TRACING THE FLOW:

CLIMATE CHANGE ACTOR-NETWORKS IN

OKLAHOMA SECONDARY SCIENCE EDUCATION

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Abstract: This dissertation reports research about the translation of climate change in science education. Public controversies about climate change education raises questions about the lived experiences of teachers in Oklahoma and the role of science education in increasing public understanding. A mixed methods research design included rhetorical analysis of climate change denial media, key informant interviews with science education stakeholders, and a survey questionnaire of secondary science teachers. Final analysis was further informed by archival research and supplemented by participant observation in state-wide meetings and science teacher workshops. The results are organized into three distinct manuscripts intended for publication across the fields of communication, science education, and climate science. As a whole the dissertation answers the research question, how does manufactured scientific controversy about climate change present specific challenges and characterize negotiations in secondary science education in Oklahoma? Taken together, the findings suggest that manufactured controversy about climate change introduces a logic of non-problematicity, challenges science education policy making, and undermines scientific consensus about global warming.

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CHAPTER I

INTRODUCTION

This dissertation reports research about the influence of public climate change education contestations on the translation of climate change education (CCE) in public school contexts. Chapter One introduces the context surrounding contemporary controversies about climate change and reviews the literature about CCE in science classrooms. A blend of Actor-network Theory and Critical Political Ecology provide a theoretical and methodological framework for tracing climate change controversies across both human and rhetorical artifacts. Next, an overview of the delimitations and limitations of the research design further contextualizes the scope of the dissertation research efforts. Finally, this chapter offers a brief synopsis of the purpose, methods, and significance of the three studies presented in this compilation.

Problem Area

There is widespread recognition that organized climate denial campaigns employ manufactured controversy to politicize and delegitimize the scientific consensus behind the theory of global warming and to stifle environmental governance (McCright & Dunlap, 2010; Moser, 2010; Schneider, 1993). Climate denial campaigns often cite questionable "scientific" counterevidence about alternative causes of global warming, deploy ad hominem attacks, and foster polarizing frames designed to question the legitimacy of environmental problems (Weart, 2011). Additional documented examples

of this scientization (or misrepresentation of scientific facts to support a particular political agenda) include using scientific information to create misinformation campaigns; reporting data from faulty scientific models; deploying absurd alternate causality arguments; misusing and de-contextualizing scientific evidence; and employing stealth budgeting to sustain structural barriers to new research (Peterson, Connolley, & Fleck, 2008, p. 1333).

In a recent article titled "Climate change sparks battles in the classrooms", Reardon (2011) suggested that political debate in the United States about the certainty of climate change has extended to the K-12 science classroom. Teachers across the nation, who are engaged in climate change education, recently reported increasing experiences with pushback about teaching climate change from schools administrators, parents, and students (Johnson, 2011). Now, according to the National Center for Science Education (2012), anti-science legislation introduced in several states aims to pair climate change with other controversial topics, like evolution, to deny scientific consensus on global warming. These legislative campaigns support efforts to 'teach the controversy' about the theory of global warming and cast the science classroom as a specific space of cultural contestation. Awareness of such campaigns engenders questions about how to facilitate climate change education efforts in the face of public controversy.

Related Literature

While science education researchers have grown increasingly concerned with widespread conceptual misunderstandings about climate change as a process (Bozodogan, 2011; Harrington, 2008; McCaffrey & Buhr, 2008), only recently has research focused on how manufactured scientific controversy influences classroom

teachers and instruction (Meehan, 2012; Wise, 2010). This section briefly outlines the literature concerning the common climate change misconceptions held by teachers, parents, and children. This is followed by a review of the sociological research which suggests that the structuring of climate change communication and decision-making in the classroom may be equally influential in attitude formation (Nicholls, 1999).

In his meta-analysis of research in CCE, Bozdogan (2011) found the most frequently encountered misconception by teachers, parents, and students related to a direct connection between global warming and the depletion of the ozone layer, even though we know them to be phenomenologically different. Similarly, Arslan, Cigdemoglu, and Moseley (2012) concluded that misconceptions are prevalent across students' understanding of the nature and consequences of global warming, as well as resolutions to global warming problems. With this awareness, teachers are encouraged to prepare by assessing students' conceptions and misconceptions- prior knowledge, beliefs, and attitudes -about climate change.

Work by Pruneau, Gravel, Bourque, and Langis (2003) directly challenged the logic of the conceptual change theory by investigating the situations where little change in initial ideas occurred after exposure to climate change curriculum. They identified barriers to change which included the complexity of the phenomena, lack of belief in the theory, ignoring data, or lack of interest. Given the range of sustained misconceptions and public attitudes about the certainty of climate change, cultural cognition researchers inform an understanding that individuals engage in the active interpretations of facts based on group relationships, rather than relying solely on scientific evidence and expertise (Kahan, Jenkins-Smith, & Braman, 2011). Theorizing climate change

knowledge in terms of worldviews and group relationships suggests that the traditional information and access deficit models of science education are limited in explanatory power (Nisbet & Scheufele, 2009).

Research in climate change attitudes confirms that individuals construct mental models about what they know, value, feel, and understand about climate change in different ways (Leiserowitz, Smith, & Marlon, 2011). Cook and Lewandowsky (2011) highlighted backfire effects wherein previously held misconceptions are reinforced when teachers do not structure classroom communication in a way that addresses students' prior exposure to climate skepticism. For instance, the familiarity backfire reinforces preexisting beliefs by not providing a persuasive alternative, the overkill backfire occurs with information overload, and the worldview backfire fails to engage cultural identity and motives. To overcome these pedagogical challenges, applied research studies suggest that teachers employ a set of communication strategies, beyond simple focus on scientific evidence, which include (a) creating simple and cognitively attractive messages, (b) employing hopeful, self-affirming frames, and (c) relating climate change to cultural influences and regional experiences (CRED, 2009; Cook & Lewandowsky, 2009). Summers, Kruger, and Childs (2001) suggested that subject knowledge should and can be distinguished from pedagogical knowledge about how to navigate controversies about environmental problems.

In sum, although environmental science educators know quite a bit about the common misconceptions held by climate change, very little is known about how manufactured scientific controversy influences the translation and performance of CCE. This literature review highlighted the need for more research to explore the

communication challenges and situated experiences of science teachers who are faced with manufactured scientific controversy in the classroom (McBean & Hengeveld, 2000). This dissertation study contributes to research in climate change denial as a social problem by exploring the power relations and complex assemblages which influence *how* climate change knowledge is communicated across several educational contexts—children's books, policy making, and individual teacher pedagogies.

Theoretical and Methodological Framework

This section outlines the theoretical and methodological framework guiding this dissertation research. Actor-network Theory (ANT) offered guidance for conceptualizing the research design, whereas Critical Political Ecology (CPE) offered an interpretive lens for examining the results. Together, these theories provide a framework for examining the translation of scientific disputes by identifying the power relations related to the construction of climate change knowledge in science classroom teaching and learning.

Actor-network theory

Deriving from the field of Science and Technology Studies (STS), Actor-network Theory is concerned with the processes which characterize socio-scientific disputes. ANT is rooted in the understanding that each entity (material or immaterial) gains its form as a consequence of their relations as well as "performed in, by, and through those relations" (Law, 1999, p. 5). As Masys (2009) explained, ANT supports climate change research across a variety of disciplines and worldviews.

> [It examines] the complex socio-technical/political/economic systems that comprise the problem space and expands our 'world view' of 'climate' change beyond physical climate to include the 'social'

> climate, 'political' climate, 'security' climate, and 'economic' climate with particular emphasis on the socio-technical domain and its cross domain influences (p. 6).

In this framework, knowledge about climate change is understood as translated by various actors across complex networks. Often employing ethnographic research methods for following the actors and examining networks inscriptions (Bishop, Van House & Buttenfield, 2003), ANT makes "visible the rich assortments of mundane things at play in educational events and how they are connected" (Fenwick & Edwards, 2010, p. 13).

The main contribution of ANT is to transform CCE inquiries from a search for social reality to an effort to trace *translations*, or the processes and moments in the circulation of interactions across time and space. ANT studies seek to identify the nodes of action and trace the configurations of actors which drive these circulations (Sheehan, 2011). *Actor-networks* are composed of multiple actors, or *actants*, engaged in mobilizing others. Actants form heterogeneous networks aligned by common interests and engaged in convincing others to *enroll* in, or accept, the interests defined by the actor-network. As an action-oriented perspective, the concept of network assemblages draws attention to the *nodes of action*, or social spaces, where power is enacted and performed.

The concept of translation applies easily to research on group formations which result from public climate change controversies. Latour (2005) articulated ANT as a way of looking rather than an explanatory theory per se. ANT consciously aims to relinquish a priori categories and assumptions about social structures by tracing the ways these

heterogeneous groups function to sustain or inhibit, in this case of this research, climate change education. Distinct from other network theories, ANT relinquishes the ontologically distinct notions of scale (macro/micro, global/local, district/school, school/classroom) in an effort to identify the intricate linkages across different enactments of climate change education policy and practices (Fenwick & Edwards, 2010).

ANT theorizes climate change actor-networks within a complex web of relations and, most notably, extends relational thinking to materiality (Saldanha, 2003). For example, both human and non-human entities form the nature of teacher work and identity. While individual teachers have agency in classroom activities, they are also relational effects of objects like buzzers, textbooks, testing, and contracts (Fenwick & Edwards, 2010). Rather than a deterministic vision, ANT defines teacher agency through a diverse set of networked relationships and presents an ontological framework that accounts for non-material "artifacts" (e.g. textbooks, standards, testing, and school climate) as actants in network translations (Fenwick, 2010).

This research adopted Latour's (2005) approach to mapping controversy as a guiding method for identifying important nodes of social negotiation which influence the advancement of climate change education. ANT methodology employs four key principles for mapping controversies and avoiding a priori assumptions about social assemblages (Latour, 2005). First, the action (or agency) of actors in the network must not be assumed but demonstrated by evidence of change in the state of affairs. This distinction is the hallmark of a good ANT study and involves asking questions like, which agencies are invoked? And what figurations carry meaning? This process

distinguishes *intermediary* actors from *mediators*. Intermediary actors transport meaning without influencing transformations, whereas mediators "transform, translate, distort, and modify meanings" (Latour, 2005, p. 39) and are not necessarily direct causes. Where intermediary forces offer predictability to the enquiry, mediators multiply the differences within controversy and are more important than any specific mediating actors (Alcadipani and Hassard, 2010).

Next, the researcher and participant figurations of actors must attend to the implications of the narrative and disciplinary representations of actors and events. For the researcher, Latour (2005) described this process as careful attention to "recording, no filtering; describing, no disciplining" (pg. 55). The third principle attends to the nature of controversy as beneficial for tracing assemblages. Research accounts should attend to the criticisms and framing of other actants (an implicit process of controversy) as a strategy for tracing actor-networks. The fourth principle requires looking to network actants themselves to offer the explanations for how agencies are successful or unsuccessful. Each of these principles guided the methodology and data collection practices across the collective studies described in this dissertation manuscript.

Critical political ecology

While ANT provided the methodological framework for how to conduct the research, Critical Political Ecology (CPE) provided the interpretive lens of explaining the role of contestations about CCE in challenging or enforcing the symbolic legitimacy of science. Political ecology aims to empirically investigate the struggle of knowledge, power, and practice which inextricably accompany the politics of environmental conflicts (Robbins, 2012; Watts, 2000). Political ecology focuses on power relations both globally

and locally, broadening the ecological analysis to the agency of individuals, movements, and community institutions and structure. Foundational thinkers Blaikie and Brookfield (1987) define this type of research as combining "the concerns of ecology and a broadly defined political economy. Together this encompasses the constantly shifting dialectic between society and land-based resources; and also within classes and groups within society itself" (p. 17). One point of departure for post-structural political ecology is to redefine these dialectical entanglements as network assemblages characterized across a complex web of relations (Robbins, 2012; Rocheleau and Roth, 2007). Efforts to trace controversies across and within network assemblages can inform a critical understanding of the ways people, groups, institutions, objects, and other assemblages leverage power to influence others.

As a sub-discipline of political ecology, CPE seeks to expose how dominant scientific discourses gain power through the narrative framing of historical facts or impositions of social norms (Forsyth, 2003). This critical lens avoids adopting an unproblematized notion of scientific truth and specifically draws attention to the polarizing effects of manufactured climate change controversies. A critical political ecology of consensus re-positions these controversies as translations and negotiations with: (a) what counts as scientific knowledge; (b) who controls its production, dissemination, and use, and; (c) how actors challenge, reinforce, or reframe the symbolic boundaries of science (Cox, 2010; Forsyth, 2003; Vogel et. al, 2007). Conceptualizing the translation of CCE within the contexts of situated science points to the power embodied in these patterns and processes of connectivity, the value judgments that are

made in knowledge-rich environments, and the inadequacy of interpersonal learning theories (Bell, 2010; Siemens 2006).

As a theoretical framework, CPE guides an understanding of how social and political contexts might influence the 'making' of climate change knowledge (Forsyth, 2003). As a methodological framework, ANT guides investigations in the messy web of relations which mediate the translation of climate change knowledge from society to science classroom (Rocheleau, 2008; Rocheleau & Roth, 2007). Figure 1.1 clarifies the epistemological and ontological orientations of this blended framework for understanding how CCE is socially constructed and problematized across actor-networks.

(Re)producing climate change	
Epistemological Skepticism *Questions <u>what</u> we can know*	Knowing through making, objectively constrained social construction within a context
(un)Doing science education	
Ontological Realism *Questions <u>how</u> we know it*	Multiple, contextually situated alternative world-states

Figure 1.1 Theorizing the 'making' of climate change (education)

Inquiries into the making of climate change (education) raise questions about *what* can be known about climate change (epistemology) and *how* it is known by individuals and groups (ontology). *Epistemological skepticism* about what is known about climate change knowledge specifically highlights the objectively constrained social construction of scientific knowledge about climate change. Investigations in this social

(re)production provide a critical arena for examining the making of scientific fact and truths across science education assemblages. *Ontological realism* recognizes multiple worldviews and situated experiences in the construction and translation of climate change knowledge (Carolan, 2005; Forsyth, 2003). Rather than questioning what we know, this approach questions how we know about climate change. Investigations in the (un)doing of science education provides a critical arena to examine how the situated experiences and worldviews of science educators might influence the translation of climate change in science classrooms**.**

Research Design

The purpose of this research was to investigate the influence of public climate change education contestations on the translation of climate change education (CCE) in public school contexts. The cross-fertilization of Actor-Network Theory and Critical Political Ecology guided the delimitation of the research questions and methods for capturing the discourse, culture landscape, and power relations which sustain controversies about climate change and climate change education. The three studies presented in this dissertation piece are unified under a common theoretical framework of climate change (education) as constantly in the 'making.' Together, the compiled research articles broadly answer the question: *How does manufactured scientific controversy about climate change present specific challenges to science education in Oklahoma?*

To answer this main research question, a three-stage mixed methods design was implemented in the spring and summer of 2013 (see Figure 1.2). The study began with a rhetorical analysis of pseudo-educational books which promote climate skepticism in

children. Next, a series of key informant interviews were conducted which aimed at assessing the state of science education in Oklahoma and leaders in climate change education. Finally, a survey of secondary science teachers was administered to capture the situated classroom experiences of science teachers engaged in climate change education and/or facing anti-science pushback. Each stage of the design was supplemented with secondary archival data, as well as participant observation during several statewide science education conferences and science teacher workshops. This type of pragmatic research program proved useful for identifying some intricate linkages between popular media, education policy, and pedagogical practices which influence the translation of climate change (education). An overview of the scope and limitations of this mixed methods design is discussed next. Additionally, a more detailed description of the specific data collection procedures and sampling methods is articulated within the text of each article chapter.

