Facing the Controversy: A Grounded Theory Study of How Teachers Plan to Address Climate Change in Their Classrooms

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Abstract
Climate change is a subject steeped in controversy. Addressing it in the classroom causes much anxiety for teachers as they struggle with how to teach it. The purpose of this grounded theory study was to uncover the information teachers deem most important to communicate to their students about climate change and the pedagogical strategies they plan to employ in doing so. This study analyzed the responses of 123 teachers who successfully completed an online climate change course. Each teacher provided qualitative data in the form of a response to a course assignment. Analysis of those responses revealed that teachers saw the paucity of vetted lesson plans and lack of time for planning and instruction as the greatest obstacles to effectively teaching about climate change. Few saw denialist opposition from parents as a significant obstacle. The abilities to draw a distinction between climate and weather, to explain carbon dioxide's role as a greenhouse gas, and to address the historical context of past climate change events were shared as critical information for students to master. However, the data revealed teachers are more likely to concentrate on creating a general awareness of climate change and its consequences than they are addressing any specific scientific content. It appears teachers would benefit from rigorous, content-based climate science courses that specifically target climate change misconceptions and that scientists should strive to make their work more accessible to teachers and the general public.

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Facing the Controversy: A Grounded Theory Study of How Teachers Plan to Address
Climate Change in Their Classrooms

By

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of the requirements for the degree
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Dedication

This work is dedicated to my beautiful bride, Sara, whose love, support, and patience knows no bounds. She is my inspiration, and took on the burden of managing our three children solo too many times to mention. Words cannot express the gratitude and love I have for her. I would also like to thank my three children, Jackson, Nolan, and Charlotte, for understanding when dad was grumpy, when he missed baseball games, bath and story time, or was just too busy to watch videos.

I owe a lot to my in-laws, David and Carol Morse, for always treating me like a son. The financial support they provided made this journey possible, and the encouragement they continue to provide is priceless.

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Biographical Sketch

Thomas Frankie is the Chief Operating Officer at Think to Lead LLC, a leadership consulting firm located in Westchester County, NY. Mr. Frankie works with dozens of major corporations, foundations, educational institutions, not-for-profits and individuals to help clarify goals and devise a blueprint to achieve them.

Tom is also a former Coordinator of Teacher Professional Development at the Wildlife Conservation Society. Based at the Bronx Zoo, Tom created nationally recognized, award-winning curricula for over 15 years.

Tom also has a broad set of experiences stemming from his work as an adjunct faculty member at several New York area universities, an editor for ABC Sports, and as a volunteer firefighter. He received his Bachelor of Arts degree in 1996 and his Master of Arts in Teaching degree in 2000, both from Fordham University. Tom began his doctoral studies in the St. John Fisher College Ed.D. Program in Executive Leadership at the College of New Rochelle in 2012. His research on how teachers plan to address climate change in their classrooms was supervised by Dr. Ronald Valenti and Dr. Christine Casey. Mr. Frankie received the Ed.D. degree in 2014.
Abstract

Climate change is a subject steeped in controversy. Addressing it in the classroom causes much anxiety for teachers as they struggle with how to teach it. The purpose of this grounded theory study was to uncover the information teachers deem most important to communicate to their students about climate change and the pedagogical strategies they plan to employ in doing so. This study analyzed the responses of 123 teachers who successfully completed an online climate change course. Each teacher provided qualitative data in the form of a response to a course assignment. Analysis of those responses revealed that teachers saw the paucity of vetted lesson plans and lack of time for planning and instruction as the greatest obstacles to effectively teaching about climate change. Few saw denialist opposition from parents as a significant obstacle. The abilities to draw a distinction between climate and weather, to explain carbon dioxide's role as a greenhouse gas, and to address the historical context of past climate change events were shared as critical information for students to master. However, the data revealed teachers are more likely to concentrate on creating a general awareness of climate change and its consequences than they are addressing any specific scientific content. It appears teachers would benefit from rigorous, content-based climate science courses that specifically target climate change misconceptions and that scientists should strive to make their work more accessible to teachers and the general public.
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Chapter 1: Introduction

Agencies throughout the U.S. government, including the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Association (NOAA) and the National Science Foundation (NSF) have voiced their support for increasing the public’s climate literacy (Cooper, 2011; Wise, 2010). More recently, the President of the United States has declared climate change to be an issue that needs to be addressed immediately (Landler, 2014). In line with that thinking, the Next Generation Science Standards (NGSS) prominently features the topic of climate change (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2012). However, as has been seen with the teaching of evolution, opinion polls suggest that many Americans reject the scientific consensus regarding climate change (Leiserowitz, Maibach, & Roser-Renouf, 2013). The result has been opposition to including climate change science in school curriculum. Climate change denialists are opposing the teaching of climate change science just as they have opposed the teaching of evolutionary science (Morrison, 2010). In fact, as of March of 2014, only nine states have adopted the Next Generation Science Standards, and Wyoming became the first state to block the Standards outright (Todd, 2014). Regarding that decision, Wyoming Representative Matt Teeters noted “[The standards] handle global warming as settled science, but there's all kind of social implications involved in that that I don't think would be good for Wyoming” (Todd, 2014).

Given the controversial nature of the topic, teachers will not only need to acquire the content knowledge and teaching methods for effectively teaching climate
change science, but they must simultaneously prepare themselves to confront the controversy and denialism that accompanies it.

To that end, the Wildlife Conservation Society (WCS) designed an online course aimed at providing teachers with the content knowledge and pedagogical strategies to minimize denialist claims and effectively teach about climate change. Through analysis of qualitative data in the form of participant responses to a specific assignment within that course, this study utilized the tenets of grounded theory to learn more about the primary issues surrounding how teachers plan to present the topic of climate change science in their classrooms.

**Problem Statement**

Climate change is arguably the most significant conservation challenge of the 21st century (Hilty, Chester, & Cross, 2012). It threatens the integrity of marine and terrestrial habitats and interrupts natural cycles such as migration and hibernation (Hilty, et al., 2012). In many parts of the world, climate change is limiting food production and driving up agricultural costs (Hansen, 2008). Some parts of the world are experiencing heavy downpours, flooding and storm surges, while others are suffering from increased drought and wildfires (Hansen, 2008). Climate change has in some way disrupted nearly all forms of transportation, including airports, roads, rail lines, and tunnels (Hansen, 2008) and catastrophic weather events are driving up insurance costs (Hansen, 2008). Infectious diseases, including vector-borne infections such as malaria, dengue fever, and food-borne infections have already demonstrated alterations in their geographic range and seasonality due to climate change (Cook & Karesh, 2008).
Recognizing that today’s students need to be prepared to face these challenges, the Next Generation Science Standards (NGSS), the newest set of national K-12 science standards, prominently features climate change. The NGSS were carefully designed to train students to become scientifically literate members of society (NGACBP, 2012). However, climate change denialists stand in opposition (Morrison, 2010). The Intergovernmental Panel on Climate Change (IPCC) unequivocally states that climate change is happening and it is “extremely likely” that human influence has been the dominant cause of the observed global warming (IPCC, 2013). In spite of the concrete scientific evidence, public opinion surveys consistently show Americans are less worried about the threat of global warming, less convinced that its effects will impact them directly, and are more likely to believe that scientists themselves are uncertain about its occurrence (Gallup, 2013).

Teachers are thus being asked to effectively teach a topic that they are unclear about themselves, may be uncomfortable addressing, and that is surrounded by political controversy. They are confused about what to teach, unsure what resources can be trusted (Wise, 2010), may potentially employ ineffective teaching strategies (Cotton, 2006), and are worried about possible repercussions from denialists (McCaffrey, 2012).

Given this scenario, the Wildlife Conservation Society (WCS) created an online course designed to equip teachers with the scientific knowledge and pedagogical skills needed to effectively teach about climate change and minimize denialism. This study aimed to use teacher responses to an assignment in that course to identify the primary obstacles teachers face in teaching climate change science and
uncover a theory concerning their ability to effectively address climate change and mitigate denialism in the classroom.

**Theoretical Rationale**

Sustainability theory, cultural theory, and social constructivism seem to be the major theories driving the research regarding the root causes of the climate change debate. WCS constructed its online climate course around narrative theory, believing it would prove helpful in arming teachers with a mechanism specifically to minimize climate change denialism. While these theories all prove effective to some extent, the uncertainty and rapid changes surrounding both climate change science and the mechanisms and methods for its instruction render them insufficient.

This study employed the tenets of grounded theory as a means of uncovering a framework, grounded in data, to most effectively help teachers teach about climate change in the face of controversy and denialism.

**Sustainability theory.** This theory is used primarily to examine the ways in which environmental problems negatively impact society (Jenkins, 2010). It operates under the premise that the health of economic and social systems is dependent upon a healthy environment (Jenkins, 2010). Its origins lie in the Brundtland Commission’s 1987 report to the United Nations General Assembly. The report called for “sustainable development,” which it defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987). Many researchers use sustainability theory to highlight the connections between
environmental degradation and the success or failure of human endeavors (Norton, 2005).

In terms of education, sustainability models often result in teachers taking on the role of “agents of change” (Cotton, 2006). Critics argue this is more the promotion of “green slogans” than it is instruction about scientific information or arguments. They claim teachers working under such a model simply persuade students to adopt specific views rather than teach a deeper understanding of the complexity of the scientific issues (Jickling, 1992). In fact, environmental education literature often explicitly encourages teachers to promote pro-environmental attitudes and behaviors (Cotton, 2006). Given the perceived debate concerning the authenticity of climate change, sustainability theory may be limited in its ability to address the real needs of teachers.

**Social constructivism.** Pruneau, Liboiron, and Vrain (2001) suggest climate change instruction must come from a critical socio-constructivism. Constructivists believe learners must construct their own knowledge in real-world contexts (Kanselaar, De Jong, Andriessen, & Goodyear, 2001). That is why Pruneau et al., (2001) found that while people may have difficulty understanding the science of climate change they are still willing to share their opinions about it. Such findings speak directly to the challenge teachers have of integrating the complexity of scientific understanding with the complexity of social responses to climate change (Vongalis-Macrow, 2010).

The ideas of Piaget, Vygotsky, and Dewey all contributed to constructivism, but researchers really began applying it to instruction in the early 1980s as a
mechanism for education reform (Kanselaar, 2002). Borrowing from Vygotsky, sociocultural theorists identify social groups and tools as the two entities that contain a body of knowledge. That knowledge cannot be separated from the group or tool (Kanselaar, 2002). For example, as a group, students need to construct their own knowledge of climate change by applying their prior knowledge and experience to the new knowledge presented by their teacher. Within the class, these individual ideas are then shared and either accepted or rejected. The students’ knowledge of climate change will therefore be a reflection of the social beliefs that exist within that class (Jonassen, Peck, & Wilson, 1999). This may or may not be helpful to teachers trying to minimize denialsim. To be effective, climate change pedagogy will need to examine the culture behind the relevant social beliefs.

**Cultural theory.** This theory attempts to explain how and why people come into conflict over risk (Thompson, Ellis, & Wildavsky, 1990). The founders of the theory, anthropologist Mary Douglas and political scientist Aaron Wildavsky, combined the definitions of culture from their respective disciplines to redefine it in terms of risk. This provided researchers with a new way of measuring group interactions (Thompson et al., 1990). Cultural theory does this by examining the two broad categories of group and grid.

The group category focuses on how closely people identify with one another. At one extreme are people who are grouped together due to some common characteristic, but who have little connection or sense of unity with the other members of the group. At the other extreme are the people who are connected by a
strong sense of identity and have strong, personal connections to other members of the group (Thompson et al., 1990).

The grid category focuses on the different roles people play within a group. At one end sit people who can work independently and can easily take on new roles. Distinct roles and specializations are filled by people at the other end (Thompson et al., 1990).

Within these two broad categories are four subdivisions of cultural orientation: (a) individualist, (b) egalitarian, (c) hierarchist, and (d) fatalist (Thompson et al., 1990). It is likely researchers are drawn to cultural theory when examining climate change because each of these categories provides a different orientation towards nature.

Individualists are people who, though relatively similar, have little obligation to one another (Rayner, 1992). Their differences are likely to be valued more than their similarities. They successfully avoid authority through self-discipline and self-regulation. Individualists believe nature is resilient; no matter what humans do to disrupt or destroy it, nature will always return to equilibrium (Mamadouh, 1999).

Egalitarians take the opposite view. They see nature as fragile and believe little can be done to remedy the harm humans inflict on it. To prevent such harm, individuals must voluntarily help others develop protective values. A strong value system can make external laws and central authority unnecessary (Mamadouh, 1999).

Hierarchs are strongly connected as a group, yet very different as individuals. They rely on institutions, hierarchies, and laws to regulate the actions of individuals.
According to Hierarchs, these institutions and laws allow us to control nature, but to do so we must rely on the expertise of specialists (Mamadouh, 1999).

Fatalist culture demonstrates sharp differences between the haves and the have-nots. Each has little sense of obligation to the other and a sense of apathy results from this lack of responsibility. Successful individuals attribute their success to their own merits and only tolerate others as examples that illustrate how successful they are in spite of others. Fatalists see nature as completely random, and believe there is little anyone can do to exert control over it (Mamadouh, 1999).

Given the way cultural theory examines how people interact and what roles they play within society, it is often looked to when researchers are attempting to explain the mechanisms behind variation in opinion (Kahan & Braman, 2003). Social consensus on climate change does not exist. Surveys of the American public going as far back as 1989 show great variability in terms of support for the idea that global warming is real, that human activities cause it, and that news reports on it are correct (Gallup, 2013). Public concern over climate change last peaked between 2006 and 2008, but receded in 2009 and 2010 as the percentage of the population remaining skeptical of the science has increased (Hoffman, 2012). Students look to their teachers as the most trusted sources of information. If teachers are consumed by uncertainty as well, they may turn to the mainstream media and the Internet where information is readily available, but poor information and misconceptions are common (McBean & Hengeveld, 2000).

Cultural theory fails to adequately address the influence the structure of a message may have on the perception of the problem. Thus, another theory is needed
to help address this deficit. WCS believed narrative theory would be able to fill this gap, and built their online course accordingly.

**Narrative theory.** The telling of stories is a basic human strategy for making sense of complex, natural phenomena. Narrative theory examines how the accounts of an event can be common, yet profound. It looks at how people use stories to make sense of the world. It also investigates how individuals make sense of the stories they tell and hear (Herman, Phelan, Rabinowitz, Richardson, & Warhol, 2012).

Vladimir Propp is regarded as the “father” of narrative theory, which has its roots in literature studies (Herman et al., 2012). By studying folktales, Propp suggested characters and their actions can always be categorized into specific roles and functions. In this way, similarities exist in very different stories (Norris, Guilbert, Smith, Hakimelahi, & Phillips, 2004). Tzvetan Todorov contributed the idea of equilibrium to the theory. Todorov argued stories begin in a state of equilibrium and are disrupted by an outside force that must be countered to return to equilibrium (Norris et al., 2004).

Narrative theory has traditionally been applied as a mid-level theory falling under the larger theories of structuralism and post-structuralism (Jones & McBeth, 2010). Poststructuralists argue each story is unique, so using it to reach generalized conclusions is impossible (Fischer, 2003). Structuralists argue that while unique, each story contains broad, general components that allow generalizations to be made (Genette, 1980). As a result, structuralists attempt to apply these generalizations to different contexts to learn more about human behavior (Herman, 2009).
Within narrative theory sits the knowledge-deficit model. It describes the transfer of information from experts to the public and the likely misconceptions that can arise therein. For example, Kellstedt, Zahran, and Vedlitz (2008) posited that under this model, scientific information about risk is correct and objective, but the public’s perception of risk is both inaccurate and subjective. Both data concerning scientific understanding and public opinion concerning climate change support his argument. In short, the knowledge-deficit model demonstrates that the public’s lack of accurate knowledge results in the division between public and scientific opinion about climate change.

A second model looks at the role of media in creating misunderstanding. Researchers contend the mainstream media tends to focus on conflict and debate (Graber, 1997), instead of neutrally and objectively reporting scientific findings. This “sensational media model” focuses on how narratives are structured and delivered (Graber, 1997).

For accurate science to truly resonate with students (and the public), those individuals must become media literate. Likewise, for science to effectively reach the public, both scientists and science teachers must become media literate as well (Cooper, 2011). Controversial issues like climate change require students to be able to critically examine the information and consider the beliefs or values behind that information (Cotton, 2006). To teach students how to do this, teachers must be aware of the beliefs and values they bring to the lesson (Cotton, 2006). In other words, classroom discussion must move beyond the focus on scientific facts and begin to include the cultural underpinnings involved in the topic.
Hoffman (2012) advocates a number of key techniques teachers should employ to help combat denialism. The first is to avoid the ideological extremes at both ends and approach the problem from the middle, where consensus-based debate is more fruitful (Hoffman, 2012). He advises teachers to avoid presenting climate change as a binary question, but instead, to focus on the specific questions scientists are asking (Hoffman, 2012). Climate change uncertainty needs to be replaced with climate change risk, so students can understand the consequences of ignoring that risk (Hoffman, 2012). Interestingly, this is the very strategy employed by the IPCC in their latest report (IPCC, 2014). Hoffman also explains that as a highly complex scientific topic, climate change science must be presented using language that the public can easily understand (Hoffman, 2012). Whatever strategies teachers employ, they must continually remind students of the responsibilities the science community has within society and train them to communicate science effectively to lay audiences (McBean, & Hengeveld, 2000).

**Grounded theory.** The theories discussed above, while effective in some ways, do not sufficiently address the problem of mitigating or even minimizing denialism. This may be largely due to the fact that climate change science is in constant flux and the interdisciplinary nature of the topic makes it difficult to apply any one specific pedagogical strategy. What is needed is a way of looking directly to the data for the answers concerning how to address the problem of teaching about climate change while simultaneously minimizing denialism.

Grounded theory was developed by sociologists Barney Glaser and Anselm Strauss (Strauss & Corbin 1994). Over time, they have built on the theory separately,
forming the Glaserian and Straussian schools of thought. The major difference between them involves how the primary research is conducted. Glaser believes researchers should approach the study with an empty mind and allow theory to emerge (Onions, 2006). Strauss believes the researcher needs a general understanding of the topic, and should use structured questions to help theory emerge (Onions, 2006). In either case, research procedures, data collection, and data analysis lead to the development of a new theory. These features allow the researcher greater freedom to explore the data and allow issues within the context of the topic to emerge (Bryant, 2002).

More recently, Charmaz (2006) identified a number of features evident in effective grounded theory. These include collecting and analyzing data simultaneously, coding data independent of pre-existing conceptualizations, identifying basic social processes in the data, and integrating data categories into a new theoretical framework (Charmaz, 2006). Charmaz presents a constructivist approach to grounded theory, emphasizing that data are constructed by both the researcher and the subjects simultaneously (Charmaz, 2006). She argues this is nearly unavoidable, given the interactions that take place between the researcher and the study’s participants (Charmaz, 2006). The researcher’s perspectives, values, and even geographical location impact those interactions, and by extension, the data that are collected (Charmaz, 2006).

