relate to how quickly they are being removed by plants?
    a. Humans are producing an equal amount to what is being removed by natural sinks, like vegetation and oceans.
    b. Humans are producing more than can be removed by natural sinks, like vegetation and oceans.
    c. Humans are producing less than is being removed by natural sinks, like vegetation and oceans.
    d. Scientists do not have enough evidence to compare the rates

17. Which of the following activities will lead to future intense storms?
    a. Ozone layer depletion
    b. Changes in the tilt of Earth's axis
    c. Variations in the energy put out by the sun
    d. Heat trapped by increased greenhouse gases

18. Climate change projections for the future are:
    a. Based on available data and predict future temperature with complete accuracy
    b. Based on available data and may actually be lower or higher than estimated
    c. Relatively uncertain because they are based on scientists' opinions, which can be wrong
    d. Not useful because it is impossible to predict what will happen in the future

Why is your choice the best answer?*

Notes:
* Students were asked to provide written explanations for two of the following items, depending on the version of the assessment they completed: 6, 8, 10, 13, 14, 18
**All students were asked to provide written explanations for items 4 and 5

APPENDIX B

Weather and Climate Unit Test Items Relevant to Climate Change

5. Which of the following reduces global warming? (1 point)
   - o Driving more frequently
   - o Reducing public transportation
   - o Reducing electricity use
   - o Cutting down forests

10. Which of the following is an effect of global warming? (1 point)
    - o Increased drought
    - o Falling sea levels
    - o Decreased coastal flooding
    - o Glacier spread

16. How does the glass of a greenhouse model the carbon dioxide and other gases in Earth's atmosphere? (1 point)
    - o The glass absorbs light and releases energy in the form of heat
    - o The glass allows light in and traps much of the radiated heat
    - o Plants in a greenhouse absorb energy from the sunlight and can grow through the winter
    - o The glass blocks incoming light and reduces the amount of heat absorbed by the plants inside.

19. What is global warming? What can people do to reduce global warming? (4 points)

APPENDIX C

Climate Change Drawing Protocol

Name: ____________________________

Climate Change Drawing

Instructions:

1. In the space below, draw what comes to your mind when you think about climate change. **Please include yourself in the drawing, and some details about how climate change relates to your life or your community (if you think it does).**

2. On the back of this page, write what you were trying to communicate through your drawing.

(Turn page over)

In the space below, write what you were trying to communicate though your drawing.

APPENDIX D

Teacher Interview Protocol

1. What are your reflections on teaching science, particularly environmental topics, this year to:
    a. Isabelle
    b. Autumn
    c. Richie
    d. Aliyah
    e. James
    f. Sophia
    g. Bobby
    h. Sarah

2. What ideas did students bring to the classroom related to the topic of climate change?

3. Do you have a sense of where their prior ideas came from?
    - Probe: Media/politics; school; personal experiences with climate change; parents/friends/peers; cultural values about environment, science, technology; other sources

4. What were the most important ideas about climate change you sought to convey in your teaching?

5. What is your sense of how students now think about the topic after instruction?
    - Probe: Perceptions, knowledge, values/concern, responses

6. Did students see climate change as relevant to their lives?
    - Did they see themselves (their community) as contributing to the problem?
    - Did they see themselves (their community) as affected by the problem?

7. Did students see themselves (their families, their communities) as responsible or capable of doing something about climate change?

8. How, if at all, do you think your students might influence their communities (e.g., their school, their family, their groups of friends, their neighborhoods) or incite change, now that they know more about climate change?

APPENDIX E

Student Interview Protocol

1. Please tell me a little about yourself and your family. [Probe: School experience, how long s/he has lived in the area, recreational activities, who s/he spends time with]

2. [Show climate change drawing completed by the student]. Can you tell me a little bit about what you were trying to show when you drew this?

3. When you think about climate change, do you think of it as something that is definitely happening? What makes you think it is/isn't happening?

4. When you think about what is causing climate change, what are some things that come to mind? How do those things cause temperatures to get warmer?

5. When you think about the effects of climate change, what are some things that come to mind?

6. Are humans involved in climate change? How so?

7. How do you feel about climate change? Have you always felt that way?

8. Do you think there is anything people could do about climate change?

9. Where have you heard information about climate change? What did you hear from those sources of information? [Probe: Family, friends, media, other cultural sources].

10. What sources of information would you trust when it comes to climate change? Are there any sources of information you wouldn't trust?

11. How has what you've learned in school helped you to understand climate change?

12. When you think about how you believe people should treat the environment, how does that relate to how you think about climate change?

13. Do you think science and technology have anything do to with climate change?

14. Can you tell me a little bit about how you chose to draw yourself in your drawing (or how you would include yourself in your drawing)? How do you see climate change as relating to your life or affecting your life? Your community?

15. Who do you think contributes the most to climate change?

16. In your view, is there anything you can do about climate change? Is there anything your family could do? Is there anything people your age could do? Is there anything communities and governments could do?

APPENDIX F

Parent Interview Protocol

1. Please tell me a little bit about yourself.

2. Do you and your child talk about environmental issues? How about the topic of climate change or global warming?

3. Did your child talk to you about anything s/he learned in Ms. Kane's class about climate change? Do you have a sense of your child's ideas about climate change?