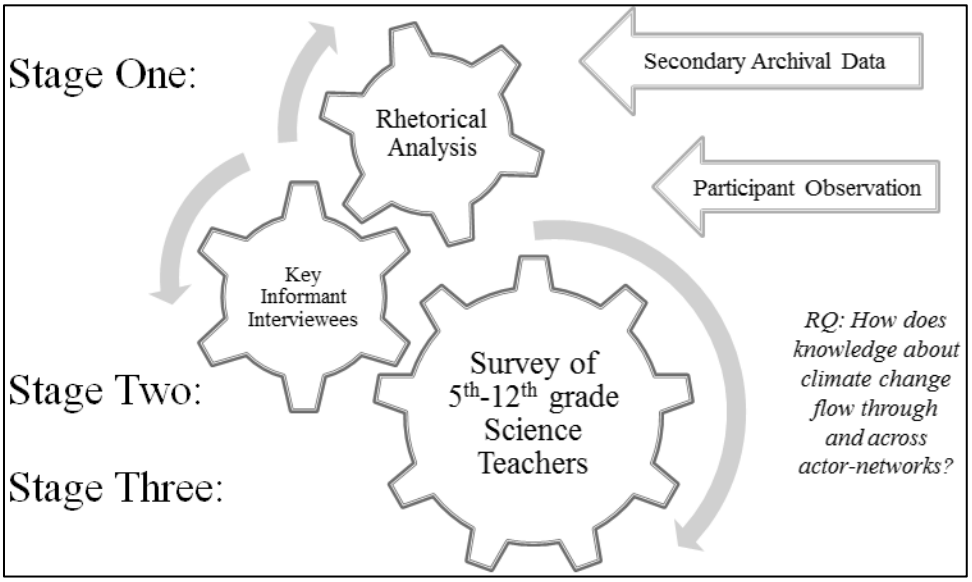


Figure 1.2 A mixed methods design for tracing climate change controversies

Delimitations and limitations

In order to maintain the focus and define the scope of the dissertation research project certain limitations and delimitations were necessary. Stage One of the research was limited to three identified skeptical books for children from a wide range of available climate change texts for children; ranging from dismissive to hesitant to adherent (Meehan, 2012). While this is a methodologically appropriate delineation for the purpose of the study, there are clear limitations to the generalizability of the research findings. The generalizability of this study is further complicated by the inability to assess the total population, potential readership, and distribution of these skeptical materials for children. Furthermore, Stage One of the design is limited by the nature of rhetorical analysis as subject to interpretation and constrained by coding delimitations. Despite improving inter-coder reliability efforts, the narrowly defined set of coding categories limits the scope of the textual analysis and leaves room for alternate pathways of interpretation. The advantage to this delimitation was to focus inquiry in the composition and translation of skeptical discourses.

Stage Two of the research included key informant interviews with science education stakeholders in Oklahoma. A snowball sample of science education stakeholders (n=17) included science teachers, school leaders, informal educators, and members of other state level professional and advocacy organizations. While this delimitation allowed the researcher to trace networks of actors across the state of Oklahoma, the snowball sampling approach limits any conclusions about the representativeness of the study findings. As a form of naturalistic and qualitative inquiry, key informant interviewees are limited in terms of replication, validity, and reliability.

For example, access to initial key informants relied on the researchers' embedded professional relationships with informal and formal education organizations. Additionally, a number of stakeholders declined to be interviewed.

Stage Three of the research involved the design of an on-line questionnaire for 5^{th}-12^{th} grade science teachers (n=115) in Oklahoma. The survey was conducted in May and June 2013 and relied on key informants for distribution across a variety of listservs. This snowball sampling again limits the generalizability of the results; however, this delimitation is informed by ANT methodology for tracing complex webs of relations. The number of responses may have been limited by time constraints on teachers due to end-of-instruction testing and summer vacation. In general, surveys are also limited by forced response categories which may not capture the full range of possible responses. To account for this, the multiple choice questions included the option of selecting "other" and entering additional responses and the attitudinal questions evoked open-ended responses (e.g. why or why not?). Unlike the key informant interviews which allowed for follow-up questions, the researcher is limited to the text of the survey and the willingness of the respondents to elaborate open-ended questions. Furthermore, self-reported data is limited to the selective memory, recall, attributions, and even embellishments of the teacher respondents. While the questionnaire was designed to be inclusive of a range of climate change attitudes and avoid bias, it is likely that negative connotations about the politics behind climate change may have limited some teachers' willingness to participate in the survey. Lastly, the survey itself was lengthy, often taking respondents up to 45 minutes to complete, and resulted in 31 incomplete surveys.

As a case study in Oklahoma politics, this collective dissertation study is limited to the worldviews and group relationships of the participants and is not generalizable to other states or communities of practice. Limitations to researcher time, funds, and access further determined the scope of the analysis. For example, efforts to plan follow-up focus groups failed due to the length of time between the survey and focus group invitations, as well as time constraints due to teachers returning to school from summer vacation. Finally, the researcher's assumptions are based on the combination of methods and findings across a variety of meanings and associations. This mixed methods study required several iterative analyses of qualitative and quantitative data and triangulation across several theoretical orientations. While this method of convergent validity is common, it is limited in its subscription to naïve realism.

In sum, the scope of the study was influenced by the limited resources of the research, as well as applications of the theoretical and methodological framework. A lack of delimitations accompanying the snowball sampling of key informants and teachers limits generalizability of the findings and the validity and reliability of the survey results. The blending of qualitative and quantitative data, while subject to interpretation, added a richness and depth to the inquiry and resulted in multiple research articles.

Preview of Each Study

This section provides the title, authorship, target journal, specific research questions, and abstract for the three unique articles resulting from this dissertation project.

"Climate change skeptics teach climate literacy? An analysis of children's books"

Authors: Nicole Colston and Julie Thomas

Target Journals: *Environmental Communication; Science as Culture*

Research Question: What rhetorical strategies reinforce the logic of non-problematicity about climate change in skeptical books for children?

Abstract: This research focused on skeptical climate change literature designed for children and parents. The purpose of the research was to explore how these pseudo-educational materials convey a logic of non-problematicity about climate change (McCright & Dunlap, 2000). Using rhetorical analyses procedures developed from previous excavations in skeptical discourses, this study identified: (a) common forms of climate skepticism (Dunlap & McCright, 2010; Rahmstorf, 2004), (b) frames for climate change policy making (Nisbet, 2009), (c) areas of contested scientific knowledge (Latour, 2005; McCaffrey & Buhr, 2012), and (d) appeals for managing the uncertainty of climate change (Norton, Sias, & Brown, 2011). The results suggest that the logic of non-problematicity about environmental problems is bolstered by contradictory forms of climate change skepticism and polarizing social conflict frames. The identified strategies for managing uncertainty complement the logic of non-problematicity by appealing to a range of worldviews and senses of agency. The discussion points to the dangers of skeptical media which broker individual decision-making about climate change (over scientific consensus) and undermine environmental concern within dominant narratives of ecological modernization. This research study contributes to new pathways in environmental communication scholarship concerned with increasing climate denial media campaigns targeted at educational contexts.

"(un)Doing the NGSS: Possibilities for climate change education in Oklahoma"

Authors: Nicole Colston and Toni Ivey

Target Journal: *Journal of Education Policy; Learning, Culture, & Social Interaction*

Research Question: What spaces of prescription and negotiation characterize climate change education efforts within and across science education communities of practice in Oklahoma?

Abstract: This exploratory research investigated how science education communities of practice in Oklahoma engage in translations of climate change education. Applications of Actor-network Theory (ANT) to educational policy making facilitate this analysis of the spaces of prescription and spaces of negotiation that characterize climate change education in Oklahoma (Fenwick, 2010; Fox, 2000). Informed by key informant interviewees with science education stakeholders and a survey of secondary science teachers, the results reported the perceived barriers to science education reform faced by educators in Oklahoma. Revisions of the State Priority Academic Science Standards (PASS) based on the nationally developed Next Generation Science Standards (NGSS) emerged as a possible node of action in the advancement of climate science education in public schools. However, entanglements with historical contestations over evolution characterize the negotiation of standards revisions and suggest that climate change concepts may indeed be erased or muted. This research contributes to the emerging body of educational studies and policy research focused on the potential of the (NGSS) to increase climate change education efforts in public schools.

"Teach the controversy: The political ecology of scientific consensus"

Authors: Nicole Colston and Jackie Vadjunec

Target Journals: *Geoforum; Science Communication*

Research Question: What situated knowledge and pedagogies do teachers have about negotiating the symbolic legitimacy of climate change consensus in the face of controversy?

Abstract: Contemporary anti-science education coalitions are increasingly linking climate change and evolution using Teach the Controversy campaigns. Awareness of this political phenomena raises questions about the extent to which portrayals of global warming predictions as mere knowledge claims undermine efforts to increase public understanding of scientific consensus about global warming (Freudenberg, 2000; Shackley & Wynne, 1996; Hulme, 2010). This critical political ecology of consensus included excavations into the problematization of climate change education via socio-historical forms of constraint which are located and performed across discourses of science teaching and learning. This research synthesizes the situated discourses of Oklahoma science teachers' attitudes about teaching climate change in the face of public controversy. The results revealed teachers marginalized by anti-science controversies but engaged in everyday acts of resistance to political, ideological, and religious norms. Contextualized within a history of contestation over the teaching of evolution, the practice of teaching the controversy is identified as a boundary ordering device that bridges convinced and skeptical discourses in the classroom. This research will contribute growing a body of interdisciplinary work interested in the co-production of

science knowledge and the power relations which sustain controversies about the scientific consensus behind global climate change.

CHAPTER II

CLIMATE CHANGE SKEPTICS TEACH CLIMATE LITERACY? AN ANALYSIS OF CHILDREN'S BOOKS

It is widely understood that climate change denial campaigns in the United States generate manufactured controversy to delegitimize scientific consensus about global warming and stifle environmental governance (Ceccarelli, 2011; McCright & Dunlap, 2000; Oreskes, 2010). Central to these campaigns are mechanisms for mobilizing the logic of non-problematicity, defined as challenges to the social construction of climate change as a problem (Freudenberg, 2000). In an exposé of the organized climate denial machine, Dunlap and McCright (2011) pointed to the widespread dissemination of climate denial media by oil companies, think tanks, front groups, and others as indicative of coordinated efforts to wield enormous political and economic power against climate change policy making. Discourse analyses and case studies of skeptical media point to the rhetorical currency of politicizing, deconstructing, and delegitimizing scientific consensus about climate change (Ceccarelli, 2011; Oreskes, 2010).

Now, it seems the public debate about the certainty of climate change has extended to our public school classrooms (Reardon, 2011). According to the National Center for Science Education website (2012), anti-science legislation (passed in several states) denies scientific consensus on global warming--pairing climate change with other

controversial topics like evolution in science classrooms. Another recent shocking example of climate denial in educational spheres, *The Skeptics Handbook* (Nova, 2009), was distributed to over 14,000 schools boards in the United States (Reardon, 2011). This handbook advised school leaders to ignore the evidence of climate change and to focus on four key issues emphasizing scientific uncertainty: (a) the greenhouse signature is missing, (b) ice cores do not support carbon as a driver of climate change, (c) temperatures are not rising, and (d) carbon dioxide is doing almost all the warming it can do). Cook (2009) quickly followed with *A Scientific Guide to the 'Skeptics Handbook'* to highlight the scientific basis of human-induced global warming and pointed to the logical fallacies within the first handbook.

The research presented in this article focused on children's books authored by climate skeptics, a unique form of media designed to counter the dissemination of a growing body of climate science literature and climate education policy making (Cooper, 2011). The goal of this research was to explore the translation of climate change denial in pseudo-educational materials targeted at parents, teachers, and children. This research asked: *what rhetorical strategies reinforce the logic of non-problematicity about climate change in skeptical books for children?* Answers to this research question will be practically significant to climate change educators organizing instruction to address common misconceptions (or climate myths), as well as science communication experts aiming to distinguish the rhetoric of climate change skepticism from the science supporting climate change (McBean & Hengeveld, 2000). After a review of the methodology and results of the study, the discussion explores the implications of media targeted at parents and children that delegitimizes climate science, appeals to independent

decision-making over scientific consensus, and casts doubt about the value of environmental policy making.

Methodology

Sampling and description of artifacts

In the process of reviewing books about climate change and global warming for children, the researchers identified a set of books with a distinctly dismissive approach to climate change education. In contrast to an adherent approach, which considers climate change as an immediate and serious problem, a dismissive approach is clearly aimed at engendering uncertainty about climate change (Meehan, 2012). Indeed, some climate change books for children were limited, or hesitant, in their attribution of human causes and provided minimal discussion of the impacts (e.g. extreme weather, food security, water security, ecosystems, society, and human health). However, the identified skeptical books notably occupied a space aimed at engendering manufacturing controversy about climate change and emboldening coalitional resistance to climate change actions (Dunlap & McCright, 2010).

A purposeful sampling of the skeptical artifacts relied on the authors' self-reported motivations for writing each book, as well as the *logic of non-problematicity* embedded in the titles of the selected children's book: (1) "Deb and Seby's Real Deal on Global Warming: The 'Other-side' of the Man-made Global Warming Issues" (Schmidt, 2008), (2) "The Sky's not Falling: Why it's OK to Chill about Global Warming" (Fretwell, 2007), and (3) "We're not scared anymore Mr. Gore (A Climate Change Story for Little Skeptics") (Hendrickx, 2008). Clearly the authors intend for parents, teachers, and children to view climate change as a *non-problem* (i.e., the sky is not falling, we can

all chill out, no need to be scared, no crisis here). Additionally, these authors self-identify as climate change skeptics.

The following summaries aim to contextualize the origins and themes of each book, including the main ideas, authors' credentials, and publishing information. First, *"*We're Not Scared Anymore Mr. Gore (A Climate Change Story for Little Skeptics)" is a self-published book by author Marc Hendrickx (2008), working as Little Skeptics Press. The author's biography lists work experience as a geologist with a Bachelor of Science degree from Latrobe University in Australia. The narrative storyline of *We're Not Scared* includes a fictional classroom visit from Al Gore, where the students cite contrarian scientific research, indict popular climate models (i.e. hockey stick graph for global warming), and evoke personal experience to disprove scientists' predictions. Crude computer illustrations and confrontational rhetoric pit teacher and students against Al Gore's presentations of science inside the school. Meanwhile, children play outside (visible through a window) in an environment of increasing glacial snow accumulation as the book progresses. An author narrated version of this storybook is available on YouTube ("We are not scared anymore Al Gore", 2008).

"Deb & Seby's Real Deal on Global Warming", a self-published book through AuthorHouse by Al Sonja Schmidt (2008), is a self-admitted response to the images of environmental destruction bombarding children in the classroom. The author has appeared on television concerning fear appeals and social norms which influence kid's global warming beliefs ("Al Sonja Schmidt on Fox Business", 2008). This book appeals to a teen audience via hip cartoons and informal slang. Framing global warming as manufactured controversy by environmentalists, the teen narrators of the *Real Deal*

reinforce political and social controversy over the existence of man-made global warming and warn about the dangers of environmental legislation. In a companion blog website by Deb and Seby, young readers can check out the facts for themselves.

"The Sky's Falling: Why It's OK to Chill about Global Warming" is written by Holly Fretwell (2007) and is identified as a Research Fellow at the Property and Environment Research Center (PERC). Informed by a BA in Political Science and an MS in Resource Economics from Montana State University, Fretwell writes articles with themes in free market environmentalism and describes environmental education as the "science of fear" (Fretwell, 2009). Playing on the story of Chicken Little, *The Sky's Not Falling* illustrates the facets of an ever-changing planet and challenges the notion of man-made global warming. The book also includes a section calling on parents to make up their own mind and encourage critical thinking in their children. Drawing on common Earth science content, the book teaches children that temperature change is natural, weather change is not necessarily bad or violent, and often criticizes the effectiveness of environmental policy making. Focused on free-market economics, the book ends by encouraging students to become enviro-prenuers (entrepreneurs who work for the environment) rather than environmentalists who "panic about environmental problems" (Fretwell, 2007, p. 76).

Coding and instrumentation

Discourse analysis, particularly research in the framing of climate change and global environmental problems, is an increasingly embraced methodology across many disciplinary research agendas (Buttel, 2000; Cox, 2010). Researchers developed a procedure for categorical coding and comparative analysis aimed at assessing the

interplay between climate skepticism and the logic of non-problematicity (Creswell & Plano Clark, 2007). Procedures for data collection included an iterative process of double-coding by the authors' for reliability during protocol modification and final analysis.

A development of the protocol for rhetorical analysis was guided by the existing literature on the rhetoric of climate skepticism and denial coalition. Four coding categories were developed for exploring the construction of global warming as a non-problem within and across each text: (1) types of climate skepticism, (2) frames for environmental policy making, (3) areas of contested scientific knowledge, and (4) appeals to children for managing scientific uncertainty. The following descriptions of each coding category details the coding constructs and rationale employed in this research.