Climate change is a complex issue surrounded by controversy, misconception, and political agendas. The theories discussed above uncover many of the issues that contribute to misconceptions surrounding the science of climate change and climate
change denialism itself. The additional allowance grounded theory makes for the accommodation of various issues within the same study is likely to uncover elements of the problem not addressed by other theories. (Glaser & Strauss, 1967).

Researchers agree classroom discussion must move beyond the focus on scientific facts and begin to include the cultural underpinnings involved in climate change studies. Hoffman (2012) advises teachers to do so by focusing on the specific questions scientists are asking. By doing so, students will be focused, as are scientists, on the risks posed by climate change and on the consequences of those risks. Thus, uncertainty fades to insignificance (Hoffman, 2012). Understanding can be bolstered by personal stories students can bring to the discussion. Such narratives would also present this highly complex topic in language that the students can easily understand (Hoffman, 2012).

The climate change course designed by WCS presents course participants with the opportunity to tell their stories about climate change and describe what they believe is most important to know about the topic. Analysis of these stories within a grounded theory framework served to both help the researcher better understand the role narrative can play in combating denialism and uncovered a new theory for how to approach the teaching of climate change.

**Statement of Purpose**

This study applied the tenets of grounded theory in an attempt to reveal the mechanics of how teachers will approach the teaching of climate change through the analysis of personal opinion. The purpose of the study was to uncover the details
concerning how teachers will address and respond to the controversy surrounding the
topic of climate change as it is introduced to the curriculum.

Research Questions

1. How comfortable are teachers addressing climate change in their classrooms?

2. What do teachers view as most important to communicate to their students about climate change, and to what extent is that consistent with the opinion of climate change experts?

As analysis of the data progressed, a third research question emerged:

3. What pedagogical strategies do teachers predict will be most effective for teaching about climate change and minimalizing denialism?

Significance of the Study

Climate change has already begun altering what we can expect and prepare for in terms of weather and climate (Hilty, Chester, & Cross, 2012). As President Obama recently remarked, “climate change is no longer a distant threat, but has moved firmly into the present” (Landler, 2014). Today’s students need to be prepared to face the challenges climate change is going to present in the future (Wise, 2010). Yet much of the American population continues to either deny climate change exists or discounts the role humans play in contributing to it (Gallup, 2013). Social, cultural, political, and ideological issues can hinder the ability of teachers to deliver scientifically sound knowledge of climate change (McBean, 2000).

Climate change science is constantly evolving and its interdisciplinary nature makes it difficult to effectively apply any one specific pedagogical strategy
(Vongalis-Macrow, 2010). These factors render the major theories driving research in this area insufficient for combating climate change denialism. By accommodating various issues within the scope of a single study, grounded theory may be able to uncover elements of the problem not addressed by other theories. (Glaser & Strauss, 1967).

Grounded theory allows for looking directly to the data to help us better understand the role narrative can play in combating climate change denialism and addressing the controversy surrounding the topic. By identifying the core obstacles teachers face in addressing climate change and comparing what those teachers deem important to teach with what experts have identified as important, this study aimed to uncover a new theory that can inform the design of pedagogical strategies to most effectively teach climate change science in the face of controversy and denialism.

**Definition of Terms**

The broad topic for this study is an examination of the strategies used by teachers to both teach climate change science and minimize denialism in their classrooms. The following definitions are provided to ensure uniformity and understanding of these terms throughout the study.

Scientifically, *climate change* refers to the major changes in temperature, precipitation, or wind patterns that are and have been occurring globally over the past several decades. For purposes of this study, *climate change* will additionally refer to the classroom topic that encompasses the teaching of the science present in the overall definition.
Climate literacy is an understanding of how humans impact climate and how climate impacts society. Climate-literate people understand how earth’s climate system works, how to evaluate scientifically credible information about climate, how to communicate about climate and climate change in a meaningful way, and is able to make informed and responsible decisions with regard to actions that may affect climate (NOAA, 2009).

The concept of denialism in science was largely developed by Mark Hoofnagle, who defined it as, “the employment of rhetorical arguments to give the appearance of legitimate debate where there is none” (Scudellari, 2010). The ultimate goal of denialism is to reject a proposition on which a scientific consensus exists (Scudellari, 2010). The operational definition in this study will specifically refer to the act of denying global temperatures are increasing and that human activity is a large contributor to that increase.

Similarly, for purposes of this study, a denialist is any individual who believes human activity has little to do with global temperature increases and/or questions the validity of the science evidencing climate change is occurring.

The word teacher as used in this study refers to any individual disseminating climate change information to others in a classroom setting. This includes classroom teachers from Kindergarten through higher education as well as informal instructional settings such as nature centers, zoos, aquariums, or museums.

Chapter Summary

In an effort to address the paucity of climate literate Americans, the Next Generation Science Standards (NGSS) prominently features climate change science
as a topic essential for a complete science education (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2012). However, opinion polls continue to demonstrate that many Americans reject the scientific consensus regarding climate change (Leiserowitz, Maibach, & Roser-Renouf, 2013). The result has been opposition to including climate change science in the curriculum (Morrison, 2010). Teachers must not only acquire the content knowledge and teaching methods for effectively teaching climate change science, but also strategies for minimizing the denialism that is sure to arise.

This study utilized the tenets of grounded theory to examine qualitative data provided by 123 teachers who participated in a climate change themed online course. Such analysis allowed the researcher to learn more about the primary issues surrounding how teachers plan to address the topic of climate change science in their classrooms.

The review of literature (Chapter 2) examines what experts believe students must know about climate change, the role of media in manufacturing a controversy surrounding climate change, typical pedagogical strategies for minimizing denialism, and implications for teacher professional development. Chapter 3 presents the research design methodology, including the qualitative approach of this grounded theory study. Chapter 4 reports the study’s findings and provides a thorough analysis. Finally, Chapter 5 then provides the implications of the findings, suggested recommendations, and the study’s limitations.
Chapter 2: Review of the Literature

Introduction and Purpose

In response to the overwhelming governmental support for increasing the scientific literacy of the American public (Cooper, 2011; Wise, 2010), the National Research Council (NRC), National Science Teachers Association (NSTA), American Association for the Advancement of Science (AAAS), and Achieve Inc. collaborated to create the Next Generation Science Standards (NGSS), the most current set of national K-12 science standards (Next Generation Science Standards, 2013). The NGSS prominently features climate change science. Despite scientific consensus on the matter, opinion polls suggest that many Americans continue to question the existence of climate change and the validity of the science behind it (Leiserowitz, Maibach, & Roser-Renouf, 2013; Morrison, 2010). Denialists are opposing the teaching of climate change science just as they have opposed the teaching of evolutionary science (Morrison, 2010). Teachers are facing the prospect of having to teach a topic for which they have inadequate content knowledge and that is surrounded by controversy. They are unsure what exactly to teach or how to teach it (Cotton, 2006). They have difficulty finding trustworthy resources and are worried about the overall controversy itself creating tension with parents, school boards, or students (McCaffrey, 2012).

Teachers will need to prepare themselves for these challenges before they can be expected to effectively address climate change science in their classrooms.
Review of the Literature

Experts agree that climate literacy should be a priority of all citizens. A solid understanding of climate change science is essential if we are to effectively address the economic and environmental challenges while leveraging the opportunities climate change will bring (National Oceanic and Atmospheric Association, 2009). To be climate literate, a person must understand how their actions individually influence the climate, and how climate influences them and society (NOAA, 2009). Climate literacy begins with an understanding of climate as a system and how changes to even one piece of the system cascades into climatic and environmental changes and feedbacks (Shepardson, Niyogi, & Roychoudhury, 2012). Once that is understood, one must obtain the knowledge of how to evaluate scientific information about climate, learn to effectively communicate about climate and climate change, and begin to make informed and responsible decisions with regard to actions that may affect climate (NOAA, 2009; Shepardson et al., 2012).

What the experts say. In an effort to promote greater climate literacy, multiple science agencies and non-governmental organizations, including the National Oceanographic and Atmospheric Association (NOAA), the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), the Smithsonian Institution, and the Association for the Advancement of Science joined with individual climate scientists to produce a guide of principles and concepts judged to be essential for one to understand climate science and be considered climate literate (NOAA, 2009). These concepts are briefly described below.
**The importance of the sun.** Climate literate individuals understand the sun is the primary source of energy for earth’s climate system (NOAA, 2009). The greenhouse effect is where gasses in the atmosphere trap heat from the sun, warming the earth and making it habitable. They also realize that concentrations of greenhouse gasses are increased and global warmth amplified by burning fossil fuels, destroying forests, and altering land cover mosaics (Haig, 2013). Changes in the sun’s intensity due to fluctuations in solar activity do impact the earth, but the effects are too small to account for the global mean warming scientists continue to record (Haig, 2013).

**How climate is regulated.** As mentioned above, being climate literate involves an understanding of the earth’s climate as a complete system. The climate system is regulated by complex interactions among the sun, the ocean, clouds, ice, landmasses, and living organisms (NOAA, 2009). Any significant change to even one of these components can influence the equilibrium of the entire system. For instance, oceans currents distribute heat and water vapor across the earth. As polar ice melts, the influx of fresh water causes changes to these currents that can lead to abrupt changes in climate (NOAA, 2009).

**Climate’s connection to living things.** To be climate literate, we must understand the connection climate has to biodiversity, the sum total of living things in a given area. All living things are adapted to the very specific climate conditions in the area they inhabit. If conditions in that area move outside those climate parameters, the organism must migrate to a new area or adapt to the changes; otherwise it will die (Bellard, Bertelsmeier, Leadley, Thuiller, & Courchamp, 2012). The climate literate person understands this connection. They are aware that past climate change events
were accompanied by mass extinctions, and can easily infer that future climate change events will result in extinction as well (Moritz & Agudo, 2013).

**Climate variability.** The climate literate person knows that changes in climate may be natural or human induced (NOAA, 2009), but in either case, climate differs from weather. Being climate literate means being able to readily distinguish climate from weather (NOAA, 2009). Climate includes the long-term, average weather conditions for a given region. Though it can be variable in that abnormal weather events may be strung together for a short period (as in a heat wave), climate remains predictable, and tells us what to expect for a given region (Rosenlof, Terray, Deser, Clement, Goosse, & Davis, 2013). Climate change becomes evident when regular patterns of weather cause our expectations to be altered (Rosenlof et al., 2013).

**How we understand the climate system.** Earth’s climate system is governed by physics, so careful scientific study can help us understand it. Climate literacy includes the ability to understand how science works. Scientists make and use observations and real-time data collection and analysis to design models and conduct experiments aimed at better understanding how the climate system works (NOAA, 2009).

**The role of human activity.** Human activities are impacting the climate system significantly (IPCC, 2013). The burning of fossil fuels has increased the concentrations of greenhouse gases and contributed to a warming of the atmosphere. Carbon dioxide in particular has increased to levels that will cause warming to increase into the next century, even if all burning of fossil fuels were to halt immediately (IPCC, 2013).
Consequences of climate change. Climate literate individuals understand climate change will have consequences for the earth system and for human lives (NOAA, 2009). As the ocean warms in response to climate change, it expands. At the same time, melting glaciers and polar ice sheets add millions of gallons of fresh water into the oceans (Larnicol et al., 2013). All cause sea levels to rise (NOAA, 2009). Understanding sea level variability is key to being climate literate (NOAA, 2009).

As sea levels rise, coastal areas become more susceptible to flooding (Sallenger, Doran, & Howd, 2012). Changing precipitation patterns are altering the availability of fresh water for human consumption (Vaghefi, Mousavi, Abbaspour, Srinivasin, & Yang, 2013). Extreme weather events, such as hurricanes, floods, wild fires, and tsunamis are occurring more frequently, causing more damage to property, and resulting in greater loss of life (Zwiers, 2013). As the ocean absorbs carbon dioxide, it grows more acidic, impacting the entire ocean food web (Yool, Popova, Coward, Bernie, & Anderson, 2013). As species migrate, they bring with them infectious diseases for which other species, perhaps even humans, have no immunity (Hilty et al., 2012).

The above constitutes what experts currently consider the essentials of climate literacy; facts every American should know and understand (NOAA, 2009). Sadly, the American public suffers from a severe deficit of climate literacy in particular, and scientific literacy in general (Sterman, 2011).
Lack of science literacy. According to the American Association for the Advancement of Science (AAAS), a science literate person is someone who is aware that

- science, mathematics, and technology are interdependent human enterprises with strengths and limitations, who understands key concepts and principles of science, who is familiar with the natural world and recognizes both its diversity and unity, and who uses scientific knowledge and scientific ways of thinking for individual and social purposes (1989, p. xvii).

Studies consistently show the American public lacks scientific literacy skills (Kutner, Greenberg, Jin, Boyle, Hsu, & Dunleavy, 2007). This makes accurate interpretation of scientific reports virtually impossible for the public (Sterman, 2011). Much of the blame rests with how science has traditionally been taught in schools. Teachers tend to teach in the same style in which they learned, focusing on memorizing information and the explanations of phenomena provided by experts. Their experiences as students shaped their own teaching (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Despite a recognized need to incorporate socially relevant science into instruction, most science teaching remains the simple dissemination of factual content (Gray & Bryce, 2006). Science teachers continue to view science as completely objective and thus rarely introduce opinion or ethical aspects into their lessons (Levinson & Turner, 2001).

In spite of having access to information from a variety of sources, textbooks remain the student’s primary source of knowledge (Lumpe & Beck, 1996). Lumpe and Beck (1996) found up to 75% of classroom instruction and 90% of homework is
based on textbook readings. In fact, it is likely the reliance on textbooks directly hinders students’ ability to become truly scientifically literate, since they are written in prose that is unreservedly accepted (Penney, Norris, Phillips, & Clark, 2003). Such writing stands in stark contrast to the language found in scientific research writing.

Lab activities where kids actually get to conduct research typically fail to support scientific literacy as well. Labs tend to be used by teachers to confirm known outcomes (Bowen, 2008). Thus, labs simply teach students to expect unambiguous outcomes or relationships and that there are always strong associations between variables (Bowen, 2008). Such instruction deprives students of both the faculty to understand actual scientific studies where random variables are the norm (such as found in climate change science) and of the experience of reading the discussions among scientists about such data (Bowen, 2008).

The result is a public that can recite scientific facts, but has little true understanding of the nature of science. In his examination of how adolescents consider socio-scientific issues, Fleming (1986b) found that 91% of students used scientific terminology to answer a technical question. Few students, however, used scientific knowledge to justify their opinion when asked to defend their position on a scientific issue (Fleming, 1986b).

In recent years, science teachers have begun calling for the inclusion of socio-scientific issues in the science curriculum. A number of federal authorities agree, indicating science teaching should more explicitly emphasize the “nature of science” as a means for promoting science literacy (Bell, 2003). The reasoning is that by developing an understanding of how science works, citizens will be better able to
distinguish good science from bad and apply scientific knowledge to their everyday lives (Bell, 2003). Support for the development of a climate literate public is evidenced by the recent endorsement of the publication *Climate Literacy: The Essential Principles of Climate Science* (National Oceanic and Atmospheric Association, 2009) by 13 different federal agencies.

**A manufactured controversy.** The deficiency in scientific literacy is particularly damaging to complex topics like climate change. Given that many science teachers have limited knowledge concerning the nature of science, they may also have, and even teach, misconceptions (Abd-El-Khalick, Bell, & Lederman, 1998). The controversy surrounding a topic like climate change may generate confusion and uncertainty about the state of the science for these teachers and, by extension, their students. Fearing objections about the content of their instruction, or simply being unsure about what content to present, teachers may avoid the topic altogether (Wise, 2010).

An informal survey of 800 National Earth Science Teachers Association (NESTA) members revealed climate change is second only to evolution in triggering protests from parents and school administrators (Reardon, 2011). Opinion polls suggest that the scientific consensus about both evolution and climate change is rejected by many Americans. What’s more, well-organized and financed campaigns are supporting this climate change denialism (Morrison, 2010).

Given these facts, it is reasonable for teachers to fear that public controversy around climate change could cause disruption in their classrooms (Morrison, 2010). Social consensus on climate change does not exist. Even when confronted by solid
science, surveys show that the American public distrusts the science and has grown increasingly skeptical of the threats climate change poses (Gallup, 2013; Hoffman, 2012). The public relies heavily on the mainstream media and Internet for information, two entities that are rife with poor information and misconceptions (McBean & Hengeveld, 2000).

The most powerful tool scientists possess for challenging poor science is the academic practice of peer review. Such a process is unfamiliar to the public, however. Most people view the process of debating a topic as evidence that there are two equally strong sides to an issue (Ceccarelli, 2011). Climate change deniers take advantage of this assumption and neutralize the power of peer review by painting such practices as a mechanism for suppressing dissenting views (Ceccarelli, 2011). Since the public typically consider all scientific viewpoints as equally valid (Corbett & Durfee, 2004), skeptics, even if few in number, can have great influence (Boykoff & Boykoff, 2004) and create the illusion of controversy. According to Ceccarelli (2011) “a scientific controversy is ‘manufactured’ in the public sphere when an arguer announces that there is an ongoing scientific debate in the technical sphere about a matter for which there is actually an overwhelming scientific consensus” (p. 196). Many researchers believe skeptics of climate change have taken advantage of this phenomenon, deliberately disseminating misleading information to manufacture a controversy (McCright, 2007; Pooley, 2010). In one recent example, the Heartland Institute funded a nationwide literature distribution from the Nongovernmental International Panel on Climate Change (NIPCC), a fictional organization. The information was an intentional misrepresentation of the most recent International
Panel on Climate Change (IPCC) report, aimed at confusing and misleading educators and others less informed of the science and the role of the IPCC (B. Moravchik, personal communication, October 30, 2013).

In addition, the acknowledgement by scientists that there is still more to learn about a topic is often interpreted to mean they do not know anything about the topic (Pollack, 2003). Such uncertainty provides the opportunity climate denialists need to manufacture controversy, and the media often helps them do it.

**The role of the media.** In his examination of how the press covers scientific topics, Nelkin (1995) claims the public understands science “less through direct experience or past education than through the filter of journalistic language and imagery” (pp. 2-3). In fact, even when people experience severe weather events, their connection to the science behind the event tends to come from the media (Corbett & Durfee, 2004).

Scientists were initially the primary sources of information about climate change, but that role shifted to politicians and interest groups by the late 1990s (Williams, 2001). With Internet access readily available in even remote locations, it is no surprise the popular media is now considered the most easily accessible source of science information (Lewenstein, 2001). Surveys confirm the vast majority of people receive their information about climate change from the popular or mainstream media (McBean & Hengeveld, 2000). Since a debate always involves at minimum two sides on an issue, media outlets ensure both sides are given equal representation and equal time (Ceccarelli, 2011). Fringe ideas presented by a minority of scientists often receive as much media exposure as the consensus among mainstream climate
scientists (Boycoff, 2008). The result is the illusion that there is a lot of disagreement among scientists over whether climate change is even happening (Ceccarelli, 2011).