4. What sources of information do you think influence her ideas the most about climate change?
   [Probe: Family, friends, school, media, other dimensions of culture]

5. Do you think that your child sees climate change and environmental issues as relevant to his/her life? If so, how?

6. Do you think there is anything your family could do to address climate change? What would you want your child[ren] to be able to do?

APPENDIX G

Focus Group Interview Protocol

Preparation:

- Set up round table with chairs
- Prepare packets of student drawings
- Remind students about completing their post drawings – provide additional copies, pencils

Procedure:

1. Introduce purpose:
    a. Help me understand how 6th graders are thinking about this topic of climate change. They take role of "expert panel" to provide their interpretations.

2. Introduce activity:
    a. Looking at several sets of drawings created by peers – discussing some questions about them. I noticed some things and drew some conclusions about what people were thinking – I want to see what you notice and hear what you think.

3. Discuss sets of drawings.

    a. Set A: Causes of climate change, human role in causes of climate change

    - *What do you interpret from the drawings in terms of what 6th graders see as the causes of climate change? The role of humans in these causes?*

    - *What is your reaction to what you see in the drawings?*

    - *Why do you think people drew these things? Where did people get their ideas?*

    - *What is the same/different about your own ideas about climate change) compared to what you see?*
        - *Do you think these drawings represent the most important causes of climate change? The most important ways humans are involved? Is anything missing?*

    b. Add Set B (they can still refer to Set A as well): Effects of climate change, how humans are affected by climate change

    - *What do you interpret from the drawings in terms of what 6th graders see as the effects of climate change? How human lives are affected by climate change?*

- *What is your reaction to what you see in the drawings?*

- *Why do you think people drew these things? Where did people get their ideas?*
  - *[Probe media for penguins on icebergs]*

- *What is the same/different about your own ideas about climate change) compared to what you see?*
  - *Do you think these drawings represent the most important effects of climate change? The most important ways humans are affected? Is anything missing?*

c. **Emotions about climate change/perceptions of climate change reality**

- *What do you interpret from the drawings in terms of how 6th graders feel about climate change?*

- *Why do you think 6th graders feel this way? How does it compare to how you feel?*

- *Do some people feel otherwise?*

  - *[Probe: Caring, not caring… Do you know anyone or have you heard of people who don't believe climate change is happening? Why do you think they believe this?*

d. **Relationship of self to climate change (identity and agency)**

- Look for the drawings where people chose to include themselves. What do you interpret from the drawings in terms of how 6th graders see climate change as related to their own lives?
  - Probe: effects (how they will personally be affected); how they are contributing to causes and solutions (why isn't the solutions part shown much – do you think people think there isn't much they can do? Why or why not? Do you think this is true?)

- *What is your reaction to what you see in the drawings?*

- *What is the same/different about your own ideas about climate change) compared to what you see?*

4. What is important for people (older generation, your generation, younger than you) to know about climate change? Why?

5. Redistribute blank drawing pages

APPENDIX H

Example of Analysis of Individual Student Data

Table A1.

Individual variation in most salient sources of information ("Sources of Information" analytic lens) within the three perceptual modes

	Influences within the perceptual mode: ***attending to information communicated by others***	Influences within the perceptual mode: ***observing human behavior***	Influences within the perceptual mode: ***observing changes in the natural environment***
Aliyah	TV news; educational media; classmates (reinforce ideas); science instruction	Electronics use (laptops); car use; energy saving	Hotter temperatures
Autumn	Internet; educational media; parents; grandmother; science instruction	Home energy use; personal stewardship actions	Hotter temperatures
Bobby	TV news; parents; grandparents; Internet;	Traffic; visible air pollution; smoking	Changes in weather
Isabelle	Parents; grandparents; TV news; television programs; Internet (Google, YouTube); science instruction	Electronics use; traffic; energy saving	Storms; changes at the beach; hotter temperatures
James	Brother; science instruction	Energy wasting; electronics use	Hotter temperatures
Richie	Educational media; science instruction; Internet; siblings	Renewable energy use;	Hotter temperatures
Sarah	Books; Internet; movies; parents; friends (reinforce ideas); science instruction	Car use; personal stewardship actions	Hotter temperatures
Sophia	Internet; mother	Personal stewardship actions; family members wasting energy; home energy use	Hotter temperatures

APPENDIX I

UNIVERSITY OF MARYLAND

INSTITUTIONAL REVIEW BOARD

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DATE:	March 30, 2015
TO:	Emily Hestness
FROM:	University of Maryland College Park (UMCP) IRB
PROJECT TITLE:	[704043-2] Middle School Science Learners' Climate Literacy Development
REFERENCE #:	
SUBMISSION TYPE:	Amendment/Modification
ACTION:	APPROVED
APPROVAL DATE:	March 30, 2015
EXPIRATION DATE:	March 22, 2016
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # *6 & 7*

Thank you for your submission of Amendment/Modification materials for this project. The University of Maryland College Park (UMCP) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

Prior to submission to the IRB Office, this project received scientific review from the departmental IRB Liaison.

This submission has received Expedited Review based on the applicable federal regulations.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Unless a consent waiver or alteration has been approved, Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others (UPIRSOs) and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of March 22, 2016.

Please note that all research records must be retained for a minimum of seven years after the completion of the project.

If you have any questions, please contact the IRB Office at 301-405-4212 or irb@umd.edu. Please include your project title and reference number in all correspondence with this committee.

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