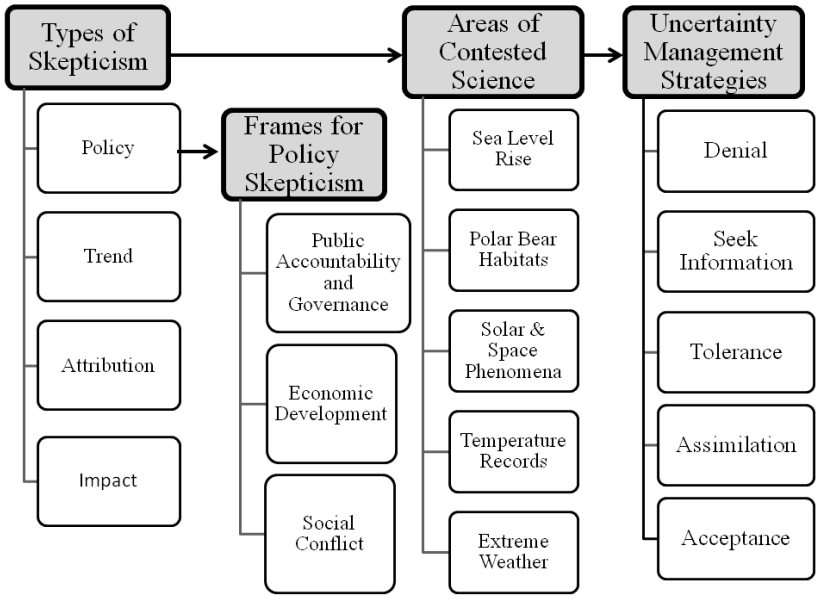


Figure 2.1 Four coding categories and their constructs

First, each book was coded for the presence of *four key climate change skepticism arguments* (trend, impact, policy, and attribution skepticism) identified as characterizing the discourse of contemporary climate denial coalitions (Dunlap & McCright, 2010; Rahmstorf, 2004). Researchers captured and coded claims and counter-claims about climate change which raised questions about what is happening (trend), what will happen (impact), what influence we have (attribution), and what we can or should do about it (policy)? The catalogued examples of each type of skepticism were expected to inform a broader understanding of the tropes of uncertainty which commonly accompany and bolster a logic of non-problematicity about climate change.

Next, identified examples of policy skepticism were coded using Nisbet's (2009) typology of *frames for scientific controversies*. Coding distinguished representations of environmental policies as either contributing to or detracting from: social progress, economic development and competiveness, morality and ethics, scientific and technical uncertainty, Pandora's box, public accountability and governance, the middle way, or a conflict or strategy (Nisbet, 2009). Content analysis focused on extracting and coding the specific framing devices, including the value appeals, latent meaning, catch phrases, images, and pop culture references which guide readers' understanding about policy controversies. Conceptualizing the global warming controversy in the United States as a "framing contest" (Benford & Snow, 2000), this deductive approach was expected to offer insight to the broker issues which create common ground among and across discourses of denial and consensus (Shackley & Wynne, 1996).

The third coding category identified areas of *contested scientific knowledge* to further explore the rhetoric of scientific uncertainty about climate change found in each

book. The protocol included an open coding review of each text which captured citations or indictments of scientific 'evidence' (e.g. referenced studies, statistics, and expert quotes), images of scientific charts and graphs, and representations of basic climate science and Earth science concepts (Glaser & Strauss, 1967). Recent research, working within a conceptual change model of science learning, points to an imperative need to address common scientific misconceptions held by teachers, parents, and students concerning climate change (Bozdogan, 2011; Lambert, Lindgren & Bleicher, 2012; McCaffrey & Buhr, 2012). In this light, the anticipated catalogue of contested science topics was anticipated to be useful for educational researchers interested in how student's form initial ideas about climate change before developing more scientific notions in the classroom, in addition to environmental communication scholars interested in further excavations in the rhetoric of climate change denial.

The final coding category in this study included *suggested strategies for dealing with the uncertainty* of science and climate change. Research by Norton, Sias, and Brown (2011) suggested an interpretative strategy for coding which proved useful for exploring how climate denial books ask readers to cope with uncertainty about scientific consensus and the reality of climate change. For this study, the authors' identified direct statements encouraging one of five common management strategies. These included *seeking information, denial, tolerance/assimilation, acceptance,* and *imagined information seeking* (Norton et al., 2011). By definition the logic of non-problematicity implies as a broad strategy of *denying* the problem with climate change, however it was expected from pre-coding that the reviewed books would also deploy a range of other uncertainty management strategies.

Results

This section reports the synthesized results of the content analysis procedures. First, we provide examples of skeptical claims (made across the books) which engender uncertainty about what is happening (trend skepticism), what will happen (impact skepticism), what influence we have (attribution skepticism), and what we can or should do about it (policy skepticism). A synthesis of contested areas of scientific knowledge highlighted strategies aimed at engendering or perpetuating common misconceptions about Earth systems via appeals to scientific authorities. Turning to specific examples of policy skepticism, the results reveal a blend of frames (public accountability, environmental governance, and social conflict) aimed at engendering controversy about environmental policy making and challenging dominant discourses about ecological modernization. Finally, the results provide examples of uncertainty management appeals which activate a complicated notion of individual agency that stands in opposition to norms of scientific consensus.

Types of climate skepticism

A typology of common climate skepticism arguments guided our initial analysis of claims and counter-claims about global warming. This section provides textual examples of some emergent themes across each type of skeptical argument. *Trend skepticism* questions the actual phenomena of climate change and rising temperatures. This form of skepticism was characterized by many appeals to scientific uncertainty and positioned global warming consensus as a function of politicized science. Efforts to undermine both science and scientific consensus are demonstrated in the provided examples (refer to Table 2.1) which point to the inability of scientists to make accurate

predictions or models, challenge the meaning and value of scientific consensus, and paint a picture of scientists as both self-interested and influenced by environmentalist politics.

Table 2.1

Examples of trend skepticism which delegitimize science and scientific consensus

Children's Book	**How can we know if global warming is happening?**
Sky's Not Falling	"There are too many factors involved that even the smartest scientists are uncertain about." (p. 10) "Think of the times the weather forecaster on TV told you it would be sunny for your soccer game but it rained instead." (p. 7)
We're Not Scared	"Computer models have not been able to predict temperature changes over the last 20 years. Why would anyone trust them to predict climate 100 years in the future?" (p. 6) "Mr. Gore, politics and religion are about consensus, not science. No one agreed with Darwin and Galileo but in the end scientific evidence proved them correct. It only takes on fact to falsify a theory." (p. 8)
Real Deal	"The real deal is, it's not easy for most scientists and researchers to make enough money to keep their work going so scientists who can connect whatever research they're doing to global warming often get money for their work they may have been super hard to get before." (p. 71)

Impact skepticism raises questions about the negative outcomes of climate change. This form of skepticism emerged as claims about the quasi-environmental benefits of improved habitats for animals and quality of life for humans. While trend skepticism largely deployed challenges to scientific models and predictions about the future, the examples of impact skepticism focused on the varying interpretations of the value of climate change. Rather than deny any impacts, the provided examples (refer to Table 2.2) trivialize the impacts of changing climate systems by pointing to sources of

negative feedback (e.g. increased plant growth and sea ice growth) and equivocating about the benefits of CO2 and warmer weather.

Table 2.2

Examples of impact skepticism focused on positive impacts to humans and habitats

Children's Book	**What will be the outcomes of climate change?**
Sky's Not Falling	"Better plant growth makes it easier to grow food. This means food could become more plentiful and starvation and famine less likely." (p. 30) "In Antarctica, at the opposite end of the earth, total sea ice is growing, and the penguins and seals that live there should like that just fine (Vaughn 2005)." (p. 9)
Real Deal	"During the Medieval Warm Period, not only did the temperature elevate, but so did the quality of people's lives. There are fewer storms and fewer floods, and the new sunny climate brought greater prosperity." (p. 7)
We're Not Scared	"As for heat waves, it actually means less people will die from the cold so it's a good thing. My Nanna says the warmth helps her arthritis." (p. 12)

Table 2.3

Examples of attribution skepticism focused on the lack of human agency in an ever-changing planet

Children's Book	**What caused climate change?**
Sky's Not Falling	"The warming on earth is like the warming we are seeing on Earth. If it's happening on Mars, where there are no humans, how can we be sure that humans cause global warming on earth." (p. 23)
We're Not Scared	"Most rises of CO_2have already happened. Adding more CO_2 won't do much to the temperature. Mum and Dad can drive all they want thank you very much." (p. 4)
Real Deal	"Although man's activities are always blamed, these gaseous livestock are responsible for 18% of GHG in the atmosphere. They produce five times more than cars, airplanes, and other forms of transportation put together." (p. 21) "Could a human change how much heat the sun puts out? Build a mountain range? Create a dessert? Keep the rain forest rainy? Fill an Ocean or drain one dry? How about stop an oncoming tornado? ABSO-TIVELY, POSTIVELY NOT!" (p.14)

Attribution skepticism raises questions about the causes of climate change. All of the texts engendered uncertainty about the possibility of human impact on a self-regulating planet and posed alternative causes to global warming other than human CO_2 emissions. The provided examples (refer to Table 2.3) are exemplary of challenges to claims of human-caused climate change, including making absurd analogies to sources of 'natural' pollution, pointing to alternative causes, and positioning humans activities as a small influence in larger, unalterable environmental systems.

Finally, *policy skepticism* raises questions about how to act in the face of climate change. Controversy over climate change policies generally focused on past failures in environmental regulations from an economic trade-off perspective.

Table 2.4

Examples of policy skepticism focused on the economic cost-benefit analysis

Children's Book	**What can we do about climate change?**
Sky's Not Falling	"So began the American love affair with the SUV which often burns more gas per mile driven than the old station wagon. Again, the end result was to use more, not less, gas." (p. 44) "Government financing encourages ethanol production without considering the full costs or the unintended consequences." (p. 48)
Real Deal	"Offsetting does nothing to cut down supposedly damaging human emissions because people who pay this fee never have to change their energy habits. So in reality, even if they could, they're not doing anything to help save the earth." (pg. 44) "This means, even if we all stopped using electricity, making things in our factories, and driving our cars it wouldn't make much of a difference at all. I would only get rid of CO_2 by only a teeny bit." (p. 13)

The provided examples (refer to Table 2.4) point to general appeals to the futility of altering CO_2 emissions outcomes, as well as more detailed and specific references to

historical failures in emissions regulations, ethanol production, carbon offsetting, and other controversial environmental policies (like DDT and clear cutting).

Mimicking classroom learning contexts, each of the reviewed books adopted educational framing devices—including sections like fun facts, pop quizzes, additional web-links, reading lists, and exercises —that help to simulate a legitimate learning environment. Table 2.5 summarizes the results of the investigation into contested areas of scientific knowledge deriving from the pseudo-scientific claims and scientific authority appeals found in the books.

Table 2.5

Emergent categories of contested science

Ice Melt/Sea Level Rise	
Sky's Not Falling	"We only monitor about 10 percent of the globes' glaciers- half are growing, half are shrinking." (p. 7)
We're Not Scared	Kids: "Even the IPCC predicts seal levels will only rise about 20 centimeters over the next 100 years. This is about the same rise that occurred last century." (p. 9)
Real Deal	"Most research says that, even if it could occur, melting ice caps and rising sea levels would take 1,000 to 5,000 years to happen!" (p. 57) Referring to Holgate (2007): "Sea level has been rising, it is rising more slowly than it has in the past. It is more likely that changes in sea level will follow the recent slowing trend of a six-inch rise over the last one hundred years or rise even less." (p. 35)
Polar Bear Habitats	
Sky's Not Falling	"Truth be told, we don't know for sure how many polar bears live in places that are too cold for humans, so it's hard to tell if total polar bear numbers are or falling." (p.36)
We're Not Scared	Teacher: "More polar bears are killed each year by hunters than climate change. If we want to help polar bears perhaps we should stop shooting them." (p. 14)
Real Deal	In references to adaptation, "Arctic air temperatures were as high, or higher than at present in the 1930's and polar bears survived. The even survived the massive melting of glaciers 10,000 years ago." (p. 96) "When you see the heart-wrenching photos of polar bears floating in the ocean on a chunk of ice . .[remember] polar bears can swim over 60 miles." (p. 99)

Table 2.5 (continued)

Emergent categories of contested science

Solar & Space Phenomena	
Sky's Not Falling	"The climate on Mars has been warming up too. As a result the polar ice caps on Mars are shrinking." (p. 23) "Scientists have found a direct relationship between cosmic rays and the Earth's temperature. Over the last one hundred years they found fewer cosmic rays and fewer clouds. As a result, the sun's energy has grown more intense." (p. 24)
Real Deal	"For years, scientists all over the world believed that more sunspots (on the sun) brought warmer weather (on the earth). . . .they found out that solar activity closely matches what happens to earth's temperature change over the last 100 years." (p. 22)
Temperature & CO_2 Records	
Sky's Not Falling	Referring to Fischer at al. (1999)-"If the temperature changed before the carbon dioxide levels rose, carbon dioxide levels are probably not the cause of the temperature change." (p. 21) "The Earth has warmed about 1 degree Fahrenheit in the last 100 years." (p. 14) "From the early 1900's to about 1940, a time when your grandparents may have been alive, temperatures rose even though carbon dioxide emissions were low, In the following years, 1940-1975, the temperature increase was slower even though carbon dioxide emissions were greater- the result of Industrial development." (p. 22)
We're Not Scared	Kids holding a graph citing McIntyre& McItrick (2003) that says: "Medieval warming period was hotter." (p. 2) Kids: "It only takes one fact to falsify a theory. For instance, if CO_2 is responsible for global warming, why is there no hot spot over the tropics." (p. 8)
Real Deal	"Ice core records show that higher CO_2 levels increase AFTER temperature rises, NOT BEFORE! So carbon dioxide can't be the reason that temperature rises." (p. 23) "Another thing we rarely hear about when it comes to greenhouse gases is that total man-made GHG contributions only add up to 0.28% of the GHG effect. That's 0.28%, way less than 1 percent!" (p. 19)
Extreme Weather	
Sky's Not Falling	"More people live in the path of storms, not that the storms themselves have become larger or more powerful due to global warming." (p. 33)
We're Not Scared	Kids: "Mr, Gore, even if you are correct, an increase in wind shear will offset higher sea temperatures leading to little or no change in hurricane activity." (p. 12)

Prevalent themes across scientific contestations included: (1) rates of ice melt and sea level rise, (2) threats to polar bear habitats, (3) the role of solar and space phenomena,

(4) accuracy of temperature and CO_2 records, and (5) the causes and impacts of extreme weather (refer to Table 2.5). Although often contradictory to other skeptical claims made in the books, these challenges to the indicators, impacts, and evidence of climate change are distinguished as legitimate and healthy scientific skepticism. Rather than encourage scientific understanding in the readers, the texts deploy pseudo-scientific arguments which simultaneously undermine science while asserting scientific authority.

Framing policy controversies

To learn more about the construction of the logic of non-problematicity, researchers examined the skeptical discourse about environmental policies, as well as individual actions, within the selected books. As Backstrand and Lovbrand (2007) explained, discourse analyses can provide insight to power relationships in environmental policy making which results from dominant narratives of ecological modernization. Nisbet's (2009) typology for science controversies provided the framework for examining the general rhetorical composition, core values, and motivational appeals embedded in the framing of policy skepticism. The final comparative analysis looked specifically to similarities and differences in how the texts portrayed controversy about climate change policies. These results illustrate blended and contrasting frames for understanding the nature policy controversy, including (1) the pairing of narratives about a lack of public accountability and poor governance with frames for economic development, and (2) the clear reinforcement of polarizing social conflict frames centered on delegitimizing environmental concern.

Public accountability and economic development

According to Nisbet (2009), *public accountability* frames position policy making as either in the public interest or serving special interests. Questions of public accountability emphasize issues over the proper use of science and experts in decision-making. *Economic development* frames, in contrast, are defined by the focus on the investments, market benefits or risks, and issues of global competitiveness. In the *Sky's Not Falling* and the *Real Deal*, analysis revealed a mutually reinforcing interaction between the public accountability and economic development frames which inform a specific value criteria for making environmental decision-making and suggest the appropriate role of governing agencies in these matters.