In matters of controversy, reporters are trained to equitably present the respective views of representatives of each side (Dunwoody & Peters, 1992). In their effort to be fair and avoid bias, reporters present the most compelling arguments of both sides with equal weight. This is highly problematic when reporting on scientific content, because it results in reporters presenting competing points of view as though they have equal scientific weight, when in actuality they may not (Gelbspan, 1998). Boykoff and Boykoff (2004) found that most mainstream press accounts of climate change in the US used the balanced approach, giving equal weight to the opposing arguments that either humans were contributing to global warming or that the warming was exclusively due to natural fluctuations (Boykoff & Boykoff, 2004).

Though the scientific community has reached a consensus on the issue, the adherence to the journalistic norm of balanced reporting has thus led to biased coverage (Ceccarelli, 2011). Climate change deniers continue to exploit the media’s use of fairness to force scientists into a false public debate. The instinctive response is to deny and ignore the debate, and only emphasize the science (McCaffrey, 2012). Denying the existence of a controversy, however, essentially concedes the debate and may be used to confirm the charge that scientists are conspiring to silence the opposition (Ceccarelli, 2011).

While journalists may carefully investigate their topics, few have a strong science background (McBean & Hengeveld, 2000). Wilson (2000) specifically studied reporters’ knowledge of global climate change. He discovered that many
reporters were confused about the basic science surrounding climate change and few were aware of the certainty among scientists concerning humanity’s role in its cause (Wilson, 2000). Thus, these reporters tended to be confused about climate change, exaggerated the debate, and underplayed the consensus (Wilson, 2000).

To ensure quality information reaches the public, McBean and Hengeveld (2000) argue that the science community must be more effective at working with the popular media to ensure that the information disseminated is accurate and presented with integrity. They suggest scientists create and maintain web sites to which journalists can turn for authentic information and make themselves available to journalists for advice, clarification, and guidance. (McBean & Hengeveld, 2000).

Climate change deniers have thus far made more successful use of the media than the scientific community has. Not only have they created the illusion of controversy, they have also successfully polarized the issue politically (McCaffrey, 2012). Climate change is an international crisis, and as such, it forces people to confront new beliefs and unfamiliar worldviews. The politicization of the topic pits cultural communities who perceive their values to be threatened by change against cultural communities who perceive their values to be threatened by the status quo (Hoffman, 2012).

In 2011, the National Science Teachers Association (NSTA) surveyed its members concerning climate change skepticism. The survey found that 82% of the 600,000 NSTA members reported having faced climate change skepticism from students and 54% faced skepticism from parents.
Fearful of public and political controversy, teachers who do include climate change in their curriculum may gravitate toward the chief strategy used for teaching another controversial topic: evolution. In this vein, they opt to teach “both sides” of climate science, introducing climate change as being caused by human activities, but also offering the possibility that climate change may be solely due to natural cycles (McCaffrey, 2012). In doing so, they make the same mistake as well-meaning journalists. By taking a topic where there is a scientific consensus and entertaining an opposing side in an attempt to provide balance and objectivity, students are left unable to evaluate where the balance of evidence lies (Corbett & Durfee, 2004).

**Climate change as a controversial topic.** Scientifically speaking, teachers who adopt such strategies set out on a dangerous path. Teaching about climate change is substantially different from teaching evolutionary science. Most notably, there is no fundamental religious argument for keeping it out of the curriculum (McCaffrey, 2012). Since, unlike the topic of evolution, there is no constitutional concern related to teaching both sides of the climate change debate, many teachers adopt that approach (McCaffrey, 2012). However, what makes climate change science unique is that unlike other controversial topics (such as evolution, nuclear energy, or cloning) the validity and not just the application of science is at issue (Wise, 2010). Other controversial topics tend to involve questions about how to apply scientific knowledge (Wise, 2010). When teaching these controversial topics, teachers tend to communicate the material very traditionally, presenting conventional, non-contentious views of the science (Gray & Bryce, 2006). Climate change, however, is different because it involves questions about the validity of the science itself. It is not
enough for students to understand the scientific principles behind climate change. They must also develop an awareness of its impact on the quality of life of people and society (Vongalis-Macrow, 2010).

Gayford (2002) found teachers tend to completely ignore these more controversial topics. When they are addressed, they tend to be fragmented across several subject areas (Gayford, 2002). As it enters the science standards, teachers will have no choice but to teach the science of climate change, since the standards currently fail to address the social controversy surrounding the topic. This presents a danger as well as an opportunity. While it opens the possibility to move students forward in terms of being able to think scientifically, it also presents the risk of creating even greater misconception and misunderstanding. Currently, when included in lessons, climate change continues to be largely taught through traditional approaches, dominated by lecture (Gray & Bryce, 2006).

Oulton, Dillon, and Grace (2004a) concluded that many teachers are simply not prepared to handle the teaching of controversial issues. They surveyed 600 teachers and the majority lacked any formal training in the teaching of controversial issues (Oulton, et al, 2004a). When formal training did occur, it most often involved instruction in three basic teaching strategies: neutrality, balance, and commitment (Cotton, 2006).

Procedural neutrality is the strategy most commonly adopted (Cotton, 2006) and involves the teacher acting as a neutral facilitator of classroom discussions. This allows instruction to take place without interference from any prejudice the teacher may have (Cotton, 2006). Many researchers, including Ashton and Watson (1998),
have criticized this approach, arguing it prevents teachers from engaging the students in dialogue. They argue that more vocal students will dominate conversations and discourage other students from expressing contrary views if the teacher remains truly neutral and out of the forum (Ashton & Watson, 1998). Cotton (2006) and others found that, in such cases, teachers may enter the discussion to champion those reluctant to speak, thereby causing their personal opinions to have greater impact than they either intended or realized (Cotton, 2006).

In contrast, the balance strategy involves teachers attempting to present a balanced picture, remaining neutral while offering students a range of alternative viewpoints (Cotton, 2006). The teacher remains personally neutral, but may take on various opinions or positions in an effort to encourage discussion on the part of the students. In theory, this appears to be an effective strategy since the true position of the teacher is not evident. Research, however, has shown that in practice, it is difficult for teachers to encourage students to present dissenting or unpopular views (Cotton, 2006). When teachers enter the discussion to encourage less confident students, they do so through their questioning or by controlling student turns in discussion. The questions they ask tend to be grounded in the teacher’s personal bias, and as such, are somewhat leading. While this strategy does enable teachers to avoid explicitly stating their personal views, such an indirect expression (as through a question) may be harder for the students to challenge than a clearly articulated direct argument (Cotton, 2006).

The third strategy is commitment, and researchers seem to agree it too is ineffective in terms of avoiding imposing the teachers’ views on the students.
Commitment involves teachers taking on the role of “agents of change” (Cotton, 2006). Doing so most often leads to teachers emphasizing “green slogans” rather than scientific arguments and persuading students to adopt specific views rather than teaching a deeper understanding of the complexity of the scientific issues (Jickling, 1992). In fact, environmental education literature often explicitly encourages teachers to promote pro-environmental attitudes and behaviors (Cotton, 2006).

The less than perfect results of these core strategies have led researchers to examine alternatives for dealing with controversial topics in the classroom. Kelly (1986) proposed a strategy called committed impartiality, where teachers express their own personal views, but explicitly encourage students to evaluate those views alongside others. Oulton et al. (2004b) agree that “teachers should make their position explicit at the start of the exercise so that pupils are aware of potential bias.” Ultimately, this strategy too can be problematic due to the unwillingness of many students to challenge their teacher.

Ashton and Watson (1998) advocate critical affirmation, whereby students are actively encouraged to adopt the views of others. The results, however, may not be terribly different from what is seen with commitment.

In a study specifically examining these strategies, Cotton (2006) concluded that teacher opinion is likely to impose itself on a lesson, regardless of the teacher’s efforts to the contrary. As such, teachers simply must choose whether that imposition will be explicit or implicit, and then plan the lesson so as to minimize its impact (Cotton, 2006).
**Strategies for minimizing denialism.** It is obvious from the literature that the search for effective strategies for teaching climate change science continues. While teaching both sides of an issue appeals to people’s sense of fairness and balance, climate change presents a unique problem in that there really is no “other side” to teach. To teach a manufactured debate would be a disservice to the students. Climate change is happening and human activity is responsible (IPCC, 2013). As such, strategies must be employed to help teachers teach the science and minimize the impact of denialism.

Research shows that classroom debates foster critical thinking skills and can enhance content knowledge (Halpern, 1998). They can help engage students in learning science and exploring the societal relevance of science topics (Halpern, 1998). McCaffrey (2012) however, argues students need to master science content before they can engage in meaningful argumentation or debate. In his view, having students debate whether climate change is happening and whether humans are responsible is counterproductive (McCaffrey, 2012). “Teaching ‘both sides’ of climate change is not sound, and can lead to more student confusion, not less” (McCaffrey, 2012, pp 25-29).

An example of this confusion was recently provided by Senator Joe Barton of Texas. In a speech, Senator Barton referenced the Biblical narrative of Noah’s flood as evidence that climate change has occurred in the past and that humans were not to blame (Kiene, 2013). He explained that following the flood, God made a pact with Noah to never again flood the earth, rendering worry about sea level rise due to climate change pointless. A counter argument could involve explanation of how
Noah’s descendants are breaking that pact and that God would rather we not flood the earth ourselves. While such arguments foster lively debate, little science emerges or is discussed and students may even be insulted in the process. For this reason, McCaffrey (2012) emphasizes the importance of students understanding scientific content prior to debate. What McCaffrey neglects to consider, however, is the important contribution culture makes to the debate.

Controversial issues like climate change require students to be able to critically examine information and consider the beliefs or values behind both that information and its source (Cotton, 2006). To teach students how to do this, teachers must be aware of the beliefs and values they themselves bring to the lesson (Cotton, 2006). Classroom discussion must move beyond the focus on scientific facts and begin to include the cultural underpinnings involved in the topic. Doing so allows one to recognize the substance of what Senator Barton was saying (or at least to understand why he said it). Hoffman (2012) advocates a number of key techniques teachers should employ to be sensitive to cultural beliefs while still combating denialism.

Hoffman (2012) advises teachers to focus on the specific questions scientists are asking. Doing so would replace uncertainty with the reality of climate change risk. This strategy would have the added benefit of helping students come to terms with the consequences of ignoring that risk (Hoffman, 2012). Hoffman also explains that as a highly complex scientific topic, climate change science must be presented using language that the lay-public can easily understand (Hoffman, 2012). This is perhaps the most important. Whatever strategies teachers choose to employ, they
should continually remind students that scientists have a moral and ethical responsibility to society. To that end, the teacher should help students learn the skills of communicating scientific information effectively to lay audiences (McBean & Hengeveld, 2000).

The impact of catastrophic events. On October 29, 2012, Hurricane Sandy struck the New York coast causing over $60 billion in damage (National Climate Data Center, 2013). At the time, it was the largest Atlantic hurricane on record (NCDC, 2013). Virtually the entire New York City subway system was flooded as were nearly all the road tunnels entering Manhattan (NYC.gov., 2013). The New York Stock Exchange was closed for two consecutive days (NYC.gov., 2013). Hundreds of homes and businesses throughout the area were destroyed by flood or fire (NYC.gov., 2013). Large sections of the city and surrounding areas lost electricity for several days, necessitating the closure and evacuation of even large hospitals (NYC.gov., 2013).

Borick and Rabe (2010) found personal experience with severe weather events, such as Hurricane Sandy, tends to stimulate the acceptance of climate change. Their study came to this conclusion despite the sharp political divisions that occur regarding most evidence of climate change. It appears Republicans and Democrats alike can agree climate change is real when confronted with personal experience of severe weather (Borick & Rabe, 2010). Eagan and Mullin (2012) confirmed these findings, but added that the impact to opinion tends to be short-lived, so permanent attitude change does not typically occur.
Regardless of whether or not a catastrophic event changes opinion, the connection people have to the science behind the event tends to come from the mainstream media (Corbett & Durfee, 2004), and can therefore remain distorted.

**Implications for teacher professional development.** Teachers need more content knowledge to effectively teach climate change science (Gray & Bryce, 2006), but that alone cannot repair the disconnect between the science of climate change and public perception (Sterman, 2011). It will require that teachers approach their teaching from a new perspective. Pruneau, Liboiron, and Vrain (2001) found people will always be willing to share their opinions about climate change, even when they distrust or don’t quite understand the science. This fact presents an excellent opportunity for teachers to integrate the complexity of scientific understanding with the complexity of social responses to climate change (Vongalis-Macrow, 2010).

Like most other citizens, many teachers hold misconceptions about climate science. Therefore, those misconceptions should be specifically targeted by professional development providers (Wise, 2010). They also need instruction on how to appropriately acknowledge and frame the public controversy (Wise, 2010). Professional development experiences should model how to “fair” to both science and the public while instructing about scientific consensus only (Wise, 2010).

This demonstrates an obvious contradiction in the literature. While many researchers suggest simply teaching the science and avoiding all manner of the controversy altogether, they cannot ignore the impact climate change has on society. They acknowledge that the importance of the issue requires that the perceived uncertainty in the science, as well as the moral and ethical dimensions attached to the
Professional development experiences need to help teachers understand that “controversial issues such as climate change are often controversial because the protagonists from their own worldview are applying reason and thereby arriving at their different perspectives” (Oulton, et. al, 2004a). Teachers need to develop the skills to help students explore how, given the same information, individuals can arrive at different perspectives on an issue (Oulton, et. al, 2004).

**Chapter Summary**

Although the latest report by the Intergovernmental Panel on Climate Change (IPCC) unequivocally states that climate change is happening and that its most likely cause is the increase greenhouse gas concentrations caused by human activity, (IPCC, 2013) opinion surveys show Americans remain only casually concerned about the threats of climate change and that even scientists themselves are uncertain about the threats (Gallup, 2013). As climate science enters the curriculum through introduction of the Next Generation Science Standards, denialists are likely to stand in opposition, just as they opposed the teaching of evolutionary science (Morrison, 2010). In light of this problem, and with a preliminary examination of the literature, a possible way to address the issue might be to examine the way teachers approach the topic of climate change science and if and how they address the social and controversial underpinnings introduced by denialists.

The following chapter (Chapter 3) details the study methodology. The remaining chapters then report the findings of this study, provide a thorough analysis,
present the implications of the findings, suggest recommendations, and detail the limitations of this study.
Chapter 3: Research Design Methodology

Introduction

While climate change is a prominent topic in the Next Generation Science Standards, denialist efforts to discredit the science continue (Morrison, 2010; NGACBP, 2012). Teachers face the challenge of having to teach about climate change while simultaneously handling the controversy surrounding it and mitigating denialism.

The purpose of this grounded theory study was to uncover how teachers will address and respond to the controversy surrounding the topic of climate change as it is introduced to the curriculum. One hundred twenty three teachers who successfully completed a climate change course through the Wildlife Conservation Society (WCS) between May 2010 and June 2013 provided qualitative data in the form of responses to a pre and post course survey, as well as a response to a course assignment. Analysis of those responses provided qualitative data regarding how these teachers plan to address climate change as a classroom topic and how they intend to respond to the controversy surrounding it.

Three research questions guided this study. However, application of the tenets of grounded theory required the researcher to remain open to modifying the questions as the study progressed. This in fact was the case, and the resulting final research questions were as follows:
1. How comfortable are teachers addressing climate change in their classrooms?

2. What do teachers view as most important to communicate to their students about climate change, and to what extent is that consistent with the opinion of climate change experts?

The third research question emerged as analysis of the data progressed:

3. What pedagogical strategies do teachers predict will be most effective for teaching about climate change and minimalizing denialism?

**Research Context**

Headquartered at the Bronx Zoo in New York City, the Wildlife Conservation Society (WCS) possesses the oldest education department of any zoo in the United States (Wildlife Conservation Society, 2012). It was the first institution of its kind to develop comprehensive science curricula that use zoos as serious resources for study, the first to offer major national teacher training seminars, and the first to design hands-on teaching environments in zoos (Wildlife Conservation Society, 2012). Its curricular programs have served millions of students and teachers in all 50 states and 15 foreign countries. Many educational programs that are now commonplace at zoos and museums were first developed and tested by WCS Education Division staff (Wildlife Conservation Society, 2012).

The breadth, quality, and proven effectiveness of its education programming have earned WCS numerous prestigious education awards from organizations such as the American Zoo and Aquarium Association, the National Science Teachers Association, the U.S. Department of Education, and the U.S. Department of Energy.
In 2001, the Education Division was the organizational recipient of the National Science Board’s coveted Public Service Award, and in a 2002 White House ceremony, WCS was presented the prestigious National Award for Museum Service, recognizing its profound contribution to New York City through its educational programming.

Within the Education Division of WCS is a department dedicated to teacher professional development (PD). The PD department provides multi-session, in-depth seminar courses that afford university credit to local, national, and international teachers and graduate students. In addition, the department provides teacher workshops at schools and informal science institutions across the country and in environmentally significant countries around the globe. Through these and other initiatives, WCS has become the largest provider of teacher training focused on environmental science in the world.

**Online courses.** A key component of the PD department’s work is a suite of course offerings in an exclusively online format. Each course runs for a six-week period totaling 54 hours of instruction and provides three graduate credits upon successful completion. Courses are presented via the Moodle learning management system, a software package for producing internet-based courses and websites. Graduate credits are awarded by Adams State University, a fully-accredited post-secondary institution located in Alamosa, Colorado. WCS and Adams State University established a formal partnership in 2007, enabling WCS courses, once approved by the Adams State curriculum committee, to be offered for graduate credit.
The partnership allows WCS to increase its audience by offering graduate credits and enables Adams State University to increase its student body, exposure, and reach.

The online course at the center of this study is titled: *Our Changing Planet: Climate Change and Wildlife Connections*. It was first designed by this researcher in 2010 to provide teachers with the content knowledge and pedagogical skills to begin addressing climate change science in their classrooms. The course consists of six, week-long modules. Each module contains a video lecture, reading assignments, discussion prompts, and an essay assignment.

While each of the six offerings of the course examined in this study were identical in terms of structure, facilitation, assignments, readings, and duration, they occurred at distinct points in time. The first two offerings occurred between June and September 2011, approximately one year prior to Hurricane Sandy. One offering began in September 2012 and thus ran during the storm itself, and three offerings occurred between June and September 2013, approximately one year after Hurricane Sandy.

**Research Participants**

**Population.** The study population consists of 123 teachers who successfully completed the WCS online course on climate change sometime between June 2011 and September 2013. These teachers represent grades Pre-K through higher education, as well as informal education institutions. The vast majority (83%) teach in New York State, but in total 15 states were represented in the study. Teachers self-selected the course out of personal interest or as a means of satisfying their various professional development requirements. Most chose the course based on the online
advertising by WCS via their organization website, and all participants registered with Adams State University for graduate credit.