In the *Sky's Not Falling*, the author combines past examples of bad governance resulting from environmental policy making with free-market viewpoints. In one example, the authors encourage students to become enviroprenuers rather than environmentalists by explaining, "Enviroprenuers don't force their beliefs on others. . . They don't think government or some other person should fix everything for them…They don't regulate—they innovate" (pg. 76). The final chapter of the book includes critical thinking exercises leading readers through the logical progression of understanding how the market works, role-playing a store owner, and then weighing market trade-offs of spending money on global warming solutions. The enviropreneur framing strategy mimics the discourse of ecological modernization through appeals to neo-liberal economic and social progress.

Economic resistance to climate change policy making is coupled with a highly contested history of poor environmental governance found across the books. In the *Real*

Deal, the author made appeals to free market ideology in the face of a detailed list of past ineffective regulations and failures in environmental governance. Most notably, environmental policy making is portrayed as a "push to end industry" and a "fight to end our personal freedoms" (Schmidt, 2008, p. 79). In terms of economic development, free-market innovations and personal free choice are prominent conservative values which trump environmental concerns.

Social conflict

In *We're Not Scared*, the author made very few policy skepticism arguments because the narrative focused on children actively engaged in pseudo-scientific argumentation about global warming trends, causes, and impacts with Al Gore. The behavior modeled by the story characters suggests that children should challenge science teachers with scientific evidence and counterclaims from personal experience. Most shockingly, in the final page of the book, the classroom teacher is pointing a gun at Al Gore as he runs away in a herd of polar bears. If the narrative as a whole raises the policy skepticism question of how to (or whether to) teach climate science in schools, then the positioning of Al Gore as the antagonist in the story is illustrative of social conflict framing.

According to Nisbet (2009), *social conflict* frames position controversy as a battle between personalities and groups. Social conflict framing is easily identified in the *Real Deal*, where global warming advocates were derogatorily named as trendy, alarmists, and radical environmentalists, despite the author's inclusion of a "sticks and stones" section explaining downfalls of name-calling like skeptic, denier, flat Earther, and immoral (Schmidt, 2008, p. 59). The book further invoked the "do as I say, not as I do" motto to

highlight the contradictions of global air travel, limousines, and electricity used by popular environmentalist celebrities. As the author of the *Real Deal* explains, "Radical environmental activist groups are not to be mistaken with all environmental groups; some environmentalist groups care about the earth, but also care about the well-being of people, first" (Schmidt, 2008, p. 35).

The social conflict frame clearly pits environmentalism against ecological modernization to the extreme point of abandoning all expected American conveniences. Bolstering the value of economic development to social progress, readers are asked to imagine the daily toils of life with no cars, electricity, or indoor bathrooms. One book quintessentially reminds children of developing countries living without electricity ("when the sun goes down, their day is over"), where people are unable to keep medicine from spoiling and use dung for campfires that cause respiratory problems (Schmidt, 2008, p. 37). Social conflict frames were not aligned by party politics, but employed a derogatory approach to environmental ethics which position consumption as a privileged but necessary lifestyle.

The texts further encouraged readers to understand environmental concern and environmental policy making as problems. In the *Real Deal*, multiple pages were allocated to indicting the use of fear and exaggeration about catastrophic outcomes to gain adherence for the theory of global warming. Environmentalists were indicted as fatalists for spreading repetitive doomsday messages through "movies, commercials, talk shows, schools, books, billboards, documentaries, websites, comic books, magazines" (Schmidt, 2010, p. 58). An entire chapter was devoted to the indictment of the "environmental machine" for actions like preventing drilling in ANWR, banning DDT

leading to malaria deaths, and focusing on doing humane animal research rather than advancing research to improve human health (Schmidt, 2008, p. 74-84).

In summary, the logic of problematicity is reinforced by the framing of climate change controversies as an issue of poor environmental governance jeopardizing U.S. economic development. Unabashedly loaded social conflict frames are found across all three texts and emphasize the dualism between skeptical and convinced logics which unfortunately characterizes contemporary US policy debates. Blended frames, of economic development and social conflict, raise concerns about lifestyle changes due to environmental governance and engender distrust about different sources of environmental concern.

Strategies for managing uncertainty

Where the Nisbet (2009) typology allowed researchers to explore the framing of policy skepticism to sustain collective inaction, the Norton et al. (2010) typology allowed researchers to further explore the logic of non-problematicity as an individual cognitive construction. The typology suggests strategies for managing uncertainty about climate change which reinforce pre-existing risk aversions and mental models of the world. As we expected, the denial strategy was reinforced by the skeptical arguments in the books, including overt claims that climate change is not happening or will positively affect our lives. Simply denying the scientific evidence of this trend and its impact is by definition the purest manifestation of logic of non-problematicity (i.e., there is no problem).

For readers still negotiating the meaning behind the public climate change controversies, some alternatives to simply *denying* the consensus conclusion were presented. Other strategies for managing the uncertainty about climate change included:

(a) seeking (or imagined seeking) more information, (b) viewing the problem as tolerable, (c) associating uncertainty with other more certain causes, or (d) accepting our inability to know truth or act (refer to Table 2.6).

Table 2.6

Strategies for managing uncertainty about climate change

Seek Information	
Sky's Not Falling	"Some people believe that humans are causing our planet to warm up, and they can sometimes be very stubborn about their beliefs. But we need to do more studying about our climate before we conclude that this is the case." (p. 3) "Knowledge really is power. . .searching for the truth about our incredible world, discovering new facts and new technologies, and using them to make smarter choices is what science is about." (p. 114)
Real Deal	"Sadly, too many of us won't do the work to find out the other side of this issue for ourselves (of course, not you, because you're reading this book)." (p. 58)
Tolerance	
We're Not Scared	Kids: "Geologists have known the climate has changed for a long time. For climate, change is the only certainty. We need to treat it like any other natural hazard and deal with it as it comes." (p. 10)
Assimilation	
Real Deal	About global warming advocates, "This fear technique works the same as when we ride a really gnarly roller coaster, or watch a freakishly spooky zombie movie. Even though deep down you know you're not any real danger, your mind gets carried away." (p. 52)
Acceptance	
Sky's Not Falling	"The truth is that no one, not even the best scientists, knows why some places are becoming warmer and others cooler." (p. 9)
Real Deal	"Think about how powerless we are . . . climate change is one of the natural miraculous things that make planet earth such an amazing creation." (p. 14-16)
Imagined Information Seeking	
Real Deal	"Luckily, there are many respected scientists who are trying to get the word out and tell us more comforting truth; that all these terrible, scary events are highly unlikely to happen." (p. 54)
Sky's Not Falling	"Let's look at the facts for ourselves and figure out what's really going on." (p. xiii)

Examples of *seeking more information strategy* to reduce uncertainty were easy to identify in the *Real Deal*. The author proposed, "If you're like me, you've probably got some really cool people in your life. People you can trust to tell you the truth and give you great information on all kinds of stuff. But where are we getting this information on global warming from?" (Schmidt, 2010, p. 64). The chapter continues to indict the media, Hollywood celebrities, schools, and politicians. Each section prompts reader to "check it out", a phrase accompanied by the image of magnifying glasses. Independent information seeking, not scientific consensus is understood as the key to deciphering the truth from the hype. Often the books themselves activate a sense of *imagined information seeking strategy*. For example, in the *Sky's Not Falling*, students are provided with a set of activities to "exercise your mind so you can make your thinking skills better" (Fretwell, 2007, p. 77). One example embedded within economic development frames is a carbon footprint activity which justifies the US carbon footprint as a sign of productivity. This is followed by other activities which demonstrate the costs of zero-pollution.

Examples of the *tolerance strategy* were easily identified in statements like, "Geologists have known the climate has changed for a long time. For climate, change is the only certainty. We need to treat it like any other natural hazard and deal with it as it comes" (p. 8). The trivialization of climate change as minor, gradual, normal, and thus tolerable is closely tied to trend and impact skepticism arguments. In this way, the tolerance strategy can be seen as conducive to a mental model that assumes changes will happen slowly or will be positive. In contrast, the assimilation strategy, discussed next,

appears better suited for a mental model that perceives climate change as natural occurrence or just a function of manufactured political controversy.

The *assimilation strategy* often accompanied social conflict frames. By definition, this strategy asks readers to assimilate uncertainty into other less uncertain categories. A prominent example is the suggestion that readers understand the global warming debate as the result of an environmental agenda rather than a true environmental problem. This fact is overtly addressed in the *Real Deal* when authors respond to evidence of global warming in the form of charts and graphs: "This fear technique works the same way when we ride a really gnarly roller coaster, or watch a freakishly spooky zombie movie. Even though deep down you know you're not in any real danger, your mind gets carried away" (Schmidt, 2010, p. 52).

The *tolerance* and *assimilation* strategies undermine the reality and urgency of climate change; whereas the *acceptance* strategy suggests one resign from managing uncertainty all together. The acceptance strategy was evident in statements that encouraged students to disassociate from the problem by accepting the inevitable uncertainty of science (e.g., "The truth is that no one, not even the best scientists, knows why some places are becoming warmer and others cooler" (Fretwell, 2007, p. 9)) and accepting the limited capacity for humans to change earth systems (e.g., "Think about how powerless we are. . . . Climate change is one of the natural miraculous things that make planet Earth such an amazing creation" (Fretwell, 2007, p. 14-16).

The results point to the rhetorical analyses of uncertainty management as valuable for understanding the cognitive structuring of the logic of non-problematicity. Indeed, the reviewed texts themselves act as a form of imagined information seeking.

Other appeals to managing uncertainty encourage an assimilation, tolerance, and acceptance as strategies to support varying worldviews and mental models of change. By engendering scientific and social uncertainty, and then managing for that uncertainty, the texts arguably embolden an individual disassociation from the causes, impacts, and solutions to climate change which is emblematic of the logic of non-problematicity.

Summary of findings

The purpose of this research was to explore some ways that students, teachers, and parents might encounter climate skepticism in pseudo-educational media. Specifically, the research asked, what rhetorical strategies reinforce logic of non-problematicity in climate skeptic books for children? The results highlighted a varied composition of skeptical arguments, blended frames for understanding environmental policy controversies, and tips for managing uncertainty which characterize a logic of non-problematicity about climate change. After a summary of the findings, the discussion points to the brokering power of appeals to independent decision-making over scientific consensus, as well as dominant narratives of ecological modernization which cast doubt about on the value of environmental concern.

The various forms of skepticism found in these children's books are conceptually consistent with other research in climate denial rhetoric. Skepticism about climate change supports a logic of non-problematicity by: (a) delegitimizing scientific consensus and deploying tropes of uncertainty to engender skepticism about climate change trends, (b) drawing on misconceptions about the self-regulating and ever-changing nature of earth systems to engender skepticism about the severity of impacts, and (c) qualifying the limits to human agency and highlighting the economic trade-offs to solving

environmental problems to engender skepticism about the causes of climate change (attribution), as well as what we can do about it (policy). Contradictory skeptical claims were commonly deployed together and the identified areas of contested science knowledge illustrated a similar contradiction in climate denial media of undermining science while asserting scientific authority (Doyle, 2011).

Blended, complementary frames for understanding the nature of climate change policy controversies included: (a) the pairing of narratives about the lack of public accountability and poor governance with frames for economic development and (b) the clear reinforcement of polarizing social conflict frames centered on delegitimizing environmental concern. Dominant narratives of ecological modernization reinforce questions about who pays the costs of policy actions, whether we should have decentralized or centralized systems, and whether the costs of acting outweigh the benefits (Backstrand & Lovbrand, 2007). While social conflict was positioned at all levels of society (news media, politics, movies, science, and now even your school), the dominant economic development frames located the problem in the politics of environmental concern and governance.

By definition the logic of non-problematicity implies as a broad strategy of denying climate change as a problem, however the results reveal appeals to other uncertainty management strategies. The sampled texts themselves act as a form of imagined information seeking. Other appeals to managing uncertainty via assimilation, tolerance, and acceptance clearly capitalize on human tendencies toward risk aversion. By engendering scientific uncertainty and then managing for that uncertainty the texts

arguably embolden an individual disassociation from the causes, impacts, and solutions to climate change.

This study is limited to just three examples of skeptical media and can only speculate about the broader dissemination and widespread impact of climate skeptic books on children, parents, and teachers. Future research focused on behavioral and attitudinal change as a result of exposure to pseudo-educational materials would be valuable. Comparative research along a range of skeptical media (e.g. dismissive, hesitant, and adherent) could inform a better understanding of the role of both society and scientific literacy in conceptual, behavioral, and attitudinal change (Kahan, Jenkins-Smith, & Braman, 2010; Meehan, 2012). To more thoroughly understand the large scale impacts of the widespread climate change denial campaigns, future research might also address group membership, rates of readership, and the dissemination strategies for various forms of pseudo-educational media produced by organizations like the Heartland Institute and American Legislative Exchange Council (ALEC).

Conclusion

Questions of how to support learners in seeking accurate information about climate change or identifying misinformation are increasingly relevant. This research aimed to contribute a better understanding of the rhetorical strategies and motivational appeals which engender apathy and inaction in the public sphere. The sampled books are examples of how contestations over climate change are rhetorically shaped through contradictory forms of skepticism and polarizing anti-environmentalist frames. The material world matters, but a myriad of rhetorical practices and ideologies serve as broker issues in resolving differences in how we understand the problem with climate change.

The results suggest that the trial of strength of skeptical discourse coalitions extends beyond tropes of uncertainty and risk management (Besel, 2011; Latour, 1997). For this reason, scholarship in environmental communication and science education will benefit from conceptualizing the controversies about climate change as an entangled set of cultural narratives, rather than primarily symptomatic of a logic schism driven by manufactured scientific controversy (Hoffman, 2011). As an exemplary approach, this study traced the rhetorical construction of doubt about climate change which supports the logic of non-problematicity. We now argue that appeals to independent decision-making and dominant narratives of ecological modernization are often overlooked broker-devices by climate deniers aimed at reinforcing apathy and inaction in the public sphere.

Appeals to *independent decision-making* (over clearly established scientific consensus) emerged as the greatest potential pedagogical dilemma for educators, environmental advocates, and communication experts interested in advancing understanding and action in the face of rapid climate change. Indeed, one of the most striking elements across all of the books efforts to question the intentions of scientists and environmentalists. One text even offered suggestions on how to "politely ask your teacher to turn that global warming movie off and teach you something that matters" (Schmidt, 2008, p. 69). Clearly, manufactured controversy about climate change easily translates into manufactured controversy about climate change education.

Appeals to independent decision-making engage readers as agents in knowledge construction, rather than positioning them as non-experts in need of a science lesson. Examples of similar appeals to independent decision-making can be seen in the legislative discourse associated with the "Teach the Controversy" movement, which deny

scientific consensus on global warming and pair climate change with other controversial topics like evolution (NCSE, 2013). But, should children, parents, and even teachers be engaged in deciding the truth about climate change for themselves?

As a brokering device across audiences, appeals to independent decision-making draw on the highly-privileged democratic ideal of pluralism to answer this question. As Cooper (2011) pointed out in her call for increased media literacy, the success of climate change denial campaigns rests on appeals to open scientific debate and empower individuals as discursive agents in the controversy. Argumentative engagements in selected areas of contested science knowledge, like polar bears habitats and solar flares, further illustrate the contradiction of undermining science while asserting scientific authority (Doyle, 2011).

Skeptical calls for independent decision-making neatly resonate within polarized narratives of conspiracy where scientists, politicians, and even teachers are not trustworthy. Pseudo-scientific claims focused on popularized areas of contested science, do more than just engender misinformation and scientific uncertainty; they activate a need for independent decision-making. Whether one chooses to assimilate the problem into social conflict frames, seek more information (or just imagine they have), the identified strategies for managing uncertainty compliment the process of independent decision-making.

Whereas appeals to independent decision-making engaged readers as agents in knowledge construction, narratives of *ecological modernization* placed the criteria for decision-making in the context of economic development. Narratives of ecological modernization focus environmental decision-making on seemingly rational questions

about who pays the costs of policy actions, whether we should have decentralized or centralized systems, and whether the costs of acting outweigh the benefits (Backstrand & Lovbrand, 2007). Unfortunately, the problematization of environmental concern rests on the anthropocentric cost-benefit-risk analysis which pits environment against economy. In this study, narratives of ecological modernization weighed individual lifestyle preferences (from toys to toilets) against a history of failed environmental regulations. Given the unrelenting slander of past environmental policies and activism, the invention of enviroprenuership seems like an utterly disingenuous effort to construct an environmental ethic based on the assumption that a deregulated free market will solve environmental problems for us.

The existence of skeptical books for children indeed raises questions about the constitutive force of such media to reinforce the logic of non-problematicity about climate change. Rather than replicating polarizing frames or overemphasizing scientific consensus, environmental communication scholars must continue to trace the rhetorical strategies and persuasive devices which sustain not just doubt about climate science, but the logic of non-problematicity and inaction across heterogeneous groups. The clear and present danger of organized climate denial campaigns is found in those rhetorical strategies which provide a sense of agency through imagined information seeking and reconfigure the core values of environmental citizenship along frames of economic development. Beyond framing (Cox, 2012), climate change communication scholars must continue to investigate new persuasive rhetorical tools, or inventional possibilities, for responding to climate skeptics who teach climate literacy (Ceccarelli, 2011).

CHAPTER III

(UN)DOING THE NEXT GENERATION SCIENCE STANDARDS: CLIMATE CHANGE EDUCATION ACTOR-NETWORKS IN OKLAHOMA

The impacts of current and impending global environmental change will affect all humans. Integration of climate change education (CCE) in secondary science education will play an important role in increasing public understanding about the consequences of and solutions to these changes (Sharma, 2012). A wide variety of agencies, organizations, and industries across the United States have developed climate change education materials to help the public understand and adapt to regional climate changes (Monroe, Oxarart, & Plate, 2013). Efforts to develop and coordinate materials specifically for students and teachers are widespread across federal interagency collaborations.

Starting in 2008, federal projects sponsored under the umbrella Global Climate Change Education (GCCE) were administered via the National Science Foundation (NSF), National Ocean and Atmospheric administration (NOAA), and the National Aeronautics and Space Administration (NASA). Now, many of these agencies are disseminating developed materials for K-12 science education. Other climate change education efforts (focused on increased public understanding of climate science) can be found on the websites of environmental organization such as the Environmental

Protection Agency (EPA) and the Nature Conservancy, as well as media sites like National Geographic, National Public Radio (NPR), and the Public Broadcasting Station (PBS).

Now, it seems the diffusion of climate change knowledge from national organizations to public schools across the country has met with resistance from parents and students, as well as anti-science education legislation at the state-level (National Center for Science Education, 2013; Reardon, 2011). Research is needed to better understand how science educators understand, incorporate, and negotiate the implementation of climate change education in the face of such controversies (McBean & Hengeveld, 2000; Taber & Taylor, 2009; Wise, 2010). This research focused on Oklahoma secondary science education communities of practice as a unique context for research in ideological contestations over climate change.

In preview, the purpose of this study was to evaluate the influence of a lack of climate change concepts in the state academic standards on teacher practices and to assess the possibilities for advancing climate change education efforts in Oklahoma. Synthesis of science education stakeholders' perceptions about climate change education controversies and self-reports by secondary science teachers engaged in climate change education offers insight to barriers and possibilities for the advancing efforts in climate change education in Oklahoma. The results point to the revisions of State science standards based on the nationally-developed Next Generation Science Standards (NGSS) as a contemporary node of action in the complex web of science education policies and practices.

Theoretical framework

Actor-network Theory (ANT) guided an approach for understanding how climate change education might be translated from national policy discourses to enacted educational outcomes at a state and classroom level. Educational policy research, focused on the integration of climate change education in conservative states like Oklahoma, cannot avoid asking important epistemological questions about who sorts meaningful information and makes decisions about what should be included in science education standards (Cox, 2010; Forsyth, 2003). Towards these ends, this exploratory research applied ANT to identify the epistemic relationships and power dynamics which influence the adoption and implementation of climate change education in science classrooms in Oklahoma (Fenwick & Edwards, 2010; Fox, 2000; Latour, 2005).

Deriving from the field of Science and Technology Studies (STS), Actor-network Theory is concerned with the processes which characterize socio-scientific disputes. Actor-network Theory was described as the sociology of translation by Callon (1986) and is rooted in the understanding that all actors gain their form as a consequence of their relations to other entities and is "performed in, by, and through those relations" (Law & Hassard, 1999, p. 5). As Brown and Capdevila (1999) explained, the essence of a concept like climate change education "can only be discerned by following the way it moves through encounters, relations, and networks" (p. 29). Applications of ANT generally guide cross-scalar investigations about which agencies are invoked and what figurations carry meaning across actor-networks (Fox, 2000; Latour, 2005).

ANT provided a set of concepts for understanding how actors enroll, or mobilize others in climate change actor-networks. *Actor-networks* are composed of multiple

actors, or *actants*, engaged in mobilizing others. Actants form heterogeneous networks aligned by common interests and engaged in convincing others to *enroll* in, or accept, the interests defined by the actor-network. As an action-oriented perspective, the concept of network assemblages draws attention to the *nodes of action*, or social spaces, where power is enacted and performed. By using the term actants, instead of actors, this study adopts the principle of *symmetrical analysis* which acknowledges the agency of both human and non-human objects as actors. For example, educational artifacts like high stakes testing and textbooks can be actants in science education classrooms. This inquiry examines how academic standards might function as *obligatory points of passage*, or critical network channels, in the translation of climate change education.

By recognizing the role of academic standards in influencing classroom instruction, this research inquiry extended beyond a pure reading of standards as governing texts with commanding authority to a more detailed study of educational standards as enacted and performed (Mulcahy, 2007). Rather than mobile and enduring, ANT helps to conceptualize academic standards as *immutable mobiles* (or intermediaries in actor-networks) which aim to embed and mobilize one 'fixed' prescription. Intermediary actors transport meaning without influencing transformations, whereas mediators "transform, translate, distort, and modify meanings" (Latour, 2005, p. 39) and are not necessarily direct causes. Intermediary forces offer predictability to the enquiry, whereas mediators multiply the differences within controversy and are more important than any specific mediating actors (Alcadipani and Hassard, 2010). This adopted framework aims to contribute to an on-going dialogue about written policy versus

enacted policy; specifically, by highlighting the actors and intermediaries which influence power relations within and across community practices (Yanow, 2000).

(un)Doing science standards

When applied to educational policy making, ANT reconfigures the policy terrain from top-down power analysis to a network analysis and, in the case of this study, provokes questions about how actor-networks constrain or enable the performance of climate change education. Often employing ethnographic research methods for following the actors and examining networks inscriptions (Bishop, Van House & Buttenfield, 2003), ANT makes "visible the rich assortments of mundane things at play in educational events and how they are connected" (Fenwick & Edwards, 2010, p. 13). In an effort to delineate the scope of the research study, the research focused on the social structures and power relations characterizing science education communities of practice in Oklahoma, including the individuals, activities, and worldviews across various assemblages of stakeholders (Fox, 2000). The resulting research design aimed to trace the complex web of relations and identify the actants which function to sustain or inhibit climate change education policies and practice (Rocheleau, 2008; Rocheleau & Roth, 2007).

Applications of ANT guided the understanding of standards as prescriptions which are performed and negotiated across complex relational ties and scales of influence (Saldanha, 2002). Fenwick's (2010) defense of ANT analysis in educational policy studies identified four standards phenomena which challenge our traditional assumptions about the power of academic standards to achieve the 'potentialities' of policy prescriptions. First, standards evoke various ordering practices, most evident across strategies for assessment and testing, curriculum guides, and accountability measures.

Second, the different emerging ontological forms of the same standards across actor-networks points to the fact that standards are not universally performed. Instead, local universality, or common protocols for practice, results from actors drawn together in common contexts. Finally, the interplay of other standards phenomena identified results in tensions between networks of prescription and negotiation which are performed anew in each assemblage.

In sum, the (un)doing of standards is characterized by spaces of prescription and negotiation across science education communities of practice. The ANT research framework guides: (a) a methodology for tracing the performance of academic standards and (b) an interpretive lens for assessing the impact of policy prescriptions on classroom practices. Theorizing about the potentiality of standards-based educational reforms requires more examination of how these performances, or the (un)doing of standards, influence the implementation of state imposed science standards. Key points of analyses for this research were those spaces which order and normalize science education (spaces of prescription) and those spaces which create provisional and divergent coalitions (space of negotiation) for climate change education. Guided by the theoretical framework outlined above, this research asked, *what spaces of prescription and negotiation characterize climate change education efforts within and across science education communities of practice in Oklahoma?*

Background

The socio-cultural landscape in Oklahoma provided a unique context for studying how science education stakeholders engage in climate change education. The widespread influence of major fossil fuel and agricultural interests, as well as the national

prominence of climate change denier Oklahoma Senator Jim Inhofe, likely influence how Oklahoman's view climate change (Antilla, 2005; Demeritt, 2006). Conservative attitudes have historically interfered with advancements in science education by generating manufactured controversy via legislative bills which advocate 'teaching the controversy' about topics like evolution and now climate change (NCSE, 2013).

The current Oklahoma Priority Academic Standards for Science (PASS) do not specify the terms or concepts related global climate change. While the OK PASS standards place learning about human-environment interactions to the Environmental Science course, the OKSDE does not mandate that students' complete end-of-instruction testing in this subject. A traditionally politically conservative Oklahoma State Legislature is positioned as a critical network channelin the current revisions of science standards; since all revisions are submitted via the Oklahoma State Department of Education (OKSDE) Superintendent of Public Instruction to the Oklahoma State Legislature for final approval. The revised standards submitted to the State Legislature have been modeled around the nationally-developed (and recently released) Next Generation Science Standards (NGSS).

Next Generation Science Standards

The NGSS offer a potential pathway for the diffusion of climate change knowledge and materials if adopted across the United States (NGSS Lead States, 2013). For example, one core disciplinary idea titled "Earth and Human Activity" informs learning progressions across grades (K-12) and explores global change in terms of interactions between humans and the environment. The NGSS are markedly well-aligned with the interagency developed *Climate Literacy: The Essential Principles of Climate*

Science available for educators through the US Global Change Research Program (McGinnis, Breslyn, Hestness, & McDonald, 2013). The inclusion of climate change across several disciplinary core ideas and science courses suggests that revisions of academic standards for science which are based on the NGSS could widely increase opportunities to increase climate change education.

Still, a recent Fordham Institute review of the NGSS only gave the new standards document a 'C', ranking it better than only 26 current State science standards (Gross, Buttrey, Goodenough, Koertge, Lerner, Schwartz, & Schwartz, 2013). Undoubtedly, the ambitious nature of Earth and space science content found in the NGSS introduces many new ideas about the science behind climate change. At the same time, the Fordham review notes the final version of the NGSS included the removal (from previous drafts) of important content related to climate change (e.g. the erasure of middle school standards for developing greenhouse effect models from atmospheric and land data) (p. 48). Furthermore, the application of assessment boundaries which purposefully position climate change and greenhouse effect as not included in the testing of core disciplinary ideas related to interdependent relationships in ecosystems and biological evolution may have an unnecessary limiting effect to the advancement of climate science knowledge.

While the Fordham review concluded that some states may already have a stronger set of standards in place, some states like Oklahoma have overall science standards which are clearly inferior to the Next Generation Science Standards and may benefit from adopting or revising state standards according to this national model (Gross et al., 2013, p. 4). The possibilities and limitations of the NGSS to reform science education broadly, and climate change education specifically, are subject to the politics of

educational reform which influence individual states. However, the NGSS has been adopted in full by Kansas and Kentucky; both are states with histories of hostile resistance to contemporary science education reforms to the introduction of topics like evolution and climate change in public schools (National Center for Science Education, 2013). The tremendous amount of discussion surrounding the integral role of NGSS to reform educational policies and inform pedagogical practices merits a more detailed review of how the science standards revisions will be integrated and mobilized in states with high levels of anti-science education contestations.

Research Methods

This section describes a Qual-quan mixed methods research design meant to identify the networks of prescription and negotiation which characterize the relational performances and everyday experiences of science teachers engaged in climate change education. This research adopted Latour's (2005) approach to mapping controversy as a guiding method for identifying important nodes of social negotiation which influence the advancement of climate change education. ANT methodology employs four key principles for mapping controversies and avoiding a priori assumptions about social assemblages (Latour, 2005). First, the action (or agency) of actors in the network must not be assumed but demonstrated by evidence of change in the state of affairs. This distinction is the hallmark of a good ANT study (Latour, 2005) and involves asking questions like, which agencies are invoked? And what figurations carry meaning? This process distinguishes intermediary actors from mediators. Next, the researcher and participant figurations of actors must attend to the implications of the narrative and disciplinary representations of actors and events. For the researcher, Latour (2005)

described this process as careful attention to "recording, no filtering; describing, no disciplining" (pg. 55). The third principle attends to the nature of controversy as beneficial for tracing assemblages. Research accounts should attend to the criticisms and framing of other actants (an implicit process of controversy) as a strategy for tracing actor-networks. The fourth principle requires looking to network actants themselves to offer the explanations for how agencies are successful or unsuccessful.

Using Latour's process as a guide, a two-stage sequential design utilized key informant interviews with stakeholders in Oklahoma science education to design an on-line questionnaire for secondary science teachers. Additionally, participant observation and field notes from state-wide science education meetings and science teacher workshops added richness to the contextual interpretation of the interview and questionnaire data. Grounded theory and descriptive statistics were used to analyze, reduce, and synthesis these results. Triangulation of data aimed to enhance the explanatory power of the study and uncover contexts not available through survey or interview alone (Baxter & Eyles, 1997; Creswell & Plano Clark, 2007).

Key Informant Interviews

Initial key informant interviewee were purposefully selected science education stakeholders and later emerged from a snowball sampling of interested science teachers, school leaders, informal educators, and members of other state level professional and advocacy organizations. These interviews were semi-structured, approximately one-hour each, and designed to solicit respondents' opinions across three themes: (1) attitudes about trends in science education in Oklahoma, (2) opinions about climate change education, and (3) experiences with public pushback or other classroom contestations.

The key informant interviews (n=17) were audio-taped in the spring of 2013 and transcribed for situational analysis using grounded theory methods (Clarke, 2005; Glaser & Strauss, 1967). Interview data served to identify key actants in climate change actor-networks, tease out nodes of action, and define points of resistance in climate change education controversies. Specifically, syntheses of the similarities and differences between key informants' attitudes, opinions, and experiences (across various scales and types of science education assemblages in Oklahoma) informed the design of a follow-up online survey questionnaire for secondary science teachers.

Science Teacher Survey

An on-line questionnaire was designed to assess science education teacher practices and negotiations in climate change education at a statewide level. The questionnaire included 48 items, organized into 4 thematic categories: (1) teacher demographics, (2) teacher professional development and resource networks, (3) climate change education practices, and (4) attitudes about climate change and climate change controversies. The political context in Oklahoma suggested a need for careful language choices, especially when framing the climate contestations component. Items on the survey allowed for the possibility of skeptical responses and avoided isolating respondents by using politicized connotations of climate change.

Beyond basic demographic information, survey items included questions about sources of information and teaching materials, access to resources for teaching science (e.g. lab space, computers, outdoor classrooms), and actors influencing their science curriculum focus, scope, and sequence. A range of questions about climate change education practices included presence of the concept in textbooks, teacher attitudes about

appropriate subject areas for CCE, and experiences with professional development. Respondents were also asked about their motivation for choosing to teach (or not teach) climate change, as well as perceived barriers to their efforts. Drawing on results from the key informant interviewees, the researchers also included questions about classroom pushback across a variety of controversial science topics. Question items were constructed to accommodate respondents who prescribed to both skeptical and convinced logics.

The questionnaire was developed in Qualtrics and distributed electronically to 5th-12th grade science teachers in Oklahoma. Key informant interviewees assisted in distributing the questionnaire to science teachers via the listservs and/or social media of various school districts, state agencies, and state teacher organizations. In an effort to increase the response rate, respondents could enter in a drawing to win one of four $20 gift cards (Warriner, Goyder, Gjertsen, Hohner, & McSpurren, 1996). The online questionnaire received 156 total responses, with 125 respondents completing the survey in full. Responses from ten respondents who taught in private schools were eliminated given the small sample, thus delimiting the participant population to public school teachers. Thus, a total of 115 teacher questionnaires were included in the final analysis.