Prior to taking the course, the teachers completed a pre-course survey, included in Appendix A, designed by this researcher as an agent of WCS. In that survey, 53 individuals (43% of the course participants) indicated they were self-contained classroom teachers who teach at least some science. Special education was solidly represented, as 31 of the teachers (25%) identified as special education teachers. The elementary grades were slightly more represented, (2nd grade alone was chosen by 41% of the participants) but overall there was a relatively even distribution across elementary, middle, and high school grades. Among the subject areas participants indicated they teach, Earth Science, Biology, and Math were the most selected. Six participants represented strictly higher education. Teachers were free to choose multiple indicators on the survey to ensure teachers who teach multiple subjects or grades could accurately report that. As a result, percentages exceed 100% and the statistics above and in the appendices should examined in that context. Figure 3.1 provides a detailed look at the population, and the appendices include the complete questions, charts and percentages as they were reported.
Figure 3.1. The Study Population. Bold numbers indicate the number of respondents who chose each answer. Percentages represent the percentage of respondents who chose each answer.
Study participants. It is difficult to establish a precise sample size before conducting a grounded theory study. This is due to the method’s inductive nature and because theory is evolving as the data are collected and explored (Strauss & Corbin, 1998). Strauss and Corbin (1998) advocate choosing participants whose main credential is experiential relevance, because that will contribute most to theory emergence (Strauss & Corbin, 1998). Accordingly, this study began with open sampling of the 123 teachers who participated in and successfully completed the WCS climate change online course. Each provided qualitative data in the form of a course assignment. Open sampling was appropriate here because it allowed the researcher to be maximally flexible and open to discovery (Charmaz, 2006).

Descriptive data. Outside of this study, an online survey was distributed to all participants who registered for the WCS online climate change course (see Appendix A). Its purpose was to gauge teacher comfort with and aptitude for teaching about climate change. The survey was created in Google Docs, and sent to course participants via a link embedded on the course registration page. A Likert scale was used in 30 of the questions, 17 were multiple choice questions, and two questions were open-ended. The identical survey was also distributed in a like manner at the end of the course, as a post-test (see Appendix B). As such, it was pilot tested each time it was run to ensure test-retest reliability. Content validity was provided by two climate scientists employed by WCS.

Both surveys were mandatory course requirements, so the completion rate should have been 100%. However, 123 teachers completed the pre course survey but
only 100 teachers completed the post course survey, setting the completion rate at 81%.

Hurricane Sandy struck the New York area during one offering of the online climate course. Technology issues resulting from the storm prevented the teachers who were enrolled in the course at that time from completing the post course survey. As a result, while all 123 teachers provided qualitative data in the form of a course assignment, post course survey data was only available from 100 of the study’s teachers.

Coding of the data acquired from these teachers revealed they possessed what Glaser and Strauss (1967) call, “the phenomenon of interest in common.” For purposes of this study, the phenomenon of interest was a statement of experience dealing with the challenges of teaching climate change science. At the study’s start, it was difficult to anticipate the exact number of categories that would emerge, and therefore provisions were made to add additional participants as the study progressed, provided they represented some quality that emerged as significant for generalization or greater understanding of the emerging theory. In spite of this preparation, no additional participants were added beyond the original 123.

**Hurricane Sandy.** Hurricane Sandy struck the New York coast on October 29, 2012. It would prove to be the largest Atlantic hurricane on record, causing $60 billion in damage (National Climate Data Center, 2013). At the time the storm struck, 23 of the study participants were in the midst of the second module of the online climate course. Many lost electrical power or suffered minor property damage and fell behind in their work. Others were completely displaced and completed the course
from hotel rooms and the homes of friends and relatives. None of the course participants lost their home completely or were permanently displaced. While these 23 teachers managed to complete the course and provide this study with qualitative data, as mentioned above, they were unable to complete the post course survey.

**Data Collection Instruments**

The sole data collection instrument used in this study was a written assignment from the online climate course, thus providing the study with archival data. It served as the final exam for the course, and presented a scenario in which course participants were to imagine themselves as a school principal charged with hiring a new science teacher; specifically to teach about climate change. Their task was to draft 10 interview questions along with acceptable and/or preferred answers. In addition, the assignment required that the interview questions allow the person being interviewed the ability to give open-ended responses, encourage the sharing of specific information, and be designed to accurately identify bias or inconsistencies in the responses. An accompanying one-page reflective essay detailed the thought process behind each question.

Analyzing elicited text is a constructive way of beginning a grounded theory study (Charmaz, 2006). The course participants produced it as their final exam, knowing a grade would be assigned to it, so they had a significant stake in the topic and in the data. Being teachers, they had experience in the relevant area and therefore viewed the assignment itself as significant. The researcher read and coded the responses, resulting in categories of teachers with similar challenges.
This instrument was chosen by the researcher because it provides a written account of the thoughts of the course participants regarding what they view as important regarding the inclusion of climate change in the classroom. In cases where the participant was impacted by Hurricane Sandy, the researcher anticipated the response may shed light on whether or not that catastrophic event impacted their opinion about climate change and how to teach it. The data also revealed anxieties the teachers had regarding climate change denialism and the strategies they view as effective for teaching the topic. Outside of this study, the instrument was pilot tested as an assignment in the online course. Thus, test-retest dependability was measured.

Dr. James Watson and Dr. Anton Seimon, two climate scientists at WCS, confirmed content validity of the course assignment. Dr. Watson is an Associate Professor at the University of Queensland and leads the Climate Change Program for WCS. As Program Leader, he oversees the climate adaptation and the climate mitigation and forestry teams. He also oversees the 13 active WCS projects (spread across 10 countries) for the United Nations Reducing Emissions from Deforestation and Degradation (REDD) program.

Dr. Seimon is a professor at Appalachian State University and a researcher at WCS. He provides technical expertise and helps incorporate anticipated impacts of climate change into the planning and implementation of conservation projects throughout WCS's 80 landscape, seascape, and species conservation programs. Both scientists actively collaborate with non-governmental organizations, university and government partners, and engage in national and international policy dialogues.
Procedures for Data Collection and Analysis

Grounded theory seeks a general understanding or explanation of phenomena (Charmaz, 2009). For that reason, it is important to note that the study’s methods and procedures required amendment as the study evolved. Grounded theory research allows the researcher to explore a problem deeply, acquiring a complex, detailed explanation of the issue (Creswell, 2013). When existing theories prove inadequate, as was the case here, grounded theory can provide a general framework to help explain how people are experiencing a phenomenon (Creswell, 2013). Consistent with the tenets of grounded theory, open, line-by-line, focused, and theoretical coding methods were used in this study in conjunction with memo writing to analyze qualitative data. Data were triangulated by examining data collected at distinct periods of time.

The interdisciplinary nature of climate change science renders the application of any one pedagogical strategy difficult. Grounded theory provided a way of looking directly to the data for the answers concerning how to address the problem of teaching about climate change while simultaneously minimizing denialism. Consistent with the features advocated by Charmaz (2006) this study collected and analyzed data simultaneously, coding that data to identify basic social processes. Data categories were then integrated into a new theoretical framework (Charmaz, 2006).

The climate change course designed by WCS presented course participants with the opportunity to tell their stories, share their concerns, and reflect on strategies for teaching about climate change. Analysis of this data within a grounded theory framework allowed the researcher to determine how teachers will respond to the
controversy surrounding the topic of climate change and how they intend to confront climate change denialism. The resulting analysis helped uncover a new theory for how to design pedagogical strategies to more effectively teach climate change science.

Study participants completed a final assignment in the WCS online climate change course that detailed their understanding of and approach to teaching about climate change. This was a mandatory assignment and was completed by 100% of the course participants. All 123 participants self-selected the course for graduate credit.

Initial open-coding of the data from that assignment allowed the researcher to learn what the research participants view as problematic and revealed those individuals who share similar views, concerns, ideas, and opinions (Glaser & Strauss, 1967).

The data was subjected to line-by-line coding by the researcher alone, enabling him to reduce the likelihood that preconceived notions were imposed on the data. As coding took place, the researcher looked for general terms that were universally familiar, but flagged deeper meaning in the context of this study. Other terms that were targeted included innovative terms that captured the experience of the course participant or “insider shorthand” that reflected their individual perspective. Such “in vivo” codes helped the researcher describe the experience of the teachers, answer fundamental questions about what exactly they were experiencing, and ultimately develop the theoretical categories to understand it (Charmaz, 2006).

Initial line-by-line coding was followed by focused coding. Comparing data with data allowed the researcher to learn what the course participants viewed as
problematic and to begin treating it analytically (Charmaz, 2006). The data were examined for relationships and sorted into categories. Those categories were then examined in relation to one another in an effort to begin weaving the initial data back together into a loose framework (Charmaz, 2006). This process of theoretical coding was conducted simultaneously with memo writing to both inform further data collection and ensure saturation (Charmaz, 2006). Memos enabled the researcher to choose data that enhanced the possibility of comparative analysis to help saturate categories (Charmaz, 2006). Memos were used to catch thoughts that occurred to the researcher while coding and that highlighted comparisons. In addition, memos manifested new questions and uncovered new directions to pursue (Charmaz, 2006).

Data collection and coding continued until no new relevant data were discovered and all categories were well developed and validated.

**Internal validity.** The credibility of findings was determined by collecting data from distinct periods in time: before Hurricane Sandy, during Hurricane Sandy and after Hurricane Sandy. Doing so enabled the researcher to check for distortions or inconsistencies in responses (Cresswell, 2013). Tentative findings or inconsistencies were clarified with the participants as needed.

**Chapter Summary**

The final essay assignments submitted by 123 teachers as the final paper in a WCS online climate change course were subjected to line-by-line, open coding to help the researcher conceptualize and categorize the qualitative data. Theoretical coding of this data was then used in an effort to identify a central phenomenon regarding teachers’ approach to addressing climate change in their classrooms and to
explore possible causal conditions. Categories were compared and relationships between them investigated through the process of selective coding.

In grounded theory studies, insights from the initial analysis and coding of the data often lead to and inform additional data collection. While that was not the case here, all methods of coding and memo writing overlapped to some extent. The process continued until a strong theoretical understanding emerged.

The following chapter (Chapter 4) reports the findings of this study and provides a thorough analysis. Chapter 5 presents the implications of the findings, suggested recommendations, and the limitations of this study.
Chapter 4: Results

Research Questions

The purpose of this study was to uncover how teachers will address and respond to the controversy surrounding the topic of climate change as it is introduced to the curriculum. To that end, three research questions were designed to guide the study. However, grounded theory seeks a general understanding or explanation of phenomena (Charmaz, 2009). For that reason, it is important to note that the study’s methods and procedures required amendment as the study evolved. In addition, the tenets of grounded theory that this study employed required the researcher to remain open to modifying the research questions as the study progressed. This in fact was the case, and the final research questions were as follows:

1. How comfortable are teachers addressing climate change in their classrooms?

2. What do teachers view as most important to communicate to their students about climate change, and to what extent is that consistent with the opinion of climate change experts?

As analysis of the data progressed, a third research question emerged:

3. What pedagogical strategies do teachers predict will be most effective for teaching about climate change and minimalizing denialism?

Data was provided by 123 teachers in the form of responses to a survey and a final essay assignment in an online climate change course. Analysis of those
responses provided qualitative data regarding the most important strategies for minimizing climate change denialism while teaching climate change science.

**Data Analysis and Findings**

Consistent with the tenets of grounded theory, open, line-by-line, focused, and theoretical coding methods were employed in this study. In addition, memo writing took place throughout the coding process. Data were triangulated by examining data from offerings of the course that ran at distinct periods of time: prior to Hurricane Sandy, during Hurricane Sandy, and after Hurricane Sandy.

Initial open coding of the data allowed the researcher to learn what the research participants viewed as problematic in terms of teaching climate change. During initial coding 152 codes emerged from the data. Focused coding of the data revealed relationships among those codes, enabling the researcher to consolidate them into 48 categories. The researcher then began weaving the initial data back together into a broad framework through advanced memo writing, examining each category in relation to all the others. Theoretical coding refined the concepts that emerged from the data until they were sorted into the four main themes of (a) Addressing the Controversy, (b) Identifying Critical Knowledge, (c) Recommending Effective Teaching Strategies, and (d) Seeking Support.

The themes and subthemes discussed below resulted directly from the grounded theory research process. As the qualitative data was a response to a course assignment, the structure of each teacher’s response was similar, yet each expressed their ideas in their own unique way. The quotations provided here are illustrative of
the course participants as a whole and were specifically included to bring clarity to the findings.

**Question 1: How comfortable are teachers addressing climate change in their classrooms?** As demonstrated in figure 4.1 below, 74% of the course participants reported in the pre course survey that they were at least moderately comfortable with the topic of climate change.

![Figure 4.1. Pre-course Comfort Understanding Climate Change. Bold numbers indicate the number of respondents who chose each answer. Percentages represent the percentage of respondents who chose each answer.](image)

Figure 4.4 demonstrates that upon completing the online climate change course, the percentage of course participants reporting to be at least moderately comfortable understanding the topic of climate change had jumped to 99%.

![Figure 4.2. Post Course Comfort Understanding Climate Change. Bold numbers](image)
indicate the number of respondents who chose each answer. Percentages represent the percentage of respondents who chose each answer.

Responses to the course’s final assignment confirmed this confidence. In that final assignment, this question concerning comfort generated two central themes: Seeking Support and Addressing the Controversy. Within the theme Seeking Support, three sub-themes emerged: (a) Identification of Personal Beliefs, (b) Reliance on Authority, and (c) Seeking Credentials.

**Seeking support.** The survey asked several questions about the major barriers teachers may face teaching about climate change. Prior to completing the course, concerns about their lack of content knowledge were second only to a lack of appropriate instructional materials.

![Figure 4.3. Pre Course: Lack of Content Knowledge as an Obstacle. Bold numbers indicate the number of respondents who chose each answer. Percentages represent the percentage of respondents who chose each answer.](image)

Other major concerns were a lack of time for planning and instruction. The appendices provide a complete breakdown of how teachers regarded various obstacles to instruction both before and after completing the online course.
Completing the climate change course did little to change their concerns about the lack of materials and planning time, but as illustrated in figure 4.3, their concern about lacking content knowledge dramatically fell in significance.

![Figure 4.4. Post Course: Lack of Content Knowledge as an Obstacle. Bold numbers indicate the number of respondents who chose each answer. Percentages represent the percentage of respondents who chose each answer.](image)

The interview questions and answers drafted by the teachers in their final assignment of the climate course often referenced looking to colleagues, school administrators, and content experts to help them deal with the teaching of climate change as well as the controversy surrounding it. Reflections often expressed the need to defend, justify, and explain their role as a teacher to parents and the community. Teachers in this study expressed a desire to dispel the notion that they are “not depending on a teaching point delivered in a teacher's guide every day in order to deliver [their] lessons.”

*Identification of personal beliefs.* Teachers evidenced concern that others may believe they are simply indoctrinating students into their own, personal beliefs. As one teacher noted,
My job is not to convince them to believe in my “opinion,” but instead to teach about things that are occurring in the world and supporting those ideas with evidence. It is important to discuss how science is full of discovery and exploration.

In fact, many designed interview questions that alluded to the importance of teachers having a strong grasp of their own values and beliefs. While some admitted they would encourage their students to aspire to similar beliefs, the majority were clear that persuasion of any kind has no place in the classroom. “Students should not be persuaded to think a certain way. They should only be presented with the facts to allow themselves to come up with their own interpretations.”

Reliance on authority. A majority of teachers openly stated they would look to authority to help them justify their actions in the classroom. Statements similar to “I would calmly refer to the Massachusetts state standards in order to justify what I am teaching” were common. Illustrative of what many said in response to anticipated challenges to their teaching is the quote “I would provide the scope and sequence of the science curriculum to demonstrate how climate change is a part of the curriculum and will most likely appear on the New York State Science Test.”

Seventy percent indicated in the pre course survey that they are less than trustful of government agencies as sources for information on climate change. Yet in their final assignment, several teachers called on the government to take direct action, claiming, “the government should account for the impacts of climate change when designing and implementing policies, programs and investments.” One teacher was
even more direct, stating she “would ask the local government to help me create the curriculum based on credible scientists’ work and research.”

Study participants also looked inward for support. Passion for the topic was frequently noted as an essential characteristic for teaching climate change. “Passion is a powerful tool and something that an employer may not have the ability to instill. Passionate people are great motivators. They inspire action. Actions that are inspired by words and deeds.” For the teachers in this study, passion is an indicator of emotional health that can support a teacher charged with bias or serve as a shield against accusations of a political agenda. As one teacher noted

I would like to see how passionate the interviewee is about climate change and children. The way they speak and approach this question can really bring to light their emotional level toward the subject (both for the good and bad).

In reflecting on one of the interview questions she drafted, one teacher asked, “Is this someone who is passionate about teaching science, who wants to become an integral part of the school community, or is this person someone who wants to clock in and out without leaving much of a mark?” Another stated “I prefer an individual who is committed to a lifestyle and philosophy of environmentalism and not someone who knows how to answer the questions the right way to get the job.”

Seeking credentials. Experience with the topic of climate change outside their role as a teacher was offered, not only as evidence of passion for the topic, but also as a credential to help bring credibility to their teaching. Many teachers said if they were hiring someone to teach about climate change they would look for a candidate with
demonstrated active participation in environmental organizations and causes. Expressing the belief that actions speak louder than words and that teachers should practice what they preach, one teacher offered "any teacher that I select should have some practical environmental experience. There are many theoretical wizards out there but someone who has had their hands dirtied in the mud brings to the classroom a different element."

Universally, the teachers in this study expressed a need to fortify their knowledge with practical field experiences and regular professional development. As one teacher wrote, “Although the candidate is not expected to know everything, they are expected to have the drive and ambition to be continuously learning and expanding their knowledge.” They advocated forging connections with university researchers and professors, governmental organizations such as NASA or NOAA, attaining various professional certifications, joining professional and academic organizations, and volunteering their time to environmental causes. “If we’re in the business of preparing students to be in the work field we need to understand what the field is like and how true research is conducted.”

As was detailed earlier, the pre course survey revealed that 83% of the teachers viewed their lack of sufficient content knowledge as at least a slightly significant obstacle to their ability to teach about climate change. That number dropped to only 42% in the survey taken after the completion of the course. However, many of the interview questions revealed the concern about content knowledge was not entirely alleviated by completing the WCS climate course. Questions drafted by the teachers often asked directly about content knowledge and resources. The idea
that any candidate for a job teaching about climate change must have "sufficient" content area knowledge was recurring. In fact, for several teachers, determining whether a candidate possessed sufficient content knowledge was the stated purpose of the interview.

One teacher defined “sufficient” as having a detailed enough understanding to be able to show students that “they have direct input into the problem by their daily choices. Showing them that they have choices and can choose to add to the problem or help in its solution is an important lesson.”

Also consistent with the survey results was the common inquiry made in the final assignment about teacher "resourcefulness." This emerged most often when teachers were expressing concern over the lack of available resources and vetted lesson plans due to the "newness" of the topic. Of particular concern was the awareness many expressed that resources would be needed to address the biggest, most commonly held misconceptions about climate change.

In addition to indicating they lack adequate content knowledge and resources, teachers in this study expressed uncertainty about what information sources to trust. Their interview reflections expressed the intention to depend mostly on primary scientific resources. “I particularly like NASA’s section about climate change, as they have consistently updated and accurate information.”

This data demonstrated a big change from the results of the survey. Both pre and post survey data showed these teachers mostly trust scientists, scientific journals, and scientific conferences for information, but only 15% indicated they actually rely on those sources for information. Instead, they claimed to be getting their information
from the mainstream media and the Internet—the two sources they reportedly trust least.

This data is inconsistent with the data from the final assignment. Questions, answers, and reflections from that assignment revealed that after completing the online climate course, scientific and governmental organizations such as the Intergovernmental Panel on Climate Change, the United States Global Change Research Program, the United States Environmental Protection Agency, and the U.S. Fish and Wildlife Services were favored sources of information.

*Addressing the controversy.* Many teachers indicated scenarios involving parents who challenge the decision to teach about climate change are likely. One even wrote, “The candidate is most definitely going to face parents and students who resist learning about climate change, which has become such a charged topic in today’s society.” In spite of this, only 28% indicated in the pre course survey that lack of parental support would be a significant obstacle to their addressing climate change in their class. The percentage even dropped to 24% after completing the climate course.

Consistent with that statistic, many stated in their final assignment that it is important that teachers know how to keep their composure and how to stand their ground in the face of controversy. Many of the questions they drafted for the interview were aimed at seeing if the candidate appeared able to handle controversy while remaining professional. As one teacher wrote, “It was important to see that the candidate knew what she was getting herself into, and how she planned to represent herself when faced with opposition.”
Almost universally, teachers agreed they would approach the controversy surrounding the teaching of climate change objectively, yet with the understanding that it is a teacher’s job to have students look at evidence, evaluate different perspectives, and make informed, well-researched decisions to back up their beliefs and attitudes.

Several teachers mentioned they would initiate a conversation with parents if a conflict were to occur. As one teacher remarked, “I would first ask for a sit down meeting with the parent so I could personally clear up any confusion about what it is I would be teaching.”

Others presented a plan to get ahead of the problem.

I would like the teacher to send out a syllabus to the parents at the beginning of the year so the parents are aware of what the students will be studying. If there are questions the parents can address them at the beginning of the year.

These conversations with parents nearly always referenced assistance from school administrators, harkening back to their reliance on authority. For example, the statement “I also feel that the principal will be the first line between myself and parents” was a common idea, and several teachers expressed the desire to work with the principal as a team to, as one teacher put it, “combat any opposition.”

Other teachers would seek support directly from parents and enlist them in the education process. As one teacher reflected

I would send home parent letters each week, letting the parents know what their children would be learning. In these letters I would let the
parents know the topic for that week and the questions that the students would be asked. Parents would have the opportunity to preview the questions, and help me build a curriculum that is suitable for their children. In me being able not to influence the student with my beliefs, I hope that I can reassure the parents that with their help we can teach the children to form their own opinions. We can do this by the parents themselves talking to their children about climate change and doing research on the topic.

In fact, their responses in the surveys indicated that a lack of parental or community support was the least significant obstacle they would face addressing climate change. In both surveys, teachers saw the lack of time for planning and implementing lessons specific to climate change as being their biggest challenge.

As mentioned earlier, upon completing the online climate change course, 99% of the course participants reported they were at least moderately comfortable understanding the topic of climate change.

Given access to quality, trustworthy sources of information, the ability to acquire the necessary credentials, and support from their school administrators, the teachers in this study indicated they would be comfortable managing the controversy surrounding the teaching of climate change in their classrooms.

**Question 2: What do teachers view as most important to communicate to their students about climate change, and to what extent is that consistent with the opinion of climate change experts?** The theme Identifying Critical Knowledge
and its sub-theme Promoting Education addressed the second question in this study.

The essence of the theme is illustrated by one teacher’s statement that, “I feel that the biggest problem affecting climate change is that people aren’t properly educated.” Similarly, another teacher wrote, “People need to understand this is real and it is happening now and there are facts that support this.”

**Identifying critical knowledge.** The interview questions drafted for the final assignment identified several pieces of information the teachers believed are essential to teaching and understanding climate change. These included details concerning specific evidence of climate change, the anthropogenic and meteorological causes of climate change, and specific consequences of climate change. Included in these questions were specific skills in addition to content. The teachers in this study indicated that in addition to learning science content, students engaged in climate change lessons should be learning scientific skills such as how to perform research and experiments, honing interpersonal skills, developing analytical skills, exercising computer skills, and enhancing literacy and math skills.

In terms of the content knowledge teachers should emphasize in climate change lessons, the data emphasized the ability to draw a distinction between climate and weather, the ability to explain carbon dioxide's role as a greenhouse gas, and the ability to address the historical context and details of past climate change events. One teacher indicated she, as an adult, found it difficult to understand the distinction between climate and weather. She anticipates explaining the differences between the two in kid-friendly language to be a great challenge.
Promoting education. With a few exceptions as noted above, the data was relatively sparse with examples of specific content knowledge teachers deemed important. Instead, the final assignment interview questions, answers, and reflections were decidedly more broad and philosophical. References to the lack of science literacy and the need to address misconceptions were numerous. Lamenting the lack of science literacy, one teacher wrote

Our public schools are charged with producing educated, critically-thinking citizens able to participate effectively in our democracy. Effective participation requires the ability to discern between reliable scientific information and misinformation, and to choose strong leadership who will act on that information. The climate change crisis demands an educated citizenry who will take individual responsibility and action while demanding the same from its leadership.

Several teachers indicated climate change education needs to reach beyond the classroom, particularly to the parents of the students. As one teacher remarked, “Parents already have their own beliefs and attitudes towards [climate change’s] relevance, which children tend to adapt.”

Others, while omitting specifics, wrote about the need to involve students in climate change mitigation and adaptation efforts: “The tenth question assesses the interviewee’s knowledge of activities in which he/she can engage and involve students to slow climate change.” Several were specific about what they wanted the students to achieve, even if they failed to indicate exactly how:
Most importantly I think it is imperative that our students leave the classroom at the end of the semester with specific experiences and information they have attained through project-based learning that allows a change in their behaviors. This would allow them to make informed decisions as stewards of the environment and taking actions on a scale that is appropriate to their comfort level.

Overall, the data from the final assignment revealed that teachers are likely to concentrate more on creating a general awareness of climate change and its consequences than they are on any specific scientific content. They expressed a desire to get students involved with addressing the problem of climate change and in empowering students to inform others.

As described in chapter 2, experts have identified several principles and concepts that are considered essential for understanding climate science and being considered climate literate (NOAA, 2009). Table 4.1 below lists those principles in tandem with selected interview questions from the final assignment teachers submitted. By inspection, these questions were selected as being illustrative of those that occurred most often and targeted the same area of understanding.
Table 4.1

**Comparison of What Experts and Teachers Deem to be Essential for Climate Literacy**

<table>
<thead>
<tr>
<th>Key Concept</th>
<th>Illustrative Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding of how the sun drives the earth’s climate</td>
<td>What do you think the fundamental drivers of climate change are?</td>
</tr>
<tr>
<td>Understanding of the greenhouse effect</td>
<td>How would you define climate change?</td>
</tr>
<tr>
<td></td>
<td>How would you teach students about carbon dioxide’s role in climate change?</td>
</tr>
<tr>
<td>Understanding the earth’s climate as a complete system</td>
<td>If the globe is warming, how is it that areas have had record cold winters?</td>
</tr>
<tr>
<td></td>
<td>Describe the major factors that influence the Earth’s temperature and how, if at all, these interact with climate change.</td>
</tr>
<tr>
<td>Understanding the connection between climate and living things</td>
<td>If you had to choose one species whose current status defines the impact of climate change, what would it be?</td>
</tr>
<tr>
<td></td>
<td>How will species, ecosystems and habitat in your community be impacted by climate change?</td>
</tr>
<tr>
<td>Distinguishing climate from weather and understanding climate variability</td>
<td>What is the difference between climate and weather?</td>
</tr>
<tr>
<td></td>
<td>What analogies or examples would you use to help students understand this difference between climate variability and climate change?</td>
</tr>
<tr>
<td>Understanding how scientists study climate</td>
<td>Analyze the evidence that scientists have used to conclude that the Earth is experiencing climate change.</td>
</tr>
<tr>
<td></td>
<td>What are some historical and current ways scientists use to track climate?</td>
</tr>
<tr>
<td>Understanding the role of human activity and behaviors</td>
<td>What is the difference between the increase in global temperature we are experiencing today compared to previous periods of global warming in earth’s history?</td>
</tr>
<tr>
<td></td>
<td>How can students take a more active role in helping to slow climate change?</td>
</tr>
<tr>
<td>Understanding the consequences of climate change, such as sea level rise, extreme weather events, and extinction</td>
<td>What affect of climate change is of most personal concern to you? Would you plan on incorporating that into your curriculum?</td>
</tr>
<tr>
<td></td>
<td>Which climate change outcomes do you find to be the most concerning?</td>
</tr>
</tbody>
</table>
As demonstrated by Table 4.1, teacher responses were highly consistent with
the experts regarding what knowledge is critical to share with students to ensure they
become climate literate.

**Question 3: What pedagogical strategies do teachers predict will be most
effective for teaching about climate change and minimizing denialsim?** The
overarching theme that emerged regarding this question was: Addressing the
Controversy. In addition, several sub-themes emerged: (a) Responding to Denialism,
(b) Identifying and Addressing Misconceptions, and (c) Suggested Teaching
Strategies.

**Responding to Denialism.** Most teachers specifically addressed climate
der change denialism, and the overwhelming majority suggested they would pay strict
adherence to scientific facts and not entertain a debate about the reality of climate
change. Some even indicated they would be confrontational if need be. For example,
one teacher indicated a challenge from a parent would be met head on:

I would present evidence, and lots of it, that show that the climate is
changing. I’d send these individuals to reliable sources for
information, and I’d ask them where they got their information about
climate change. I would explain how science works, that scientists
propose explanations, conduct experiments, collect data, and see if the
data supports their explanation. I’d especially highlight the years of
research, the quantity of data collected from different studies that all
point in the same direction, the value of getting information from peer-
reviewed scientific journals, and the importance of recognizing
manufactured controversies in order to increase viewership and sell
more advertisements. I’d supply data on local and global changes to
help people see the big picture. I’d ask them to remember that
scientists do not have an agenda. Their goal is to understand how the
natural world works. We’ve learned an awful lot of climate change and
we continue to learn more with each study.

One teacher handily captured the thoughts of others regarding intolerance for
denialist views, writing

I would not devote classroom time to the “evidence” against it. As a science
teacher, my goal is to create active learners who are as knowledgeable about a
topic as can be. There are plenty of areas in other fields that have doubters,
but no time is wasted in the classroom on say, Holocaust deniers.

Other teachers took a less hardened stance, expressing the need to let parents
know that what they are teaching is grounded in scientific data: “I feel that I need to
let them know that this is not just my personal opinion, but that what I am teaching is
backed up by research. It would be my hope that parents would understand and accept
this.”

A minority of teachers did admit to being open to denialist threads: “I would
discuss the facts about climate change and assure the parent that they have the
opportunity to provide their child with any other viewpoints outside of school. I
would not shy away from the fact that what I am teaching is factual but that there is
still more to learn about climate change.” Another stated, “I will make sure that the
parents of my students understand that I am teaching my class science facts and I will
not encourage them to feel one way or another about any science issues that we discuss.”

**Identifying and addressing misconceptions.** The reflective part of the final assignment often revealed the importance teachers give to knowing the biggest misconceptions about climate change so they can be suitably addressed. Many indicated they would begin climate change lessons or units by first determining the students’ background knowledge and misconceptions about climate change.

**Suggested teaching strategies.** All the teachers in this study mentioned teaching strategies at some point, either in the questions they asked or in their reflective essays explaining why they asked the questions. Of all the strategies mentioned, those involving student motivation and creating connections to the students’ lives were most numerous. One example of how such strategies were discussed is the following:

Science should be taught by a teacher who has the ability to excite students about science and allow them to make connections with their environment. Children are natural scientists. They enter school wanting to know how and why everything works. So it is important to engage the students in hands on learning.

Motivation was described as important because, “For many people climate change is happening, but it’s not happening to them. It’s polar bears and other species that are nowhere near them.” In describing one of their interview questions, another teacher noted, “In order to make students care about something, you need to connect
the learning to them and something they are interested in. Is this person smart enough and creative enough to link climate change to the students’ lives?” Another stated,

Being a teacher myself, I understand that it is difficult to get students to feel invested in an issue. With this question, I wanted to see what methods the teacher would use to create that self-to-world connection that would make the topic of climate change tangible to students.

Inquiries designed to see if the candidate being interviewed understood the importance of making climate change tangible for students peppered virtually every final assignment. While they too often lacked in specifics regarding pedagogical strategy, they almost always addressed the importance of cultivating a personal connection for the student. As one teacher noted, “By getting kids out into the local community, seeing the impact they have, it opens the door for students who may not see the knowledge in the classroom to approach the topic.”

Several teachers indicated they would invite students to share current event articles and provide plenty of classroom time to open debate. Current event suggestions often referenced Hurricane Sandy as an event that could help make the topic real for the students: “Because we're in New York, I would make a connection between extreme weather, climate change, and the recent events of Hurricane Sandy. This dramatic disaster along the east coast impacted many children directly or indirectly in some way.”

Another teacher wrote about how knowing “that a good portion of this school’s population was displaced due to Hurricane Sandy, they are familiar with the effects that a storm like that can bring.”
One of the more interesting strategies suggested by the teachers in this study involved self-discovery. As the teacher explained it:

Ask all students, even those who are not challenging climate change, to write down his/her feelings on climate change in the form of a diary or journal entry. After the class is completed, read the entries to identify what exactly the student challenges and provide students with specific scientific research that supports climate change. Provide students with vetted readings and research for them to complete on their own and then discuss in class. It’s important the students understand that there is a culture of communication in the classroom and they can voice their opinions without fear of punishment.

The use of visual aids such as charts, graphs, and figures was a common suggestion in the questions asked, as was the vetting of sources and the use of technology. A good example of this came from one teacher’s explanation for asking about the potential use of technology:

The reasoning behind this question is to see how the teacher will allow his or her students to conduct research and collect data. Computers are everywhere and are great tools but can provide misleading information. The good response is critical where it is extremely important to teach the student what credible resources there are on the internet. The internet is a great tool but also is an outlet of false information. Good resources as well as bad resources should be reviewed. Trusted materials should come from website that end with
.gov, .org and is the author credible? It's essential to identify and evaluate the credentials and motivations of the organization or people responsible for maintaining a website. Students should be taught how to find the point of view or bias on information. Does the document come from a server sponsored by an organization with a specific agenda (political, commercial or philosophical)? Without being able to navigate good resources and facts all arguments will be futile. Students should have an opinion but when it comes to scientific areas, opinions should be backed up with evidence.

Another common suggestion involved collaboration. One teacher declared, “Collaboration is key to making sure our students are well-rounded and respectful individuals,” and advocated collaboration among all school staff to ensure a cooperative learning environment. Many indicated that climate change is a topic that can easily be applied across the disciplines. Some teachers even gave specifics, such as “It would be a powerful learning experience for students to investigate the politics of climate change in conjunction with learning about the science of climate change.”

Many of the interview questions teachers drafted inquired about the candidate’s “plans about crossing content areas,” and some went so far as to ask about the “skills you will tackle while addressing climate change that students could use in other classes.” Nearly all of the final assignments contained at least one interview question that addressed how other subject areas, such as math, reading, writing, and art, could be incorporated into a lesson or unit on climate change.
Other strategies spoke to direct action—mitigating or adapting to climate change on the local level. Many expressed the desire to reach beyond the classroom and inquired about the use of resources in the community or specific ways to get the community involved. As one teacher noted:

If this person is passionate about what they do, it will be exciting to hear their ideas about how to make the school a better place and how they will take their content area and make positive changes in both the school community and their students.

Hands-on, service oriented projects were also featured prominently in the data. In particular, many referenced citizen science initiatives that could help mitigate the effects of climate change. One teacher thought it is critical that students leave the classroom at the end of the semester with specific experiences and information they have attained through project-based learning that allows a change in their behaviors. This would allow them to make informed decisions as stewards of the environment and taking actions on a scale that is appropriate to their comfort level.

Many emphasized the importance giving students ideas on ways they can personally help to lessen the impact of climate change: “There are a number of things that individuals can do to help “fight” climate change, and a good teacher should be able to give students ideas on how they can do that.”

A handful of teachers took things a step further, advocating a forum for students to educate others. “I think this is part of the educational system that is often forgotten and since the community members pay taxes to the schools, they need to
see what these kids are learning. It’s a way for the students to thank and give back to their community as well as inform the misinformed.”

**Summary of Results**

This chapter provided detailed and rich descriptions of how the teachers in this study plan to address and respond to the controversy surrounding the topic of climate change. In the final assignment to an online climate change course, the teachers in this study revealed that they plan to confront climate change denialism with scientific facts. They see having little time devoted to lesson planning and implementation as the greatest obstacle to teaching about climate change, but are confident that with support from school administration they can collaborate with colleagues to address climate change misconceptions and motivate students to develop the desire and skills to help mitigate the effects of climate change.

In Chapter 5, the themes presented here are used to provide a theoretical model and grounded theory of the process of addressing climate change in the classroom while minimizing the impact of denialism. In addition, it also addresses the implications of that theory for both researchers and practitioners.
Chapter 5: Discussion

Introduction

This chapter presents a discussion and interpretation of the results of this grounded theory study. Implications of the findings reported in Chapter 4 are discussed, along with the study’s limitations, and recommendations for educators, professional development providers, and others concerned with the teaching of climate change science. The chapter concludes with recommendations for future research and a conclusion that also serves as an overall summary of the study.

The objectives of this study were to identify the core obstacles teachers face in teaching about climate change and exploring how they propose to handle the surrounding controversy. In addition, the study intended to identify key pedagogical strategies teachers believe will allow them to effectively teach about climate change in the face of denialism. The objectives of this study have been met, and the results are presented in Chapter 4.

The problem statement detailed in Chapter 1 describes climate change as arguably the most significant conservation challenge of the 21st century (Hilty, Chester, & Cross, 2012). The drafters of the Next Generation Science Standards (NGSS) specifically included climate change to prepare students to face the challenges climate change will present, (NGACBP, 2012), but climate change denialists are opposed to the topic’s inclusion and have actively resisted its inclusion in the classroom (Morrison, 2010). Teachers are thus being asked to effectively teach
a new topic that is surrounded by controversy. Broadly, the literature indicates teachers are confused about what to teach, unsure what resources can be trusted (Wise, 2010), are likely to employ ineffective teaching strategies (Cotton, 2006), and are worried about possible repercussions from denialists (McCaffrey, 2012).