Participant Observation and Secondary Archival Research

The researchers participated in several state-wide meetings and teacher workshops designed to advance environmental education in Oklahoma. Extensive field notes captured the lived experiences of teachers within this community of practice. Archival data collected included the Oklahoma State Department of Education website (OKSDE), news media, state teacher organization websites, policy briefs, curriculum

resources, and other educational statistics databases. This data was used to inform a historical and more collective understanding of the state of science education in Oklahoma. Together, participant observation and archival research methods assisted in the triangulation of data across the collective experiences and memory of the key informants and survey respondents.

Results

This research focused on science education communities of practice and the lived experiences of teachers as mediators in climate change actor networks. This results section provides a snapshot view of the barriers to and engagements with climate change education in science classrooms in Oklahoma. Overall, the results present participants' perspectives on the problematisation of climate change and climate change education. First, an actor-network map outlines the spaces of prescription and negotiation which characterize ongoing revisions of the OK Priority Academic Standards for Science (PASS) and the perceived role of the NGSS in mediating science education reform. Next, an overview of the state of science education, as reported by key informants, aims to tease out some of the structural barriers to science education (in general) from climate change education (specifically). Next, the results of the online survey provide insights to individual strategies and barriers to teachers' engagements with climate change education in Oklahoma. Finally, the results explore key informants' and teacher survey respondents' attitudes about the role of State academic standards on science education practices and the perceived possibilities for revisions of PASS to increase efforts in CCE.

Actor-network map

The overarching research question asked: *what spaces of prescription and negotiation characterize climate change education efforts within and across science education communities of practice in Oklahoma?* The results highlighted the spaces of prescription which order and normalize science education in Oklahoma and revealed tension with those spaces of negotiation where provisional and divergent coalitions mobilize climate change education efforts (see Figure 3.1). Classroom science teachers engaged in climate change education revealed spaces of negotiation otherwise invisible in public sphere discourse about the impacts of anti-science politics in states like Oklahoma.

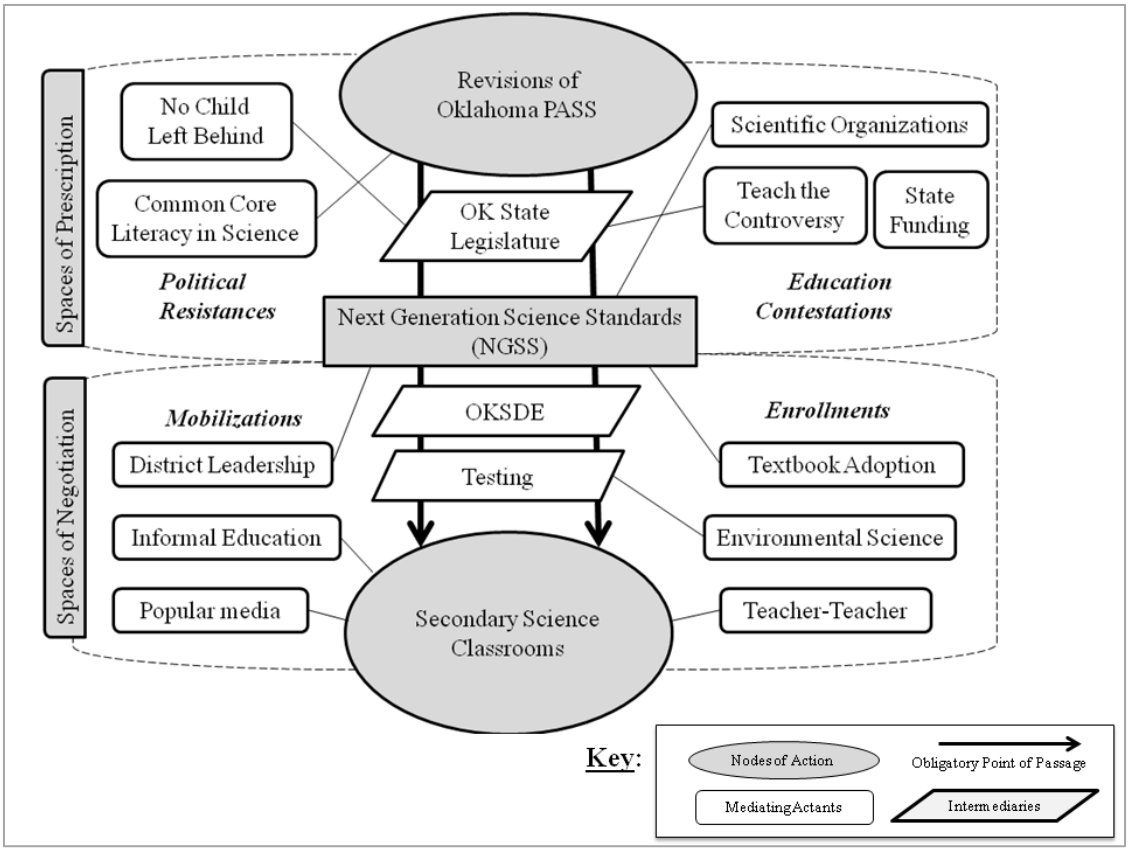


Figure 3.1 Actor-network map theorizing the translation of climate change education

Evaluating the presence and possibility for climate change education in science classrooms revealed a network of prescription driven by conservative political control over state science standards. This included *political resistance* to nationally developed standards and *educational contestations* about classroom science content and school funding. Across key informants and science teachers alike, the presence of climate change in state standards was perceived to be an obligatory passage for inclusion in classroom instruction. Furthermore, while climate change standards were often perceived as an obligatory point of passage for inclusion in classroom instruction by key informants, the State Legislature was viewed as an obligatory point of passage for inclusion of climate change concepts in standards revisions. The ordering power of standards is enacted through state-mandated testing and textbooks, as immutable mobiles, which are currently perceived to marginalize environmental science and omit adherent approaches to climate change in science curriculum. In the case of this study, enactments with climate change education emerged regardless of its omission from State standards.

Despite politicized efforts to prevent climate change education in science classrooms (by excluding or muting terms and concepts from the academic standards), teachers emerge as mediators of climate change education pedagogy and knowledge. Spaces of negotiations include *mobilizations across actor-networks* (school leaders, popular media, and informal education) and examples of *teacher enrollments* in CCE (textbooks, testing, and teacher networks). The prescriptive power of state standards to dictate instruction is mediated by the individual teacher enrollments and mobilization of school resources. Oklahoma science teachers' desire for increased efforts in CCE at their

schools and opportunities for professional development suggests that science classrooms in Oklahoma may be important nodes of action in climate change actor-networks.

Barriers to science education 'reform'

Results of key informant interviews verified that the challenge of teasing out the barriers to climate change education from the general barriers to science education.. This section synthesizes the perceived barriers to improved science education which influence practices in science teaching and learning in Oklahoma. Most key informants identified institutional structures (specifically a lack of funding, disparities across rural and urban schools, and a general lack of coordination and leadership from the OKSDE) as barriers to science education in Oklahoma.

Lack of funding was the most frequently cited barrier to science education which has included a 28% decrease in public school funding over the past five years (OETA, August 10, 2012). Key informants explained how this lack of funding impacted teacher raises, opportunities for professional development, and access to adequate science texts and materials. As one school district leader described the state of science education in Oklahoma (especially, in the wake of No Child Left Behind (NCLB) legislation of 2001):

> It is one of those perfect storms. . .you couldn't have orchestrated it better than increase the rigor, and increase the demand for highly trained teachers, highly proficient teachers. And at the same time that you reduce all the funding that enables that to occur.

Several key-informants who served as science curriculum coordinators described a growing disconnect between science educators that had emerged due to budget cuts. Lack of funding for travel limited opportunities for coordination of curriculum across the

urban school districts in Oklahoma's largest cities; Tulsa Public Schools is home to over 40,000 students and Oklahoma City Public Schools hosts more than 45,000 students. One key-informant reflected on the role of budget cuts on in-state travel:

> Our opportunities for collaboration have been drastically decreased in the last four years, due to budget cuts. The Tulsa Metro Consortium and the OKC Metro Consortium used to meet quite often to share ideas and to work together. But due to travel restrictions, there has probably been a divide that has grown over the last 4 years.

Key informants reported very little state-wide coordination of science curriculum by the OKSDE. The key informants' intimate understanding of the Oklahoma science education communities of practice revealed disparity between rural and urban schools in the degree, quality, and presence of coordinated or standardized science curriculum. As a former rural teacher explained:

> The nature of science education in Oklahoma is very dichotomous. The urban and suburban schools have a very structured curriculum that is all very similar. But then when you go to the rural areas you have very disparate and often times inequitable science education opportunity.

As one key informant noted, the differences across curriculum possibilities are magnified when you consider that it is only feasible for districts to have a science coordinator if they have more than 15,000 students. In Oklahoma, the OKSDE website reports that just 9 out of 540 public school districts (Tulsa, Oklahoma City, Edmond, Moore, Putnam City, Lawton, Midwest City/Del City, Norman, and Union) have this many students. As such,

the overwhelming majority of districts do not have an individual to coordinate science education efforts.

Many key informants also cited the regular turn-over in the position of Director of Science Education at the OKSDE as an important mediator in the lack of coordination of science education in Oklahoma. Turnover in leadership and decentralization of OKSDE communication reflect a lack of meaningful engagement with science education communities across the state. For example, a unifying practice across the last three state science directors was a regular science education email distributed via listserv to subscribing members. These emails contain legislative information and pertinent professional development opportunities for science educators. However, each science director reportedly creates a new listserv when entering the position and email archives are not maintained by the OKSDE after leaving the position. As such, science educators often experience a lapse in communications with each new state science director.

Similar criticisms about OKSDE leadership emerged from several curriculum coordinators who cited, with frustration, the recent Fordham Institute study of State science standards across the nation which gave Oklahoma an 'F' for the lack of science standards related to evolution, but also for poor marks across content, rigor, clarity, and specificity (Lerner, Goodenough, Lynch, Schwartz, & Schwartz, 2012). Notably, the Oklahoma end-of-instruction (EOI) tests at the high school level are only required for Biology I. The Fordham Institute recommended that state policymakers "consider adding physical science and Earth and space science to the high school examination and including a wider variety of test item types" (Lerner et al., 2012, p. 26).

Key informants from informal education agencies expressed a similar frustration with the lack of leadership from the OKSDE, especially in support for environmental science and Earth science education. For example, the current Oklahoma PASS science standards available on the OKSDE website do not include the words climate change and only situate learning about human-environment problems in the high school Environmental Science standards. While there are state science standards for Environmental Science, they are not included in state EOI tests.

Both curriculum coordinators and teacher educators confirmed that tested subjects often take priority over other instruction in terms of both curriculum planning and the assignment of experienced teachers. Reflecting on teachers' interest in professional development in environmental science topics, one informal teacher educator remarked:

> They are not interested if it is not on the test. And nowadays, it's not just end of the year but also benchmark tests throughout the year. There are exceptions to that, where there are teachers that are going to go above and beyond and make the effort to find materials and to teach [climate change] but those teachers are few and far between.

Illuminating the implications of standardized testing on high school curriculum, as well as other college readiness initiatives emphasized by the OKSDE, one curriculum coordinator explained how Environmental Science teachers are likely to be less experienced,

> We are going to place our strongest teachers where we have the most need. Our strongest classroom teachers [tend] to be those teaching Biology, because it is a tested subject. This is also true of classes like

> Chemistry and Physics, because of our emphasis on trying to get the students college and career-ready.

The prioritization of tested subjects is illustrative of the overt power of standards on classroom teaching and learning which might detract from climate change education efforts in Oklahoma.

Emphasis on the power of testing mandates to order classroom practices led key informants to identify the curricular motivations of AP Environmental Science teachers as an avenue for mobilization and formation of climate change actor-networks in Oklahoma. Indeed, the clearest prescriptive pathway to intensive climate change education in Oklahoma is Advance Placement (AP) coursework which is based on a set of standards created by the College Board. The College Board website reports that the AP Environmental Science test bases 10-15% of the exam on global change concepts, as well as 6 other human-environment topic areas. In this sense, teachers of AP classes are compelled to include climate change in their curriculum regardless of the politicization of the topic or its absence in the state standards. While it is unclear how many students are enrolled in AP Environmental Science, the College Boards' website reports for AP programs show that very few students in Oklahoma, only 614 in 2013, actually took the AP Environmental Science exam.

In summary, key informants reported the lack of coordination of science curriculum across the state is influenced by an insufficient education budget, disparities across a decentralized school district system, and inconsistent leadership in science education from the OKSDE. While the lack of testing simultaneously mutes the power and perceived importance of state-developed standards for general environmental science

courses, the curricular obligations of AP Environmental Science teachers exist outside the prescriptions of State academic standards.

Beyond networks of prescription to climate change engagements

An on-line questionnaire proved useful for gathering self-reports from secondary science teachers actually engaged in climate change education. The influence of state mandated testing on curriculum choices is suggestive of the overt material power of standards on classroom teaching and learning. However, classroom engagements cited by teachers illustrate a lack of climate change concepts in the state science standards does not necessarily preclude teachers from addressing the topic in Oklahoma science classrooms.

An on-line questionnaire completed by 5^{th}-12^{th} grade science teachers (n=115) helped to identify the experiences of teachers engaged in climate change education. Table 3.1 highlights the demographic variables (age, gender, school location, and years of teaching experience) of the teacher sample organized by grade-level(s) taught. Teachers were asked to indicate the most influential actors on the *scope and sequencing of science education* at their schools. Teachers ranked state curriculum standards (76%) and individual teachers (57%) as the most influential. Similarly, teachers were asked to identify their *sources of information for opportunities in science teaching and learning*. Approximately two-thirds of respondents ranked other teachers as one of their top 3 sources for information about opportunities in science teaching and learning. Teacher respondents remained more segmented across other responses, with approximately one-third of respondents indicating each of the following in their 3 primary sources of information: state teacher organizations (e.g. OSTA), informal education organizations

(e.g. OERB or Project WET), and national teacher organizations (e.g. NSTA or NAAEE). Approximately one-quarter of the respondents identified each of the following in their top sources of information: the OKSDE, district curriculum coordinators, science organizations, and principals.

Table 3.1

Demographic profile of on-line questionnaire respondents

	Middle School (n=39)		High School (n=62)		Both Levels (n=14)		Total Sample (n=115)	
	#	%	#	%	#	%	#	%
Teaching Experience								
≥2 years	3	8	4	7	4	29	11	10
3-5 years	2	8	9	15	1	7	12	10
6-10 years	5	13	15	24	0	0	20	17
11-20 years	13	33	18	29	6	43	37	32
21-30 years	8	21	13	21	2	14	23	20
30+ years	8	21	3	5	1	7	12	10
Age								
24-30 years	5	13	11	18	2	14	18	15
31-40 years	2	6	14	23	1	7	17	15
41-50 years	16	41	14	23	5	36	35	30
51-69 years	16	41	23	37	6	43	45	40
Gender								
Female	30	77	40	65	9	64	79	69
Male	9	23	22	35	5	36	36	31
School Location								
Rural	15	38	30	48	9	64	54	47
Urban	9	24	9	15	4	29	22	19
Suburban	15	38	23	37	1	7	39	34

[1] Middle school (5^{th}-8^{th} grade), high school (9^{th}-12^{th} grade), and both grades (middle and high school)

In sum, while teachers report standards as a driving force in curricular decisions, many also reported a high sense of agency as individuals in determining the scope and

sequencing of their science teaching. Additionally, teachers tended to identify other teachers or teacher organizations as their primary sources of information about science teaching and learning opportunities (more often than state and district sources).

Teachers were also surveyed about their preparation to teach climate change education. Only one out of 5 survey respondents reported learning about global climate change in their previous college or advanced course work. The respondents indicated that in the past two years they primarily relied on self-directed learning experiences over the past two years, including magazines, books, and websites. As a whole, participating teachers reported a willingness to engage in *future professional development about climate change* (64% responded 'yes' and 30% responded 'maybe').

Despite the lack of climate change concepts in the State science standards, when asked about how they taught about climate change in the classroom, 50% reported that they taught climate change lessons informally, 30% reported that they taught formal lessons about climate change, and 20% reported that they did not address climate change in their science classrooms. Table 3.2 reports on climate change education engagements across grade levels of teachers, including access to resources and perceived barriers to implementation of CCE. Of all of the teachers who reported teaching climate change (either formally or informally), 70% spent less than 4 hours per school year on the topic of global climate change.