The primary goal of this study was to identify the primary obstacles teachers face in teaching about climate change and uncover a theory concerning their ability to effectively address climate change and minimize denialism in their classrooms. Three research questions guided the study:

1. How comfortable are teachers addressing climate change in their classrooms?
2. What do teachers view as most important to communicate to their students about climate change, and to what extent is that consistent with the opinion of climate change experts?
3. What pedagogical strategies do teachers predict will be most effective for teaching about climate change and minimizing denialism?

These questions are answered and discussed below in relation to the implications of the study’s findings.

**Implications of the Findings**

The teachers in this study indicated they get most of their climate change information from the mainstream media and the Internet, even though these were the two sources they trusted the least. Due to cost and ease of access, they will continue to look to the Internet and mainstream media for content even when they know information can be acquired from more trustworthy sources.
The lack of vetted, ready-to-use resources and a lack of time for preparation and instruction were reported to be the biggest obstacles to these teachers addressing climate change in their classrooms. The teachers in this study are confident they can handle parental concerns by being transparent in their teaching and sticking to the scientific facts. This suggests, however, that these teachers may avoid incorporating socially relevant science into their instruction.

The key to the confidence the teachers in this study expressed seems to be administrative support. As climate change enters the curriculum, school administrators should prepare themselves to absorb the brunt of any objections as teachers will most likely deflect opposition and objections onto school administrators and politicians.

This study indicated teachers intend to teach more about climate change than they plan to teach climate change science content. They plan to focus on those things that will result in changes in student behavior and will help students acquire the information and skills they need to influence the behavior of others.

By limiting the focus on scientific content and instead helping their students develop an understanding of how science works, these teachers may, as Bell (2003) proposes, enable their students to more easily distinguish good science from bad science and apply scientific knowledge to their everyday lives (Bell, 2003). This is consistent with the experts at NOAA, who declared the most critical thing to communicate to students is how to be climate literate. They shared the belief that
their students should construct their own knowledge in real-world contexts, but may unconsciously be ignoring social aspects of the topic.

**Question 1: How comfortable are teachers addressing climate change in their classrooms?** While nearly three quarters of the teachers in this study entered the WCS online climate change course already believing they had a good grasp of the topic, it appears the information they were exposed to and learned in the course enhanced their understanding. In that sense, it appears the course was effective. These teachers presumably are less unsure about what to teach, have acquired some trusted resources, and have begun to think about effective pedagogical strategies to help them teach about climate change. Since 99% of the teachers reported they left the experience more confident in their understanding of climate change, it appears they should now be more comfortable addressing the topic in their classrooms. This may serve to demonstrate the importance of quality, rigorous, content-based professional development and the value of exposing teachers to the concrete science and detail behind climate change.

Still, many of the interview questions they drafted as part of their final course assignment inquired directly about content knowledge and resources. This may indicate they remained somewhat concerned about being deficient in content knowledge. It also likely demonstrates the great importance these teachers place on acquiring accurate and relevant content information regarding climate change.

**Obtaining information.** Surveys continue to show that the American public relies heavily on the mainstream media and on the Internet for climate change information (McBean, & Hengeveld, 2000). They tend to distrust science, and they
remain generally skeptical of climate change, even in the face of conclusive scientific evidence (Gallup, 2013; Hoffman, 2012). The findings in this study serve as a reminder that teachers are part of that general public.

Consistent with what McBean and Hengeveld (2000) found, the teachers in this study revealed that they get most of their climate change information from the mainstream media and the Internet, in spite of the revelation in the surveys that these were the two sources they trusted the least. Given that many science teachers have limited knowledge concerning the nature of science and are trolling the Internet for information, they likely also have and may even teach misconceptions about climate change (Abd-El-Khalick, Bell, & Lederman, 1998). The controversy surrounding a topic like climate change coupled with the unreliable information available in the mainstream media and on the Internet may generate confusion and uncertainty about the state of the science for these teachers and, by extension, their students.

Apparently, teachers are going to these sources because that is where the information is most readily available. The teachers in this study declared lack of resources, time for preparation, and instruction to be the biggest obstacle to addressing climate change in their classroom. In fact, wanting more time for planning and instruction is possibly the most common demand made by teachers across all subject areas and topics (Fitzgerald & Schneider, 2013). This study seems to reveal that even when teachers know information can be acquired from a more trustworthy source, they will continue to get their content information from the Internet and mainstream media simply because doing so requires less time and effort.
Of course, the Internet in and of itself is not an unreliable resource. Teachers may very well be acquiring their information by accessing peer reviewed scientific journals online. However, it is probable that teachers will avoid paying a subscription service for journal access when they can acquire information from free web pages. If that is in fact the case, McBean and Hengeveld (2000) are correct in their urging the science community to work with the popular media to ensure quality information reaches the public.

_Avoiding the controversy._ Almost universally, teachers in this study stated they would avoid the controversy surrounding the teaching of climate change by teaching the topic objectively. They plan on approaching climate change as they do any other topic, by having the students examine evidence, letting them evaluate different perspectives, and eventually make informed, well-researched decisions to back up their beliefs and attitudes. This perspective will be explored further below in the discussion of teaching strategies.

Surprisingly, while many of the teachers mentioned they expect parents to raise objections to the teaching of climate change, only 24% voiced lack of parental support as a significant concern. The data the teachers in this study provided indicates teachers are confident they can handle parental concerns by being transparent in their teaching and sticking to the scientific facts. This may be a mistake. Presenting climate change as completely objective and failing to introduce opinion or ethical aspects into climate change lessons ignores the need to incorporate socially relevant science into instruction (Levinson & Turner, 2001). With controversial topics, students need to be able to critically examine information and consider the beliefs or values behind both
that information and its source (Cotton, 2006). Classroom discussion must move beyond the focus on scientific facts and begin to include the cultural underpinnings involved in the topic.

The key to the confidence the teachers in this study claim to possess seems to be administrative support. Teachers who referenced regularly communicating with parents to remain transparent in what they are teaching nearly always referenced support from school administrators. In some cases, administrators such as principals and superintendents were portrayed as shields to insulate the teacher from objections to the teaching of climate change.

This seems to mean that as climate change enters the curriculum, school administrators should prepare themselves to absorb the brunt of any objections. The data appears to indicate teachers will most likely deflect opposition and objections onto school administrators. References to state standards and curriculum guidelines were numerous in the data, and may be an indication that teachers will embrace the position that they are only doing what they are told to do. Even the references the teachers in this study made to collaboration with colleagues and the cross-curricular possibilities climate change presents may be veiled strategies designed to insulate themselves personally from controversy and enlist others to share in any repercussions should they occur.

Teachers are comfortable addressing climate change in their classrooms. However, they lack easy access to vetted climate change lessons, resources, and expertise. As a result, they look to the mainstream media and the Internet for easily accessible information and help, where they likely encounter unreliable information
and possibly may acquire (and later disseminate) misconceptions about climate change.

**Question 2: What do teachers view as most important to communicate to their students about climate change, to what extent is that consistent with the opinion of climate change experts?** The teachers in this study see the teaching and acquisition of content knowledge as far less important than the development of a solid understanding of the nature of science. Throughout the data provided in this study they advocated the learning of scientific skills, the honing of interpersonal skills, the developing of analytical skills, the exercising of computer skills, and the enhancing of literacy and math skills.

To that end, it appears they intend to teach more about climate change than they plan to teach climate change science content. They seem to want to focus on those things that will result in changes in student behavior, and will help students acquire the information and skills they need to influence the behavior of others.

These teachers are likely to concentrate more on creating a general awareness of climate change and its consequences than they are on any specific scientific content. The data contained numerous expressions of the desire to get students involved with addressing the problem of climate change and in empowering students to inform others.

This approach is consistent with the research. As discussed in Chapter 2, while other controversial topics involve questions about the application of scientific knowledge, climate change involves questions about the validity of the science itself. As a result, the teachers are likely correct in determining that teaching students the
scientific principles behind climate change is insufficient. Experts opine that teachers must help students develop an awareness of the impact climate change has on people and society (Vongalis-Macrow, 2010), which is exactly what the teachers in this study propose.

By limiting the focus on scientific content and instead helping their students develop an understanding of how science works, these teachers may, as Bell (2003) proposes, enable their students to more easily distinguish good science from bad science and apply scientific knowledge to their everyday lives (Bell, 2003). However, what the teachers in this study minimized, is the fact that at some point, students will need to master the science content if they are to engage in any meaningful debate.

The data provided by the teachers in this study indicate they will prioritize helping students understand how human actions influence the climate, and how even small changes can impact the entire climate system. Students can then begin to make informed and responsible decisions with regard to actions that may affect the earth’s climate. This strategy is consistent with what the experts at NOAA declare to be the most critical thing to communicate to students: how to be climate literate.

**Question 3: What pedagogical strategies do teachers predict will be most effective for teaching about climate change and minimalizing denialsim?** As Vongalis-Macrow found (2010), the interdisciplinary nature and constant evolution of climate change science makes it difficult to apply any one specific pedagogical strategy. The data provided by teachers in this study supported that claim. In fact, few pedagogical strategies were described in detail. Instead, teachers regularly addressed the importance of cultivating personal connections for each student. They wrote often
about understanding the importance of making climate change tangible for students and described how lessons needed to be relatable to local situations and how climate change needed to be presented in a real world context.

Fleming (1986b) found that 91% of students he studied used scientific terminology to answer technical questions, but few used scientific knowledge to justify their opinion when asked to defend their position on a scientific issue (Fleming, 1986b). The data in this study had a decidedly constructivist bent, as the teachers shared the belief that their students should construct their own knowledge in real-world contexts (Kanselaar, De Jong, Andriessen & Goodyear, 2001). By allowing their students to somewhat self-direct their learning about climate change, rather than focusing on the detailed science of climate change, these teachers may be addressing the concern Fleming uncovered.

**The favored strategy.** To accomplish relevance for the students and make lessons the most authentic, teachers favored cross-curricular, hands-on, service learning projects. Such projects minimize the dissemination of factual content and maximize the incorporation of socially relevant science into instruction. The stated teaching goal of many of the teachers in this study was to inspire action, not just to relay content knowledge.

This is a vast improvement over the typical science labs traditionally used in schools. Instead of teaching students that there are always strong associations between variables and that unambiguous outcomes are normal, as Bowen (2008) suggested these labs do, service-learning projects provide students the opportunity to engage in the real-world science where random variables are more likely. Such
methods also provide the students with the experience of reading scientific studies, the faculty to understand the scientific process, and the opportunity to contribute to the field.

While favoring service-learning projects, as discussed above, the teachers plan to present climate change science as completely objective. Levinson and Turner (2001) found this to be a typical approach, and the teachers in this study appear to exemplify their point that teachers rarely introduce opinion or ethical aspects into their lessons (Levinson & Turner, 2001).

The teachers confirmed the inadequacy of sustainability theory in this context by expressing concern that others may believe they are simply indoctrinating students into their own, personal beliefs. The majority were clear that persuasion of any kind has no place in the classroom, and were adamant that students would be presented with facts alone and encouraged to come up with their own interpretations.

As mentioned earlier, while many researchers suggest this strategy may be effective, it somewhat ignores the impact climate change has on society. The importance of the issue requires that the perceived uncertainty in the science, as well as the moral and ethical dimensions attached to the topic, must be addressed (Gray & Bryce, 2006). Thus, it may be necessary for teacher to share their personal opinion.

That does not mean opting to teach “both sides” of climate change, as some teachers suggested. As discussed in Chapter 2, teachers who do so would be countering the scientific consensus and would likely leave students unable to evaluate where the balance of evidence lies (Corbett & Durfee, 2004). By creating confusion
for the students, having students debate both sides of the issue is simply counterproductive.

In any case, Cotton’s (2006) research demonstrated it is unlikely these teachers would succeed in keeping their opinion out of the discussion anyway. Therefore, in designing a service-learning project for students to engage in, it may be more productive for the teacher to simply choose whether the imposition of their opinion will be explicit or implicit, and then plan the lesson to minimize its impact (Cotton, 2006).

Limitations

This grounded theory study has five notable limitations. The first is the researcher’s position at the time the data was collected. At that time, the researcher was employed by WCS as Coordinator of Professional Development. In that role, the researcher created the WCS climate change course and all the assignments it contained. That includes the final interview assignment that provided the qualitative data used in this study. In addition, the researcher was the course instructor four of the six times it was offered. Thus, the researcher’s role and relationship with the study population may have impacted the findings.

The second limitation is the fact that the final course assignment was used as the sole data collection instrument in this study. The study participants submitted the assignment (to the researcher in four of the courses) for a grade in the online climate change course. In many cases, a passing grade was not only attached to graduate credits, but also to salary scales. This fact may have influenced what the study
participants wrote in the assignment, and may bring the genuineness of some of the data into question.

A related limitation involves the correlation between what scientists recommend and what the study participants advocated as important to teach. The data study participants provided closely mirrored what climate change experts advocate. The thoughts of climate change experts were detailed in the climate change course the study participants completed, and as mentioned above, the data instrument was submitted for a grade. This likely influenced how the assignment was written and what it contained, though it also indicates the study participants learned something from the course.

The fourth notable limitation is that 83% of the study population teaches in the state of New York, mostly in New York City. Their experience with climate change controversy may not accurately reflect the experiences of those in other states. Likewise, their shared perspective may have overly influenced the overall findings.

Finally, the study’s one delimitation is that 23 teachers were unable to complete the post course survey due to technological complications following Hurricane Sandy. While minor, the absence of the post course responses from these 23 individuals does affect how the pre and post course data can be compared.

Recommendations

Based on this study’s findings and implications, recommendations for future research, teacher professional development, the science community, and school officials are provided.
**Recommendations for future research.** Climate change science is ever-evolving and its inclusion in the mainstream curriculum is still new; therefore, research should continue to be conducted regarding the strategies employed by teachers to address the topic and minimize the controversy.

This dissertation study described the lived experiences of 123 teachers, but the majority teach in New York City. It is recommended that similar studies be conducted to describe the lived experience of teachers in other cities and states where the controversy may be more pronounced. It would be insightful to compare the opinions and experiences of these teachers to gain a more universal understanding of the problem of addressing climate change in the classroom.

A second research recommendation involves the favored pedagogical strategies revealed by the teachers in this study. The implementation of these strategies should be evaluated and compared to others in an effort to determine if they are as effective as this study suggests.

Finally, this study suggests teachers will aim to inspire students search for and implement measures that can assist the adaptation to and mitigation of climate change. These students may even be inspired to pursue a scientific career as a result. Funding should be sought for the development of a demonstration project implementing the project-based programming model the teachers in this study suggest. Evaluation of such a model will help clarify whether providing students the opportunity to “get their hands dirty” with science in a field study experience actually improves student content mastery, scientific literacy, and overall student outcomes.
Recommendations for teacher professional development. Teachers are prudent to seek more content knowledge to effectively teach climate change science. However, the connections climate change science has to public perception requires that teachers also pursue, as Vongalis-Macrow (2010) alluded to, resources that can help them integrate the complexity of scientific knowledge with the complexity of the social responses to climate change.

It appears teachers tasked with teaching about climate change would benefit from enrolling in and completing rigorous, content-based climate science courses that specifically target climate change misconceptions and include a socio-scientific component. Teachers often seek professional development in the form of courses specifically designed for teachers (Gulamhussein, 2013). Whereas a course on climate change designed for scientists may discuss the intricacies of the chemistry behind the greenhouse effect, a similar course designed with teachers in mind may gloss over the details in exchange for generating a broader understanding of the content. Such courses tend to be designed so students learn about a topic rather than actually exploring the specifics of the topic (Gulamhussein, 2013).

In their search for professional development courses, perhaps teachers should broaden their scope, look beyond the education arena, and begin enrolling in courses designed to teach informational content in specific disciplines, such as science. Likewise, universities, museums, informal education centers, and government agencies tasked with education should begin creating, marketing, and making content-based courses more available to teachers. The teachers in this study made it clear they are willing to fortify themselves with credentials. These were described as
both formal (in the form of certifications, degrees, and affiliations) and informal like field experiences and partnerships. The federal and state governments, school districts, universities, informal education institutions, and teacher groups should work to make such opportunities readily available to teachers. These institutions should sponsor grants to provide teachers with some hands-on time with scientists in both academic and field settings.

**Recommendations for the science community.** The data examined in this study appears to indicate the science community has the ear of teachers, revealing they mostly trust scientists, scientific journals, and scientific conferences for information. If, however, only a small percentage (15% in this study) are actually utilizing those resources, the problem may be access. It would behoove the science community to harness the trust teachers have in them and make themselves and their work more accessible to teachers and the general public.

This may entail more submissions to open access journals and mainstream press venues such as magazines and newspapers. It may also mean ensuring their findings are presented in ways that are most useful to teachers; limiting jargon and making concrete connections to the daily lives of people.

School administrators and school boards should take note as well. Perhaps school libraries should explore the possibility of improving or expanding their access to periodicals and online journal sources. Teachers disseminate a large amount of information to a very broad audience. They can be a valuable outlet for countering the misinformation so prevalent on the Internet, but to do so, they must be able to easily access the information the science community possesses.
**Recommendations for school officials.** School administrators should understand that teachers do not want to be blamed for misinforming students, and they do not want to have to justify their teaching. School administrators can provide teachers with a sense of security by assuring them the administration will field all questions concerning curriculum content.

The assignment that provided the data in this study was a hypothetical interview. In hiring a teacher to teach about climate change, school officials may focus on finding the best educator and scientist they can find, but this study suggests that education and science simply may not be enough. The data presented in this study suggest that the person hired to teach about climate change may need to lead that school in a new way of thinking. Climate change science has become a political act as much as a scientific discipline. As such, political and verbal skills may prove as valuable as pedagogical and scientific qualities.

This study has shown a strong climate change curriculum can possibly be the vehicle to a scientifically literate public. For that to become a reality, teachers will need to receive rigorous scientific instruction accompanied by real-work field experiences and time with or (at the very least) access to working scientists. School administrators will need to be supportive of teachers and fully prepared to absorb and shield teachers from any denialist charges or opposition. These administrators would benefit from training on how to best provide such support and handle repercussions that stem form the inclusion of climate change in the school’s curriculum.

**Conclusion**
**Statement of the problem.** Climate change is arguably the most significant conservation challenge of the 21st century (Hilty, Chester, & Cross, 2012). Recognizing the need to prepare students to face the challenges climate change does and will present, the Next Generation Science Standards (NGSS) prominently includes climate change and aims to train students to become scientifically literate members of society (NGACBP, 2012). However, public opinion surveys consistently show Americans mistrust the scientific evidence of climate change, believe scientists themselves are uncertain about its occurrence and harbor misconceptions about the topic (Gallup, 2013). In addition, climate change denialists stand in direct opposition to the inclusion of climate change into school curriculum (Morrison, 2010).

Teachers are thus being asked to effectively teach a topic that they are unclear about themselves, may be uncomfortable addressing, and that is surrounded by political controversy. They are confused about what to teach, unsure what resources can be trusted (Wise, 2010), may potentially employ ineffective teaching strategies (Cotton, 2006), and are worried about possible repercussions from denialists (McCaffrey, 2012).

Given this scenario, the Wildlife Conservation Society (WCS) created an online course designed around narrative theory to equip teachers with the scientific knowledge and pedagogical skills needed to effectively teach about climate change and minimize denialism. This study aimed to use teacher responses to an assignment in that course to identify the primary obstacles teachers face in teaching climate change science, and uncover a theory concerning their ability to effectively address climate change and mitigate denialism in the classroom.
Theoretical rationale. Sustainability theory, cultural theory, and social constructivism seem to be the major theories driving the research regarding the root causes of the climate change debate, and WCS constructed its online climate course around narrative theory. However, the uncertainty and rapid changes surrounding both climate change science and the mechanisms and methods for its instruction render them insufficient in addressing the needs of teachers. This study therefore employed the tenets of grounded theory as a means of uncovering a framework, grounded in data, to most effectively help teachers teach about climate change in the face of controversy and denialism.

The study’s purpose and research questions. The purpose of the study was to uncover the details concerning how teachers will address and respond to the controversy surrounding the topic of climate change as it is introduced to the curriculum. Three research questions guided the study:

1. How comfortable are teachers addressing climate change in their classrooms?
2. What do teachers view as most important to communicate to their students about climate change, and to what extent is that consistent with the opinion of climate change experts?
3. What pedagogical strategies do teachers predict will be most effective for teaching about climate change and minimalizing denialism?

Methodology and study population. At the center of this study is an online course designed to provide teachers with the content knowledge and pedagogical skills to begin addressing climate change science in their classrooms. Six offerings of
the course were examined in this study. The study population consisted of 123 teachers who self-selected and successfully completed the course. These teachers represented grades Pre-K through higher education and 15 different states. The majority (53%) indicated they were self-contained classroom teachers who teach at least some science.

This study began with open sampling of these 123 teachers. Each teacher provided qualitative data in the form of a course assignment in addition to completing a pre and post course survey designed to gauge their comfort with and aptitude for teaching about climate change.

The qualitative data came from the course’s final exam, which presented a scenario in which course participants were to imagine themselves as a school principal charged with hiring a new science teacher; specifically to teach about climate change. Their task was to draft 10 interview questions along with acceptable and/or preferred answers and a reflection detailing the thought process behind each question.

Consistent with the tenets of grounded theory, open, line-by-line, focused, and theoretical coding methods were applied to the qualitative data. In addition, memo writing took place throughout the coding process.

Initial open coding of the data allowed the researcher to learn what the research participants viewed as problematic in terms of teaching climate change. Focused coding of the data revealed relationships among codes that enabled the researcher to consolidate them into categories. Advanced memo writing examined those categories in relation to one another and allowed the researcher to begin
weaving the initial data back together into a broad framework. Theoretical coding refined the concepts that emerged from the data until they were sorted into the four main themes of (a) Addressing the Controversy, (b) Identifying Critical Knowledge, (c) Recommending Effective Teaching Strategies, and (d) Seeking Support.

**Major findings.** Seventy four percent of the course participants reported prior to the course that they were at least moderately comfortable with the topic of climate change. Upon completing the course, that percentage had risen to 99%. Similarly, concerns about their lack of content knowledge was second only to a lack of appropriate instructional materials at the start of the course, but dramatically fell in significance upon completion.

The study’s participants understood the “newness” of climate change limits the number of vetted classroom materials available, but they expressed great uncertainty about what information sources to trust. They indicated they mostly trust government agencies and primary scientific resources, but reported getting the majority of their information from untrusted sources such as the mainstream media and the Internet.

Teachers indicated they would look to colleagues, school administrators, and content experts to support them in dealing with the controversy surrounding the teaching of climate change. The majority favored obtaining as many credentials as possible and expressed a need to fortify their knowledge with practical field experiences and regular professional development.

Few indicated scenarios involving parents who challenge the decision to teach about climate change would present a significant obstacle to their teaching. Several
teachers mentioned they would initiate a conversation with parents if a conflict were to occur. These conversations with parents nearly always referenced assistance from school administrators.

The data revealed several pieces of information the teachers believed are essential to teaching and understanding climate change. These included details concerning specific evidence of climate change, the anthropogenic and meteorological causes of climate change, and specific consequences of climate change. The teachers in this study indicated that in addition to learning science content, students engaged in climate change lessons should be learning specific scientific skills, such as how to perform research and experiments, as well as cross-curricular skills.

In terms of the content knowledge teachers should emphasize in climate change lessons, the data emphasized the ability to draw a distinction between climate and weather, the ability to explain carbon dioxide's role as a greenhouse gas, and the ability to address the historical context and details of past climate change events.

Overall, the data revealed that teachers are likely to concentrate more on creating a general awareness of climate change and its consequences than they are on any specific scientific content. They expressed a desire to get students involved with addressing the problem of climate change and in empowering students to inform others.

Most teachers specifically addressed climate change denialism, and the overwhelming majority suggested they would pay strict adherence to scientific facts
and not entertain a debate about the reality of climate change. A minority of teachers did admit to being open to denialist threads.

Of the teaching strategies mentioned by the study participants, those involving student motivation and creating connections to the students’ lives were most numerous. Statements emphasizing the importance of making climate change tangible for students peppered virtually every course assignment. While they too often lacked in specifics regarding pedagogical strategy, they almost always addressed the importance of cultivating a personal connection for the student.

Collaboration among all school staff was also emphasized as a way to ensure a cooperative learning environment. Many indicated that climate change is a topic that can easily be applied across the disciplines, and advocated hands-on, service oriented projects. In particular, many referenced citizen science initiatives that could help mitigate the effects of climate change.

**Implications of the findings.** It appears the information teachers were exposed to and learned in the online climate change course enhanced their understanding. These teachers presumably are less unsure about what to teach, have acquired some trusted resources, and have begun to think about effective pedagogical strategies to help them teach about climate change. Since 99% of the teachers reported they left the experience more confident in their understanding of climate change, it appears they should now be more comfortable addressing the topic in their classrooms. This may serve to demonstrate the importance of quality, rigorous, content-based professional development and the value of exposing teachers to the concrete science and detail behind climate change.
The teachers in this study revealed that they get most of their climate change information from the mainstream media and the Internet, in spite of their revelation that these were the two sources they trusted the least. They identified lack of vetted resources and a lack of time for preparation and instruction to be the biggest obstacles to addressing climate change in their classroom. In their search for resources, this study seems to reveal that teachers will continue to get their content information from the Internet and mainstream media, even when they know information can be acquired from a more trustworthy source. This is likely due to ease with which information can be acquired from these less trustworthy sources.

The data the teachers in this study provided indicates teachers are confident they can handle parental concerns by being transparent in their teaching and sticking to the scientific facts, but doing so suggests the need to incorporate socially relevant science into instruction will be ignored.

The key to the confidence the teachers in this study claim to possess seems to be administrative support. As climate change enters the curriculum, school administrators should prepare themselves to absorb the brunt of any objections as teachers will most likely deflect opposition and objections onto school administrators and politicians.

It appears the teachers in this study intend to teach more about climate change than they plan to teach climate change science content. They seem to want to focus on those things that will result in changes in student behavior, and will help students acquire the information and skills they need to influence the behavior of others.
These teachers are likely to concentrate more on creating a general awareness of climate change and its consequences than they are on any specific scientific content, an approach that is consistent with the research. By limiting the focus on scientific content and instead helping their students develop an understanding of how science works, these teachers may, as Bell (2003) proposes, enable their students to more easily distinguish good science from bad science and apply scientific knowledge to their everyday lives (Bell, 2003). However, at some point, students will need to master the science content if they are to engage in any meaningful debate. Even so, the teachers in this study were consistent with the experts at NOAA in declaring the most critical thing to communicate to students is how to be climate literate.

The data in this study had a decidedly Constructivist bent, as the teachers shared the belief that their students should construct their own knowledge in real-world contexts (Kanselaar, De Jong, Andriessen & Goodyear, 2001). However, the stated plan to present climate change science as completely objective, while a typical approach, is a strategy that somewhat ignores the impact climate change has on society.

**Recommendations.** Climate change science is ever-evolving and its inclusion in the mainstream curriculum is still new; therefore, research should continue to be conducted regarding the strategies employed by teachers to address the topic and minimize the controversy. Similar studies should be conducted to describe the lived experience of teachers in other cities and states, and the implementation of these
strategies should be evaluated and compared to others in an effort to determine their effectiveness.

It appears teachers tasked with teaching about climate change would benefit from enrolling in and completing rigorous, content-based climate science courses that specifically target climate change misconceptions. It is recommended that school districts, universities, informal education institutions, and teacher groups should work to make such opportunities readily available to teachers.

The science community must begin harnessing the trust teachers have in them and make themselves and their work more accessible to teachers and the general public through open access journals and tailoring their findings to mainstream press venues.

Finally, school administrators can provide teachers with a sense of security by providing them access to the resources and credentials they need and assuring them the administration will field all questions concerning curriculum content.
References


Appendix A

Pre Course Survey Responses

123 responses

Which of the following best describes your primary professional role? (Choose all that apply)

- Self-contained Classroom Teacher: 53 (43%)
- Cluster Teacher: 23 (19%)
- ELL Teacher: 7 (6%)
- Administrator: 2 (2%)
- Special Education teacher: 31 (25%)
- Teaching Assistant: 0 (0%)
- Paraprofessional: 0 (0%)
- Informal Educator: 6 (5%)
- Gifted and Talented Teacher: 7 (6%)
- Non-Teaching Coach: 1 (1%)
- Other: 31 (25%)

People may select more than one checkbox, so percentages may add up to more than 100%.

Which grades or levels do you teach? (Check all that apply)

- Kindergarten: 17 (14%)
- 1: 29 (24%)
- 2: 51 (41%)
- 3: 35 (28%)
- 4: 26 (21%)
- 5: 27 (22%)
- 6: 33 (27%)
- 7: 27 (22%)
- 8: 30 (24%)
- 9: 28 (23%)
- 10: 30 (24%)
- 11: 31 (25%)
- 12: 29 (24%)
- Undergraduate: 5 (4%)
- Graduate: 0 (0%)
- Other: 40 (33%)

People may select more than one checkbox, so percentages may add up to more than 100%.
What do you teach? (Check all that apply).

Overall, how comfortable do you feel about your UNDERSTANDING of climate change?

How much have you learned about climate change from each of the following sources? - Colleagues

How much have you learned about climate change from each of the following sources? - Peer-review science journals

How much have you learned about climate change from each of the following sources? - Visual media (television, movies)
How much have you learned about climate change from each of the following sources? - Social media (newspapers, books, magazines)

- nothing: 6 (5%)
- a little: 31 (25%)
- some: 52 (42%)
- a good amount: 28 (23%)
- a lot: 6 (5%)

How much have you learned about climate change from each of the following sources? - Print media (newspapers, books, magazines)

- nothing: 0 (0%)
- a little: 27 (22%)
- some: 54 (44%)
- a good amount: 34 (28%)
- a lot: 8 (7%)

How much have you learned about climate change from each of the following sources? - Internet

- nothing: 2 (2%)
- a little: 29 (24%)
- some: 54 (44%)
- a good amount: 26 (21%)
- a lot: 12 (10%)

How much have you learned about climate change from each of the following sources? - Radio

- nothing: 34 (28%)
- a little: 40 (33%)
- some: 35 (28%)
- a good amount: 9 (7%)
- a lot: 5 (4%)

How much have you learned about climate change from each of the following sources? - Informal Science Institutions (museums, zoos, aquariums, nature centers)

- nothing: 7 (6%)
- a little: 37 (30%)
- some: 41 (33%)
- a good amount: 26 (21%)
- a lot: 12 (10%)
Deforestation in the tropics is driving countless species toward extinction and accounts for nearly 20% of the global greenhouse gas emissions. Identify one mitigation strategy conservationists may take to address this problem.

Making the public aware of the problem and advocating recycling. Planting more trees. Developing programs that teach people ways to support themselves that do not require the cutting down of the forest. Leave corridors intact for migration; needs multinational agreement. Designated preserves (no chop areas). Education of the masses. Replanting the forests. Community based conservation - working with indigenous people to protect their forests. Work with governments to impose carbon footprint laws, limit the amount of deforestation that can take place. Raise public awareness to change public attitudes . . .

Please indicate whether each sentence is a description of ‘weather’ or ‘climate’. - Katrina was the strongest hurricane to ever hit New Orleans.

Please indicate whether each sentence is a description of ‘weather’ or ‘climate’. - It has never gone above 100 degrees in May.

Please indicate whether each sentence is a description of ‘weather’ or ‘climate’. - There is a severe thunderstorm watch in effect for NYC.
Please indicate whether each sentence is a description of ‘weather’ or ‘climate’. - It has not rained at all yet this month.

![Weather vs Climate Chart]

Please indicate whether each sentence is a description of ‘weather’ or ‘climate’. - This winter should be colder than normal.

![Weather vs Climate Chart]

Which of the following statements most closely represents your own, personal view?

- Most scientists agree climate change is happening and human activity is to blame. 63 51%
- Most scientists agree climate change is happening, but humans are only partially to blame. 43 35%
- Scientists disagree about whether or not climate change is happening. 10 8%
- Scientists disagree about whether or not humans are to blame for climate change. 7 6%

Climate change has occurred in the past, but current climate change is different because

- greenhouse gases were not a factor in past climate events. 13 11%
- current climate change is not impacting as many species of plants. 2 2%
- humans are now in a position to adapt to the impacts of climate. 16 13%
- it is occurring at a far greater rate than any period in earth’s history. 92 75%

Which of the following statements about climate change is most accurate?

- Scientists are overstating evidence of climate change to protect their own interests. 6 5%
- Scientists are hiding evidence that climate change is part of a natural cycle. 13 11%
- The media is manufacturing controversy to gain viewers / readers. 80 65%
- The media is hiding evidence that climate change is part of a natural cycle. 24 20%

How much do you trust or distrust the following as a source of information about climate change? - Scientists

- Highly Trust 51 41%
- Trust 57 46%
- Somewhat Trust 14 11%
- Distrust 1 1%
- Highly Distrust 0 0%
How much do you trust or distrust the following as a source of information about climate change? - Peer-reviewed science journals

- Highly Trust: 36 (29%)
- Trust: 63 (51%)
- Somewhat Trust: 23 (19%)
- Distrust: 1 (1%)
- Highly Distrust: 0 (0%)

How much do you trust or distrust the following as a source of information about climate change? - Scientific conferences

- Highly Trust: 25 (20%)
- Trust: 71 (58%)
- Somewhat Trust: 24 (20%)
- Distrust: 2 (2%)
- Highly Distrust: 1 (1%)

How much do you trust or distrust the following as a source of information about climate change? - Social media (Twitter, Facebook, blogs, etc.)

- Highly Trust: 1 (1%)
- Trust: 2 (2%)
- Somewhat Trust: 39 (32%)
- Distrust: 57 (46%)
- Highly Distrust: 24 (20%)

How much do you trust or distrust the following as a source of information about climate change? - Internet

- Highly Trust: 1 (1%)
- Trust: 8 (7%)
- Somewhat Trust: 88 (72%)
- Distrust: 20 (16%)
- Highly Distrust: 6 (5%)

How much do you trust or distrust the following as a source of information about climate change? - Mainstream news media

- Highly Trust: 1 (1%)
- Trust: 10 (8%)
- Somewhat Trust: 74 (60%)
- Distrust: 30 (24%)
- Highly Distrust: 8 (7%)
How much do you trust or distrust the following as a source of information about climate change? - IPCC

- Highly Trust: 14 (11%)
- Trust: 26 (21%)
- Somewhat Trust: 73 (59%)
- Distrust: 7 (6%)
- Highly Distrust: 3 (2%)

How much do you trust or distrust the following as a source of information about climate change? - Professional development workshops

- Highly Trust: 13 (11%)
- Trust: 55 (45%)
- Somewhat Trust: 55 (45%)
- Distrust: 0 (0%)
- Highly Distrust: 0 (0%)

How much do you trust or distrust the following as a source of information about climate change? - Government agencies

- Highly Trust: 5 (4%)
- Trust: 32 (26%)
- Somewhat Trust: 69 (56%)
- Distrust: 12 (10%)
- Highly Distrust: 5 (4%)

How much do you trust or distrust the following as a source of information about climate change? - Informal Science Institutions (museums, zoos, aquariums, nature centers)

- Highly Trust: 26 (21%)
- Trust: 57 (46%)
- Somewhat Trust: 39 (32%)
- Distrust: 0 (0%)
- Highly Distrust: 1 (1%)

How much do you trust or distrust the following as a source of information about climate change? - Business or industrial corporations

- Highly Trust: 1 (1%)
- Trust: 2 (2%)
- Somewhat Trust: 41 (33%)
- Distrust: 53 (43%)
- Highly Distrust: 26 (21%)
How much do you trust or distrust the following as a source of information about climate change? - Community relationships (schools, town meetings, friends, family, church groups).

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Which of the following scenarios best illustrates why teaching climate change is important?

- Young people need to be introduced to the controversy surrounding climate change. 14 (11%)
- Students need to understand how climate change is part of the earth’s natural cycle. 27 (22%)
- Schools have a duty to produce citizens who can make informed scientific decisions. 80 (65%)
- It is essential that students understand the strengths and weaknesses of science. 2 (2%)

How significant are these obstacles to your incorporating climate change into your work? - Lack of time for planning

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How significant are these obstacles to your incorporating climate change into your work? - Lack of instruction

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How significant are these obstacles to your incorporating climate change into your work? - Lack of sufficient content knowledge

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How significant are these obstacles to your incorporating climate change into your work? - Lack of institutional (school) support

Not Significant 24 20%
Barely Significant 24 20%
Slightly Significant 32 26%
Significant 28 23%
Highly Significant 15 12%

How significant are these obstacles to your incorporating climate change into your work? - Lack of parental (community) support

Not Significant 27 22%
Barely Significant 29 24%
Slightly Significant 32 26%
Significant 21 17%
Highly Significant 14 11%

How significant are these obstacles to your incorporating climate change into your work? - Lack of access to trusted scientific information

Not Significant 21 17%
Barely Significant 24 20%
Slightly Significant 39 32%
Significant 28 23%
Highly Significant 11 9%

How significant are these obstacles to your incorporating climate change into your work? - Lack of access to appropriate instructional materials

Not Significant 11 9%
Barely Significant 8 7%
Slightly Significant 34 28%
Significant 52 42%
Highly Significant 18 15%

How significant are these obstacles to your incorporating climate change into your work? - Lack of scientific consensus about climate change
Glaciers and polar ice is melting.
Your hometown is facing warmer than average temperatures.
Your hometown is facing colder than average temperatures.
Computer models show earth is getting warmer.
Hurricanes and other storms are getting stronger.
Reports from the IPCC explicitly state the earth is warming.
Penguins and polar bears are declining in numbers.
Extreme weather events (storms, droughts, floods) are more frequent.