In response to a question item about *barriers to climate change education*, teachers most commonly cited a lack of time (53%), limited professional development opportunities (45%), and the need for quality resources (45%). Middle school teachers more frequently reported a lack of personal training and/or professional development on

the topic of climate change as a barrier to classroom CCE instruction. Despite overwhelming support for increased climate change education, when asked about forming their own opinions about global warming, most teacher respondents reported needing *some more* (40%) *to a lot more* (34%) information. Additionally, only 8 teachers reported *not needing anymore information* to make up their mind.

Table 3.2

Climate change education engagements by grade-level of teacher

Survey Item/ Response	Total Sample (n=115)		Middle School (n=39)		High School (n=62)		Both Levels (n=14)	
	#	%	#	%	#	%	#	%
Teach About Climate Change								
Yes, Formal lessons	36	31	10	26	22	35	4	29
Yes, Informal lessons	60	52	20	51	32	52	8	57
No	19	17	9	23	8	13	2	14
Climate Change in Textbook								
Yes, introduced in text	71	62	20	52	46	74	5	36
No, not introduced in text	44	38	19	49	16	26	9	64
Teaching Resources								
Write my own	75	78	22	73	42	78	11	92
Textbook	47	49	14	47	27	50	6	50
Science organizations	46	48	11	37	30	56	5	42
Informal education	21	22	6	20	13	24	2	17
Barriers to Implementation								
Lack of Time	51	53	17	57	32	59	2	17
Lack of training on topic	43	45	19	63	20	37	4	33
Lack of quality teaching resources	43	45	17	57	22	41	4	33
Lack of alignment with state standards	30	32	8	27	18	33	4	33
Concern over classroom pushback	21	22	4	13	11	20	6	50

[1] For the teaching resources and barriers to implementation items, participants were instructed to 'select all that apply' and could therefore select more than on response.

Teachers were also asked their opinions about the science supporting global warming trends and primary causes of current climate change. More than half of the respondents (56%) disagreed with the statement, *most climate scientists agree about the causes of recent climate change.* One-third of the respondents disagreed with the statement, *recent climate change is happening mostly because of humans.* When asked to choose from a list of possible causes, the open-ended responses provided by the respondents selecting 'other' indicated that some teachers have hesitancy and reservations about making distinctions between the human vs. natural causes of climate change.

Many respondents also had reservations about the methods, evidence, and scientific consensus supporting climate change theories. Further analysis of items related to scientific consensus revealed that approximately one-quarter of the sample agreed with two statements: *The evidentiary basis supporting global warming is weak and even wrong* (23%) and *the methods used to determine global warming are not reliable* (23%). In sum, teachers reported needing more information about global warming and expressed doubt about the scientific consensus regarding current climate change (i.e. questions about the trends, causes, and impacts of global warming).

Despite this knowledge deficit, when asked where they acquired their climate change instructional materials for the classroom, respondents most commonly indicated that they wrote their *own lesson plans* (78%). Teachers reported their instructional materials came from *textbook(s)* (49%) and *scientific organizations* (48%). Non-textbook sources of curriculum cited by teachers included scientific organizations (e.g. NASA, Scientific American), environmental education curriculum (e.g. Project Wild,

PLT Green schools), and other popular media (e.g. *Inconvenient Truth*, NPR's *It's All about the Carbon)*.

Over one-third of the sample (38%) reported climate change was *not* addressed in their textbooks. High school teachers were more likely to note their science textbooks addressed the concept of global climate change than middle school teachers. Survey respondents were asked to identify the textbook(s) that they used in their science class to teach climate change. The four textbooks most commonly cited textbooks by teacher respondents (specifically, Glencoe Earth Science, Holt McDougal Earth Science, Prentice Hall Earth Science, and Prentice Hall Biology) have been characterized in previous research as presenting hesitant approaches to climate change (Meehan, 2012). In contrast to an adherent approach, which considers climate change as an immediate and serious problem, a hesitant approach tends to avoid directly attributing the cause to humans and provides minimal discussion of the impacts like extreme weather, food security, water security, ecosystems, society, and human health.

In sum, teachers reported a lack of knowledge about climate change, but also reported composing climate change lessons themselves. More often respondents identified lack of time, personal training, and access to resources as greater barriers to these engagements than lack of alignment with state standards or concern over classroom pushback. Still the lack of climate change content in State science standards, curriculum guides, and textbooks are perceived as obligatory points of passage for some respondents.

It seems while a lack of knowledge may limit teachers understanding of the science behind climate change theories, it did not influence the respondents' overall agency in or attitudes about increasing efforts in climate change education. Individual

science classrooms notably emerged as spaces of negotiation, in the face of prescriptive limitations, where science teachers enact resistive agency through formal and informal CCE lessons. Rather than normalize science education, these spaces highlight the provisional and even divergent coalitions supporting climate change education efforts in Oklahoma.

(un)Doing the NGSS: negotiating standards revisions

This section continues to explore key informants' and teacher survey respondents' attitudes about the role of State academic standards on science education practices and the perceived possibilities for standards revisions to increase efforts in CCE. Triangulation with archival data illustrates that the history of revisions of State academic standards for science in Oklahoma are historically embedded with contestations over the erasure of the term evolution. Ambiguities, tensions, and resistances resulting from the currently on-going revisions of Oklahoma science standards raise questions about the possibilities for standards-based reform to mobilize increased efforts in CCE in science classrooms.

The recently completed Next Generation Science Standards (NGSS) are slated to be integrated into states across the count. The most recent draft revisions of the Oklahoma Priority Academic Standards for Science released by the OKSDE are indeed modeled (rather than fully-adopted) on the NGSS. However, key informants report being weary from both the 2008 and 2011 state standards revisions processes. Concerned about the impact on the quality and coordination of science education, one district leader explained that there was very little time to implement the 2011 standards:

> We are looking at several standards sets within a short timeframe, which is hard for our teachers. It is very wasteful to develop curriculum around one, and then throw it away, and then develop it around another. It would have made a lot of sense to wait for NGSS, and then taken it and used it right from the beginning.

Other key informants involved in the 2011 revisions expressed reluctance to participate in the tedious and highly politicized process again. Prior to the 2013 revisions (ongoing), the Oklahoma State science standards were significantly revised to include inquiry-based learning (content and process) in 2008 and then again in 2011 in coordination with Common Core (which focused on mathematics and reading literacy). As one key informant who served on the revisions committee characterized it, the 2011 revision involved a "scandalous" erasure of the term evolution by the OKSDE from the draft submitted by the revision committee prior to being approved by the State Legislature.

Some key informants reported the relationship between OKSDE and science education communities of practice to be hostile and unsupportive. The on-going development of the current State science standards revision process was highly secretive prior to its release for public comment. Some key informants who served on the current revisions committee reported that they were required to sign confidentiality forms with threat of possibly losing their teacher licenses if they discussed details of committee meetings. Given experiences with the Legislature and OKSDE during the 2011 revisions, key informants expect a similar muting of controversial topics like evolution and climate change in the upcoming revisions.

A lack of clarity and public transparency from the OKSDE about the State standards revision process, as a whole, encourages widespread confusion about the relationship between the current revisions on OK PASS and the on-going and highly contested implementation of the Common Core Standards for mathematics and reading. Key informants described the difficultly of helping teachers and other education stakeholders distinguish the Common Core Standards (as primarily reading and math standards) from the Next Generation Science Standards (NGSS). This also included attempts to make explicit the differences between federal mandates (i.e., NCLB) and nationally developed science standards (i.e., NGSS).

Dominant educational discourses based in the rhetoric of State's rights and conservative values seem to muddle popular understanding of the science standards revisions process. The current OKSDE Superintendent of Public Instruction is reportedly resistant to nationally developed standards (rather than standards developed with Oklahoma values). The Tulsa World recently quoted her as describing the Common Core Standards for Literacy in science and social studies as "laced with very liberal principles" and calling for the continued revisions of science standards in alignment with state values (Harper, 2013). For many stakeholders, these contestations are typical of the OKSDE and similar to the authoritarian and conservative discourse of the predecessor State Superintendent of Public Instruction (who held the position for 20 years prior to 2011). This is lack of transparency is symptomatic of the poor communication between the OKSDE and other science education stakeholders described above.

The ambiguity of constant revisions and politicization of the process frustrated many teacher educators, who have come to expect that science standards will just keep

changing and that adapting curriculum to them is a waste of time. The extended revision process creates moving targets for educators and further frustrates groups interested in teacher preparation and improving student learning outcomes. Some crucial informal science and environmental education stakeholders have come to question the value of aligning with State standards at all. One informal science educator spoke about the influence of standards on the focus of educational programming at their State agency:

> And so, in 2011 we just said, "Let's just stop until the NGSS science standards come out. Let's wait until Oklahoma figures out how to incorporate the standards. We will hold off on any teacher workshops." And then we [stopped teacher training and] began to start doing camps for kids.

A deliberate choice by a prominent informal education agency to stop providing a teacher professional development workshop demonstrates the immense power of ambiguity surrounding the revisions process.

In this light, the introduction of the NGSS to the on-going State science standards revisions in Oklahoma emerged as an important cross-scalar node of action with the opportunity to mediate improvements in science education practices in Oklahoma. Key informant interviewees familiar with the science standards process expressed enthusiasm about how the NGSS model might improve practices in science education in Oklahoma. A general desire for standards based in realistic learning progressions with conceptual development across grade-levels was clearly evident in the collective narratives of the key informant interviewees. One informal teacher educator reflected on the importance of this change in science education approaches:

> I think the NextGen has begun to build on concepts year after year. Instead of saying, 'Okay we can only talk about weather in 5th grade, because that is what the standards say. In 4th grade we can't talk about that, you will get it next year.' We have segmented the curriculum so much, and that's why kids don't get science right now because they don't see how things are connected. Like how Biology, Physics, and Chemistry all have connections to each other.

Formal educators also expected NGSS would make sense as a guide for coordinating curriculum across grades and school sites. One administrator faced with the challenged of meeting state testing goals in a limited number of instructional days explained:

> . . . one of the good things about NGSS is the way that it structures the sequence. So that the course flow in NGSS is a lot more logical than what we had with [Oklahoma] PASS standards. What we have to do is look at all our curriculum maps. We do not necessarily do pacing guides, because we have done away with the "you have to be here by this day" mentality. But we do have suggested timelines.

In response to anticipated erasures of concepts related to evolution and global warming by the OKSDE, key informants reported that some of the science curriculum coordinators in the Metro Consortiums have collectively agreed to structure curriculum using the NGSS, regardless of the outcome of State science standards revisions. For curriculum coordinators to choose curriculum pathways based on the nationally-developed standards represents a significant act of resistance to the OKSDE. Given the

detailed learning progressions and adherent approaches to climate change outlined in the NGSS, the decision to model these standards is an important node of action in the mobilization of CCE actor-networks in Oklahoma as well.

Another outcome of the ambiguity linked to standards revision is the most recent delays in the science textbook adoption cycle. New science textbooks have not been adopted in Oklahoma since before the standards revisions process in 2008 (OSTE, 2013). Regardless of the inclusion of climate change concepts in the revised standards, the advancement of NGSS at a national scale could also provide opportunities to advance more adherent approaches to global climate change content through the updates to textbooks. Although Oklahoma schools will not have the opportunity to buy any newly approved science textbooks until July 2015, the postponement of new textbook choices emerges as another possible actant in the translation of contemporary and adherent climate science in Oklahoma.

In sum, contestations driven by tensions between OKSDE and state legislative veto power over educational standards creates limitations and possibilities for CCE in Oklahoma. Tracing the interaction between spaces of prescription and negotiation revealed that the NGSS is a key artifact in the ordering of climate change education in Oklahoma. The politicization of climate change seems squarely placed on the inadequacy of the OKSDE to provide sustained leadership in science education, as well as anti-science attitudes in the Legislature.

The secrecy behind and ambiguity of constant revisions to science standards has mobilized action by district science curriculum coordinators to follow national curricular leadership via the NGSS. This act of resistance suggests meaningful pathways for

increased climate change education driven by an institutional dependency on prescriptive uniformity. Similarly, the implementation of the NGSS on a national scale may provide opportunities for improved presentation of climate change concepts in textbooks. Taken together, this snapshot of the emerging and multiple co-existing ontological forms of climate change education across national, state, and local universalities suggests a notable counter-narrative to conventional discussion about the threat of conservative politics.

Conclusion

The on-going revisions of State science standards emerged as a recognizable node for action with the possibility of enrolling teachers and mobilizing efforts in CCE. Examining stakeholders perceptions about the process of standards revisions illustrates how, in this case, the ambiguity of the process allows multiple actors across different trajectories to exercise domination, submission, and even resistance in science education communities of practice. Most detrimental to the advancement of climate change education is the lack of transparency and air of secrecy about the process of revisions. While the on-going revisions of the State of Oklahoma academic standards for science are reportedly being modeled on the NGSS, the standards will still need approval from the State legislature. The draft of the science standards, released on the OKSDE website for public comment in January 2014, confirmed a great deal of parallelism to the NGSS document. However, comparison of the NGSS and OKSDE draft reveal the erasure of the term evolution and the muting of some concepts related to climate change (i.e., content related to melting glaciers and climate modeling).

The (un)doing of standards is characterized by spaces of prescription and negotiation across science education communities of practice. Even if the new revisions

of the State science standards include concepts related to climate change, institutional barriers to the coordination and advancement of science education, especially untested topics like environmental science and Earth science, remain prominent across the State. Dissemination of climate change via institutionalized educational networks will likely face meso-scale structural barriers driven by the need for improved coordination of science education and increased funding support. Teachers' engagements with climate change are mediated by a lack of knowledge and resource support. Addressing this issue on a broad scale will require an increase in access to resources for teacher training and classroom instruction about climate change.

In the example of Oklahoma, despite a high level of interest and motivation by teachers and other stakeholders, there remain a number of political and institutional barriers to science education reform in general. Policy analysis concerned with the diffusion of climate change knowledge should focus on the ways powerful networks emerge, what connects assemblages in extended networks, what identities and behaviors are translated, and how stakeholders might enroll and mobilize others across climate change actor-networks (Fenwick & Edwards, 2010). The circulation and *(un)*doing of standards modeled along the NGSS will likely re-order science curriculum in Oklahoma, but the ability for these prescriptions to meet their potentialities remains to be seen. On a national and state level, efforts to disseminate climate change education cannot rely on the adoption of standards like the NGSS to do the work. We conclude by encouraging Oklahoma's science education stakeholders interested in advancing Earth science, environmental science, and other geosciences education to take advantage of this time of growing interest in climate change education initiatives rather than shy from perceived

political pushback. By demystifying the power of manufactured controversy about climate change to mediate school science practices, science education stakeholders can now begin to ask more productive questions about how to support climate change education efforts. ANT makes important contributions to educational studies by asking: How are science teachers enlisted (or enrolled) in climate change actor- networks? What roles and scripts are established? What qualities or motivations are implied by successful networks? What could make climate change education functional, useable, or even indispensable? By asking these questions, enrolled science educators can begin to shift the locus of power and develop enduring assemblages of climate change actor-networks.

CHAPTER IV

TEACHING BOTH SIDES:
A CRITICAL POLITICAL ECOLOGY OF CONSENSUS

Introduction

Researchers from diverse disciplines have traced the political and rhetorical contestations which influence public perceptions about the scientific consensus about climate change (Ceccarelli, 2011; Demeritt, 2009; Hulme, 2010; McCright & Dunlap, 2010; Oreskes, 2010; Washington & Cook, 2011; Weart, 2010). Now, efforts to link climate change to other controversial science education topics are apparent in the anti-science legislative efforts associated with the 'Teach the Controversy' movement (NCSE, 2012; Scott, 2013). In 2013, legislative bills in Colorado, Kansas, Montana, and Oklahoma coupled climate change and evolution in attacks against consensus-based science education (Branch, 2013). In Oklahoma, HB 1674 titled the *Scientific Education and Academic Freedom Act* supported efforts to teach both the strengths and weaknesses of controversial scientific theories, including global warming and evolution. Teach the controversy frames in the news media are often associated with common sources and geographical areas (Grimm, 2009), however more research is needed to contextualize the influence of teach the controversy campaigns on science educators within these situated political landscapes.