Glaciers and polar ice is melting. 115 93%
Your hometown is facing warmer than average temperatures. 53 43%
Your hometown is facing colder than average temperatures. 36 29%
Computer models show earth is getting warmer. 58 47%
Hurricanes and other storms are getting stronger. 74 60%
Reports from the IPCC explicitly state the earth is warming. 46 37%
Penguins and polar bears are declining in numbers. 65 53%
Extreme weather events (storms, droughts, floods) are more frequent. 100 81%

The greenhouse effect and global warming are essentially the same thing. 22 18%
Without the greenhouse effect, there would be virtually no global warming. 51 41%
Without global warming, there would be virtually no greenhouse effect. 5 4%
There is no scientific consensus as to whether or not the greenhouse effect I do not know. 42 34%

The sun 98 80%
The moon 30 24%
The ocean 81 66%
Clouds 45 37%
Volcanoes 32 26%
Earthquakes 14 11%
The greenhouse effect 105 85%
El Nino 33 27%
Polar ice 57 46%
Earth's rotation 56 46%

In 2005, the world experienced an exceptional hurricane season in the Atlantic, unlike anything ever witnessed or recorded before. Which of the following statements about that year is most accurate?
If such a season does not recur within the next 30 years, scientists are likely to look back at 2005 as a solid example of climate variability.

If such a season does not recur within the next 30 years, scientists are likely to look back at 2005 as a solid example of climate change.

If such a season occurs again within the next 30 years, scientists are likely to look back at 2005 as a solid example of climate variability.

I do not know.

Identify three (3) climate change related impacts on wildlife:

Migrating to different areas where they can survive. Penguins/polar bears perishing from lack of fish and ice. Turtles sex is determined by the weather - too much of one can only produce a certain sex. Decline in polar bear population due to habitat loss. Migratory birds changing how far north or south they migrate. Change in insect population in a given area as seasonal temperatures change (warmer winters leading to a higher tick population for example) Fish seek colder waters or perish i.e., trout. Birds and smaller mammals move to higher altitudes and latitudes. Range for Megafauna is red.
Appendix B

Post Test Survey Responses

100 responses

Which of the following best describes your primary professional role? (Choose all that apply)

![Professional Roles Bar Chart]

Self-contained Classroom Teacher: 53 (43%)
Cluster Teacher: 23 (19%)
ELL Teacher: 7 (6%)
Administrator: 2 (2%)
Special Education Teacher: 31 (25%)
Teaching Assistant: 0 (0%)
Paraprofessional: 0 (0%)
Informal Educator: 6 (5%)
Gifted and Talented Teacher: 7 (6%)
Non-Teaching Coach: 1 (1%)
Other: 31 (25%)

People may select more than one checkbox, so percentages may add up to more than 100%.

Which grades or levels do you teach? (Check all that apply)

![Grades Bar Chart]

Kindergarten: 17 (14%)
1: 29 (24%)
2: 51 (41%)
3: 35 (28%)
4: 26 (21%)
5: 27 (22%)
6: 33 (27%)
7: 27 (22%)
8: 30 (24%)
9: 28 (23%)
10: 30 (24%)
11: 31 (25%)
12: 29 (24%)
Undergraduate: 5 (4%)
Graduate: 0 (0%)
Other: 40 (33%)

People may select more than one checkbox, so percentages may add up to more than 100%.
What do you teach? (Check all that apply).

People may select more than one checkbox, so percentages may add up to more than 100%.

Overall, how comfortable do you feel about your UNDERSTANDING of climate change?

How much have you learned about climate change from each of the following sources? – Colleagues

How much have you learned about climate change from each of the following sources? - Peer-review science journals

How much have you learned about climate change from each of the following sources? - Visual media (television, movies)
How much have you learned about climate change from each of the following sources? - Social media (newspapers, books, magazines)

- nothing: 3 (3%)
- a little: 8 (8%)
- some: 37 (37%)
- a good amount: 43 (43%)
- a lot: 9 (9%)

How much have you learned about climate change from each of the following sources? - Print media (newspapers, books, magazines)

- nothing: 1 (1%)
- a little: 6 (6%)
- some: 27 (27%)
- a good amount: 54 (54%)
- a lot: 12 (12%)

How much have you learned about climate change from each of the following sources? – Internet

- nothing: 0 (0%)
- a little: 1 (1%)
- some: 18 (18%)
- a good amount: 53 (53%)
- a lot: 28 (28%)

How much have you learned about climate change from each of the following sources? – Radio

- nothing: 10 (10%)
- a little: 30 (30%)
- some: 25 (25%)
- a good amount: 15 (15%)
- a lot: 0 (0%)

How much have you learned about climate change from each of the following sources? - Informal Science Institutions (museums, zoos, aquariums, nature centers)

- nothing: 1 (1%)
- a little: 11 (11%)
- some: 36 (36%)
- a good amount: 37 (37%)
- a lot: 15 (15%)
How much have you learned about climate change from each of the following sources? - Community relationships (schools, town meetings, friends, family, church groups)

- nothing: 25 (25%)
- a little: 30 (30%)
- some: 30 (30%)
- a good amount: 10 (10%)
- a lot: 5 (5%)

How much have you learned about climate change from each of the following sources? - professional development workshops

- nothing: 12 (12%)
- a little: 11 (11%)
- some: 28 (28%)
- a good amount: 27 (27%)
- a lot: 22 (22%)

Deforestation in the tropics is driving countless species toward extinction and accounts for nearly 20% of the global greenhouse gas emissions. Identify one mitigation strategy conservationists may take to address this problem.

- Regulation on the amount of trees removed versus new planted.
- Conservation/protected areas where deforestation has occurred.
- Education of local people and purchasing valuable land.
- Provide information on sustainable harvest techniques and development of ecotourism to replace income loss due to conservation of ecosystem.
- One mitigation strategy could include land use practices such as shifting cultivation by local communities and reduced-impact-logging. Also create sustainable rotating crops and harvesting cycles can be demonstrated.
- Strengthening national forest govern...  

Please indicate whether each sentence is a description of ‘weather’ or ‘climate’. - Katrina was the strongest hurricane to ever hit New Orleans.

- Weather: 77 (77%)
- Climate: 23 (23%)

Please indicate whether each sentence is a description of ‘weather’ or ‘climate’. - It has never gone above 100 degrees in May.

- Weather: 18 (18%)
- Climate: 82 (82%)

Please indicate whether each sentence is a description of ‘weather’ or ‘climate’. - There is a severe thunderstorm watch in effect for NYC.

- Weather: 94 (94%)
- Climate: 6 (6%)
Please indicate whether each sentence is a description of ‘weather’ or ‘climate’. - It has not rained at all yet this month.

Please indicate whether each sentence is a description of ‘weather’ or ‘climate’. - This winter should be colder than normal.

Which of the following statements most closely represents your own, personal view?

Climate change has occurred in the past, but current climate change is different because

Which of the following statements about climate change is most accurate?

How much do you trust or distrust the following as a source of information about climate change? – Scientists
How much do you trust or distrust the following as a source of information about climate change? - Peer-reviewed science journals

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<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

How much do you trust or distrust the following as a source of information about climate change? - Scientific conferences

<table>
<thead>
<tr>
<th>Trust Level</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Trust</td>
<td>32</td>
<td>32%</td>
</tr>
<tr>
<td>Trust</td>
<td>47</td>
<td>47%</td>
</tr>
<tr>
<td>Somewhat Trust</td>
<td>21</td>
<td>21%</td>
</tr>
<tr>
<td>Distrust</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Highly Distrust</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

How much do you trust or distrust the following as a source of information about climate change? - Social media (Twitter, Facebook, blogs, etc.)

<table>
<thead>
<tr>
<th>Trust Level</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Trust</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Trust</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>Somewhat Trust</td>
<td>36</td>
<td>36%</td>
</tr>
<tr>
<td>Distrust</td>
<td>45</td>
<td>45%</td>
</tr>
<tr>
<td>Highly Distrust</td>
<td>16</td>
<td>16%</td>
</tr>
</tbody>
</table>

How much do you trust or distrust the following as a source of information about climate change? – Internet

<table>
<thead>
<tr>
<th>Trust Level</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Trust</td>
<td>18</td>
<td>18%</td>
</tr>
<tr>
<td>Somewhat Trust</td>
<td>70</td>
<td>70%</td>
</tr>
<tr>
<td>Distrust</td>
<td>9</td>
<td>9%</td>
</tr>
<tr>
<td>Highly Distrust</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

How much do you trust or distrust the following as a source of information about climate change? - Mainstream news media

<table>
<thead>
<tr>
<th>Trust Level</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Trust</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Trust</td>
<td>11</td>
<td>11%</td>
</tr>
<tr>
<td>Somewhat Trust</td>
<td>64</td>
<td>64%</td>
</tr>
<tr>
<td>Distrust</td>
<td>22</td>
<td>22%</td>
</tr>
<tr>
<td>Highly Distrust</td>
<td>3</td>
<td>3%</td>
</tr>
</tbody>
</table>

How much do you trust or distrust the following as a source of information about climate change? – IPCC
How much do you trust or distrust the following as a source of information about climate change? -

Professional development workshops

<table>
<thead>
<tr>
<th>Trust Level</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Trust</td>
<td>21</td>
<td>21%</td>
</tr>
<tr>
<td>Trust</td>
<td>58</td>
<td>58%</td>
</tr>
<tr>
<td>Somewhat Trust</td>
<td>18</td>
<td>18%</td>
</tr>
<tr>
<td>Distrust</td>
<td>9</td>
<td>9%</td>
</tr>
<tr>
<td>Highly Distrust</td>
<td>1</td>
<td>1%</td>
</tr>
</tbody>
</table>

Government agencies

<table>
<thead>
<tr>
<th>Trust Level</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Trust</td>
<td>8</td>
<td>8%</td>
</tr>
<tr>
<td>Trust</td>
<td>41</td>
<td>41%</td>
</tr>
<tr>
<td>Somewhat Trust</td>
<td>10</td>
<td>10%</td>
</tr>
<tr>
<td>Distrust</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Highly Distrust</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

Informal Science Institutions (museums, zoos, aquariums, nature centers)

<table>
<thead>
<tr>
<th>Trust Level</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Trust</td>
<td>28</td>
<td>28%</td>
</tr>
<tr>
<td>Trust</td>
<td>61</td>
<td>61%</td>
</tr>
<tr>
<td>Somewhat Trust</td>
<td>10</td>
<td>10%</td>
</tr>
<tr>
<td>Distrust</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Highly Distrust</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

Business or industrial corporations

<table>
<thead>
<tr>
<th>Trust Level</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Trust</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>Trust</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>Somewhat Trust</td>
<td>37</td>
<td>37%</td>
</tr>
<tr>
<td>Distrust</td>
<td>40</td>
<td>40%</td>
</tr>
<tr>
<td>Highly Distrust</td>
<td>18</td>
<td>18%</td>
</tr>
</tbody>
</table>
How much do you trust or distrust the following as a source of information about climate change? - Community relationships (schools, town meetings, friends, family, church groups).

- Highly Trust: 2 (2%)
- Trust: 25 (25%)
- Somewhat Trust: 60 (60%)
- Distrust: 11 (11%)
- Highly Distrust: 2 (2%)  

Which of the following scenarios best illustrates why studying climate change is important?

- Climate change is causing the ozone hole to grow and let in more solar radiation: 9 (9%)
- Climate change is causing changes in the geographic range and seasonality of certain infectious diseases and food-borne infections: 76 (76%)
- Climate change may increase crop yields by lengthening the growing season significantly: 1 (1%)
- There is still no consensus among scientists on the causes and effects of climate change: 14 (14%)

Which of the following scenarios best illustrates why teaching climate change is important?

- Young people need to be introduced to the controversy surrounding climate change: 10 (10%)
- Students need to understand how climate change is part of the earth’s natural cycle: 6 (6%)
- Schools have a duty to produce citizens who can make informed scientific decisions: 83 (83%)
- It is essential that students understand the strengths and weaknesses of science: 1 (1%)

How significant are these obstacles to your incorporating climate change into your work? - Lack of time for planning

- Not Significant: 10 (10%)
- Barely Significant: 11 (11%)
- Slightly Significant: 29 (29%)
- Significant: 33 (33%)
- Highly Significant: 17 (17%)

How significant are these obstacles to your incorporating climate change into your work? - Lack of time for instruction

- Not Significant: 8 (8%)
- Barely Significant: 5 (5%)
- Slightly Significant: 24 (24%)
- Significant: 46 (46%)
- Highly Significant: 17 (17%)
How significant are these obstacles to your incorporating climate change into your work? - Lack of sufficient content knowledge

<table>
<thead>
<tr>
<th>Significance</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Significant</td>
<td>26</td>
<td>26%</td>
</tr>
<tr>
<td>Barely Significant</td>
<td>32</td>
<td>32%</td>
</tr>
<tr>
<td>Slightly Significant</td>
<td>27</td>
<td>27%</td>
</tr>
<tr>
<td>Significant</td>
<td>13</td>
<td>13%</td>
</tr>
<tr>
<td>Highly Significant</td>
<td>2</td>
<td>2%</td>
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</tbody>
</table>

How significant are these obstacles to your incorporating climate change into your work? - Lack of institutional (school) support

<table>
<thead>
<tr>
<th>Significance</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Significant</td>
<td>20</td>
<td>20%</td>
</tr>
<tr>
<td>Barely Significant</td>
<td>18</td>
<td>18%</td>
</tr>
<tr>
<td>Slightly Significant</td>
<td>32</td>
<td>32%</td>
</tr>
<tr>
<td>Significant</td>
<td>23</td>
<td>23%</td>
</tr>
<tr>
<td>Highly Significant</td>
<td>7</td>
<td>7%</td>
</tr>
</tbody>
</table>

How significant are these obstacles to your incorporating climate change into your work? - Lack of parental (community) support

<table>
<thead>
<tr>
<th>Significance</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Significant</td>
<td>26</td>
<td>26%</td>
</tr>
<tr>
<td>Barely Significant</td>
<td>25</td>
<td>25%</td>
</tr>
<tr>
<td>Slightly Significant</td>
<td>25</td>
<td>25%</td>
</tr>
<tr>
<td>Significant</td>
<td>18</td>
<td>18%</td>
</tr>
<tr>
<td>Highly Significant</td>
<td>6</td>
<td>6%</td>
</tr>
</tbody>
</table>

How significant are these obstacles to your incorporating climate change into your work? - Lack of access to trusted scientific information

<table>
<thead>
<tr>
<th>Significance</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Significant</td>
<td>30</td>
<td>30%</td>
</tr>
<tr>
<td>Barely Significant</td>
<td>29</td>
<td>29%</td>
</tr>
<tr>
<td>Slightly Significant</td>
<td>17</td>
<td>17%</td>
</tr>
<tr>
<td>Significant</td>
<td>16</td>
<td>16%</td>
</tr>
<tr>
<td>Highly Significant</td>
<td>8</td>
<td>8%</td>
</tr>
</tbody>
</table>

How significant are these obstacles to your incorporating climate change into your work? - Lack of access to appropriate instructional materials

<table>
<thead>
<tr>
<th>Significance</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Significant</td>
<td>15</td>
<td>15%</td>
</tr>
<tr>
<td>Barely Significant</td>
<td>17</td>
<td>17%</td>
</tr>
<tr>
<td>Slightly Significant</td>
<td>35</td>
<td>35%</td>
</tr>
<tr>
<td>Significant</td>
<td>20</td>
<td>20%</td>
</tr>
<tr>
<td>Highly Significant</td>
<td>13</td>
<td>13%</td>
</tr>
</tbody>
</table>
How significant are these obstacles to your incorporating climate change into your work? - lack of scientific consensus about climate change

Not Significant: 36%
Barely Significant: 26%
Slightly Significant: 22%
Significant: 10%
Highly Significant: 6%

Which of the following factors do you consider to be valid evidence that the earth is getting warmer? (Check all that apply)

- Glaciers and polar ice is melting: 98%
- Your hometown is facing warmer than average temperatures: 54%
- Your hometown is facing colder than average temperatures: 27%
- Computer models show earth is getting warmer: 66%
- Hurricanes and other storms are getting stronger: 77%
- Reports from the IPCC explicitly state the earth is warming: 77%
- Penguins and polar bears are declining in numbers: 72%
- Extreme weather events (storms, droughts, floods) are more frequent: 90%

People may select more than one checkbox, so percentages may add up to more than 100%.

Which of the following best describes the relationship between the greenhouse effect and climate change?

- The greenhouse effect and global warming are essentially the same thing: 20%
- Without the greenhouse effect, there would be virtually no global warming: 73%
- Without global warming, there would be virtually no greenhouse effect: 2%
- There is no scientific consensus as to whether or not the greenhouse effect exists: 1%
- I do not know: 4%

Which of the following are major drivers of earth’s climate? (Check all that apply)

- The sun: 82%
- The moon: 26%
- The ocean: 72%
- Clouds: 43%
- Volcanoes: 47%
- Earthquakes: 17%
- The greenhouse effect: 94%
- El Nino: 33%
- Polar ice: 53%
- Earth’s rotation: 50%

People may select more than one checkbox, so percentages may add up to more than 100%.
In 2005, the world experienced an exceptional hurricane season in the Atlantic, unlike anything ever witnessed or recorded before. Which of the following statements about that year is most accurate?

- If such a season does not recur within the next 30 years, scientists are likely to look back at 2005 as a solid example of climate variability. 
  - 53% 
- If such a season does not recur within the next 30 years, scientists are likely to look back at 2005 as a solid example of climate change. 
  - 18% 
- If such a season occurs again within the next 30 years, scientists are likely to look back at 2005 as a solid example of climate variability. 
  - 31% 
- I do not know 
  - 6% 

Identify three (3) climate change related impacts on wildlife:
- Loss of habitat 
- Loss of food change in nesting/hatching 
- Changing availability of food 
- Changing patterns in courtship and mating 
- Expanding ranges of invasive species 
- Drought, melting sea ice, loss of habitat. Changes in temperatures may effect migration, coral bleaching, more severe storms 
- Phenology - change in timing of life cycle events stressing food chains, loss of habitat: Polar Bear & Walrus loss of Polar ice pack increased duration of heat stress: Coral bleaching. For many species, the climate where they live or spend part of the year influences key stages of their annual life cycle, ...

WCS conservationists have observed some bird species nesting more than a week earlier than they did 25 years ago. This shift may interrupt an important correlation between the hatching of chicks and the emergence of insect prey, a key source of food for baby birds. Identify one adaptation strategy these scientists can take to help save these bird species.

- Bird sanctuaries/protected areas 
- Insects (same types) brought in from other areas 
- Release insect into area 
- Establish bird populations in more suitable locations 
- I thought it was the other way around. That the insects were hatching before the birds arrived? Find alternative food sources. Protect the remaining wetlands in the breeding grounds. Conduct research on the change in phenology of the insects in correlation to migration of the birds. Timing of migration may well shift to coincide with the hatch of prey. Scientists can identify another insect prey this bird can adapt to. I would think ...