Teach the controversy campaigns capitalize on the rhetorical strength of public debate about climate change, as well as the tentative nature of science, as justification for regulating the balanced teaching of science in public schools. Perhaps indicative of the symbolic power of manufactured scientific controversy, classroom science teachers across the United States report increasing protests from parents and school administrators who challenge the scientific consensus behind climate change (Reardon, 2011; Johnson, 2012; Petrinjak, 2011; Wise, 2010). When applied to climate change education, teach the controversy frames capitalize on the scientific uncertainty appeals associated with public debate about global warming and then deploy appeals to fairness, openness, and independent decision-making rhetoric which align with neatly with already popularized anti-evolution campaigns (Scott & Branch, 2003). In this way, efforts to manufactured doubt about the scientific consensus behind climate change are easily incorporated in entanglements about how science should be taught in school.

Awareness of the coupling of evolution and climate change in teach the controversy campaigns engenders questions about the best ways to advance climate change education in science classrooms across the United States (Inman, 2012; McBean & Hengeveld, 2000; Taber & Taylor, 2009; Wise, 2010). Teach the controversy campaigns have been strongly contested by the scientific community and within the context of science education are considered "scientifically inappropriate and pedagogically irresponsible" (Ceccarelli, 2011; Nisbet & Mooney, 2007; Scott & Branch, 2003). While science educators recognize the need to address important conceptual misunderstandings about the causes and impacts of climate change (Bozdogan, 2011;

Harrington, 2008; McCaffrey & Buhr, 2008;), the politicization of environmental problems adds to the complexity of teaching climate science.

Concerns about the ideological power of educational curricula which treats the causes of global warming as an open-question or controversial are prominent in contemporary discussions about climate change education in science classrooms (Bedford, 2010; Bedford & Cook, 2013; Meehan, 2011). Indeed, a key question among climate scientists, educators, and policy advocates asks whether or not portrayals of global warming predictions as mere knowledge claims undermine efforts to increase public understanding of scientific consensus about global climate change (Buttel , 2000; Shackley & Wynne, 1996; Hulme, 2010)? This research applies the lens of critical political ecology to investigate this question within the unique political landscape which drives contestations about climate change education in public schools in Oklahoma. Here, we explore how discourse coalitions deploying teach the controversy frames might influence the making, or performance, of climate change education in secondary science classrooms.

A Critical Political Ecology of Consensus

Political ecology aims to empirically investigate the struggle of knowledge, power, and practice which inextricably accompany the politics of environmental conflicts (Robbins, 2012; Watts, 2000). Political ecology focuses on the power relations both globally and locally, broadening the ecological analysis to the agency of individuals, movements, and community institutions and structure. Foundational thinkers Blaikie and Brookfield (1987) define this type of research as combining 'the concerns of ecology and a broadly defined political economy. Together this encompasses the constantly shifting

dialetic between society and land-based resources; and also within classes and groups within society itself" (p. 17). On point of departure for post-structural political ecology is to redefine these dialectical entanglements as a subject to network assemblages characterized across a complex web of relations (Robbins, 2012; Rocheleau & Roth, 2007). Efforts to trace controversies across and within network assemblages can inform a critical understanding of the ways people, groups, institutions, object, and other assemblages leverage power to influence others.

Discourse coalitions, like the Teach the Controversy movement, bring together social actors, aligned through language, stories, images, and terminology, and who often exist across different networks and interests (Hajer, 1995). Research in discourse coalitions allows political ecologists to bridge scales of influence and focus on how power relations are enacted in through processes of scientific knowledge-production. Several models for constructivist science have been articulated (Callon, 1995). Beyond the orthodox notion of science as truth, science can be viewed as (a) a competition between scientists and organizations for resources, (b) a historically bound outcome of socio-cultural practice, and (c) an extended translation shaping boundaries between social and natural worlds (Forsyth, 2003, 101). Adopting an extended translation model, climate change frames and scientific orthodoxies are understood as more than cognitive models (Corbett, 2006); instead the symbolic meanings created by the definition of environmental problems serves to structure and organize the social world.

Synthesizing points of cross fertilization and connectivity between the sub-disciplines of science and technology studies (STS) and cultural and political ecology (CAPE), this article applies the lens of critical political ecology to examine the role of

contestations about climate change education (CCE) in enforcing the symbolic legitimacy boundaries of science. Conceptualizing the translation of climate change education with contexts of situated science points to the power embodied in these patterns and processes of connectivity, the value judgments that are made in knowledge-rich environments, and the inadequacy of interpersonal learning theories. As an emerging sub-discipline, critical political ecology seeks to expose how dominant scientific discourses gain power through the narrative framing of historical "facts" or impositions of social "norms" (Forsyth, 2003). This critical lens avoids adopting an unproblematized notion of scientific truth and specifically draws attention to the polarizing effects of manufactured pedagogical competitions between consensus-based and controversy-based approaches to climate change education. A critical political ecology of consensus re-positions these pedagogical competitions as negotiations of epistemological questions about (a) what counts as scientific knowledge, (b) who controls its production, dissemination, and use, and, (c) how actors challenge, reinforce, or reframe the symbolic boundaries of science (Cox, 2006; Forsyth, 2003; Vogel et. al, 2007). This article seeks to make contributions to a critical political ecology of scientific consensus by focusing on the epistemic linkages between science and science education which highlight the role of science teachers in the coproduction of climate change knowledge (Jasanoff, 1995; Latour, 2005).

Everyday acts of resistance

An understanding of the everyday mechanics of schooling as a disciplinary technology points to the powerful role of science education as a mediating discourse within climate change politics. The political objects and actors thesis argued by political ecologists theorizes that from deeply structured and marginalizing socio-political

conditions emerge processes of alliance and resistance to hegemonic forces (Robbins, 2010). In response to the overt power of dominant discourses, political ecologists point to the more covert *everyday acts of resistance* which emerge as oppositional or confrontational acts which restore power (both symbolically and materially) to marginalized groups (Scott, 1986). Theories of resistance suggest that while such acts may be intentional or unintentional, as well as recognized or unrecognized by others, they are (pre)configurations to larger collective political contestations. Everyday acts of resistance, as hidden transcripts, are powerful symbolic tools for subordinated groups exactly because often they are largely uncoordinated, incremental and even disguised (Hollander & Einwohner, 2004).

In the tradition of the Foucauldian critique of power, this excavation aims to discover how socio-historical forms of constraint associated with a teach the controversy discourse coalitions are located and performed within and across discourses of teaching and learning (Deacon, 2006). Analyzing the discourse, contexts, and material relationships which sustain spaces for CCE tests the rhetorical strength of anti-science contestations on classroom practices (Besel, 2011). Towards these means, Summers, Kruger, and Childs (2001) argued that science teachers pedagogical knowledge about how to navigate controversies about environmental problems should and can be distinguished from subject knowledge. Attention to pedagogical discourses reveals the ways science teachers (re)produce, transmute, and even betray dominant scientific discourses sustained by consensus-based norms and orthodox notions of fact (Lee, Levine, & Cambra, 1997).

Theories of everyday acts of resistance inspire applications of ethnographic methodologies for capturing the micro-social processes of teachers engaged in controversies over science education (Ortner, 1995). This article provides a snapshot of the communication challenges and situated experiences of science teachers who are faced with anti-science controversies in the classroom (McBean & Hengeveld, 2000). The socio-cultural landscape in Oklahoma provided a unique context for studying how science education stakeholders engage in the translation and negotiation of climate change education. Conservative politics impose religious norms across science education contexts. Also, the widespread influence of major fossil fuel and agricultural interests, as well as the national prominence of climate change denier Oklahoma Senator Jim Inhofe, likely influence how Oklahoman's view climate change (Antilla, 2005; Demeritt, 2006). This research began by asking: *what pedagogical knowledge guides Oklahoma science teachers' negotiation of the symbolic legitimacy of climate change consensus in the face of controversy?*

Data collection

A mixed methods design for data collection included: (a) key informant interviews with science education stakeholders in Oklahoma (n=17) and (b) an on-line survey responses from middle school and high school teacher respondents (n=115). To begin the research, key informant interviews were conducted in the Spring of 2013. Purposefully selected and snowball interviewees included science teachers, school leaders, informal educators, and members of state-level education organizations. These semi-structured conversations lasted approximately an hour and were intended to solicit opinions across three themes: (1) attitudes about trends in science education in

Oklahoma, (2) opinions about climate change education, and (3) experiences with public pushback or other classroom contestations. The key informant interviews provided a projective socio-gram for tracing science education assemblages in Oklahoma and were crucial to identifying nodes of action and points of resistance to climate change education. After the interviews conducted were audio recorded and transcribed (Ogborn, 2012), comparative analysis of the interview transcripts guided development of an on-line survey for teachers.

Next, a survey questionnaire was distributed electronically via listservs and social media to 5^{th}-12^{th} grade science teachers in Oklahoma. Key informant participants assisted in distributing the questionnaire to science teachers via school district, agency, and advocacy listservs. The political context in Oklahoma suggested a need for careful language choices, especially when framing the climate contestations component. Items on the survey allowed for the possibility of skeptical responses and avoided isolating respondents by using politicized connotations of climate change. The survey questionnaire took about 45 minutes to complete and aimed to capture Oklahoma science teacher attitudes about climate consensus, their situated experiences with classroom pushback, and other strategies for translating climate change education in Oklahoma science classrooms. A total of 115 teacher questionnaires were included in the final analysis. The on-line survey questionnaire included 48 questions, organized into 4 thematic categories: (1) teacher demographics, (2) teacher professional development and resource networks, (3) climate change education practices, and (4) attitudes about climate change and climate change controversies.

In sum, a two-stage Quan-qual sequential design utilized key informant interviews with stakeholders in Oklahoma science education to design an on-line questionnaire for secondary science teachers. Additionally, participant observation and field notes from state-wide science education meetings and science teacher workshops added richness to the contextual interpretation of the interview and questionnaire data. Grounded theory and descriptive statistics were used to analyze, reduce, and synthesis these results. Triangulation of data aimed to enhance the explanatory power of the study and uncover contexts not available through survey or interview alone (Baxter & Eyles, 1997; Creswell & Plano Clark, 2007).

Findings

Teachers' views on climate change consensus

While the survey respondents overwhelming supported increased efforts in climate change, many of these teachers also expressed doubt about the scientific consensus behind climate change. More than half (56%) of the respondents disagreed with the statement, *Most climate scientists agree about the causes of recent climate change*. Approximately one-quarter of the respondents each agreed with the statement, *the evidentiary basis supporting global warming is weak and even wrong* (23%), *the methods used to determine global warming are unreliable* (23%), and *recent climate change is happening mostly because of humans* (30%). Teachers' general lack of understanding about scientific consensus, coupled with reservations about climate scientific evidence and methods, indicates meaningful symbolic legitimacy deficits.

When asked about forming their own opinions about global warming, 34% of survey respondents reported needing *a lot more* information and another 40% of teachers

indicated needing *some more* information. Additionally, only 8 respondents reported *not needing anymore information* to make up their mind. While the need for more information was common across all respondents, only some teachers understand the role of manufactured scientific controversy in public discussion about climate change. Nearly all (92%) of the surveyed teachers recognized the existence of public controversy about climate change, but the perceived reasons for this controversy varied.

Open-ended responses from teacher respondents explaining the reasons for public controversy about climate change were exemplary of three dimensions of the cultural reproduction of doubt: (a) a *lack of knowledge*, (b) *selective choice*, and (c) *deliberate deception* (Proctor & Schiebinger, 2008). Examples of representative responses for each of these culturally mediated pathways for the transmission of doubt are available in Figure 4.1. Approximately one-third of teachers perceived the controversy as a function of the type of disinformation commonly associated with climate change denial campaigns. The remaining teacher respondents indicated that public controversy about climate change is either driven by, (a) a lack of information or (b) misinformation driven by selective choice.

Many teachers' understanding of climate change controversies as driven by a lack of information or misinformation is likely a reflection their own self-reported need for more information. In these cases, public controversy is confused with legitimate scientific debate (e.g. "Controversies over models used and also how change can be brought about are hot topics concerning climate change"). Alternatively, teachers identifying disinformation as driving the public controversy about climate change both affirmed and

challenged the merits of scientific consensus (e.g., "Follow the money. Government incentivizes the belief that climate change is man-made from CO2 emissions").

Lack of knowledge	Misinformation/ Selective Choice	Deliberate Disinformation
"Changes are happening every day and people are not noticing."	"It is a difficult issue to address without major changes to lifestyle. It's easier for the public to ignore or argue with the science than it is to change human behavior."	"The power of fossil fuel industry and their power over politicians and the media."
"I think there is too much apathy."	"The general public thinks that extremes in winter temperatures and weather events are evidence against global warming."	"The debate is mostly driven by people who have a hidden agenda that has nothing to do with [helping] our environment."
"Some people think that climate change is no big deal."	"I have heard a lot of people say they aren't concerned because it will not affect them in their lifetime."	"Ignorance on the part of our leading Senator Inhoffe, who keeps denying it and putting out propaganda against it."
"Lack of scientific knowledge by the general public. If I were not in education, I am not sure I would be as aware of the climate change controversy."	"There are people who have not looked into it and understand that there are several causes, including natural cycles along with human impacts. "	"I think that climate change is being jammed down our throats as fact, not theory. I personally have issues with politicians who use junk science and fear mongering to advance their own agendas, while flying around in their private jets."

Figure 4.1

Examples of the perceived reasons for public controversy over climate change

In sum, a critical political ecology of consensus looks to the cultural reproduction of doubt in and by teachers. Questions about why controversies about climate change exist revealed teachers' attitudes about who controls the production and dissemination of scientific knowledge, but also their attitudes about how and why actors challenge the

symbolic legitimacy of climate change consensus. While the need for more information was common across all respondents, they varied in their understanding about scientific consensus and the role of manufactured doubt in the problematization of climate change. Doubts about scientific consensus point to some significant deficits to the symbolic legitimacy of climate change science across educational translations. Teachers' self-reported lack of knowledge about climate change is indicative of their construction of climate controversies as a function of lack of information or misinformation, rather than disinformation.

Situated pedagogical knowledge and everyday acts of resistance

This section turns to excavations in teachers' pedagogical knowledge about *how* to negotiate controversies about climate change in science classrooms. The phenomenological pairing of climate change with other controversial science education topics (like evolution and the age of the Earth) destabilizes notions of scientific consensus and problematizes climate change education. The analysis below identifies a complex set of negotiations and resistances enacted by classroom teachers in response to controversial science topics. Examples of teachers engaged in everyday acts of resistance to ideological contestations illuminate strategies for managing the boundaries of science and religion in classroom learning experiences.

Teacher respondents reported past experiences with pushback about controversial science topics from parents, administrators, other teachers, students, friends and family, and church communities. Table 4.1 illustrates that teacher experiences with pushback across all topics (including climate change) comes mostly from students and parents. Reports from teachers also indicated that they experience pushback over evolution at a

much greater frequency than pushback over climate change. Nearly two-thirds (67%) of teachers reported experiencing no pushback related to teaching about climate change or global warming. Only 25% of respondents agreed that *increased efforts to include climate change education in science curriculum would lead to pushback or controversy*. However, the results indicate that experiences with public pushback often do not originate with co-workers or administrators.

Additional open-ended questionnaire items prompted teacher respondents to provide narrative descriptions their experiences with classroom pushback which indicated that there are limits to the coercive and ideological power of climate change denial on the practices of science teachers. Teacher respondents recognized that anti-science controversies -- including contestations about the age of the earth, the formation of the solar system, and human evolution -- as commonplace in a religiously conservative state.

Table 4.1

Sources and topic of pushback experienced by teachers

Source of Pushback	Climate Change/ Global Warming		Solar Systems/ Planet Formation		Age of the Earth/ Geologic Time		Evolution	
	#	%	#	%	#	%	#	%
Students	14	12	20	17	37	32	48	42
Parents	10	9	5	4	13	11	34	39
Teachers	7	6	2	2	5	4	17	15
Family/Friends	6	5	2	2	2	2	16	14
Church	1	1	8	7	16	14	25	22
Administrators	0	0	2	2	4	3	9	8
No Pushback	77	67	76	66	55	48	40	35

[1] This data includes teacher self-report of types of experiences with classroom pushback. The respondents were instructed to "select all that apply". As such, the table reflects the only number of teachers who selected each source/topic item and the percentage of the total sample.

Rather than choosing to stop teaching contested subjects, other teachers explained that they get more comfortable over time by developing strategies to better present the topic to students while still managing parental concerns. For example, one experienced teacher reported confidence in dealing with any classroom pushback:

> I get [more] resistance over evolution more than anything else that I teach. No one has ever brought up an issue with climate change or global warming. I have been teaching long enough [though] that I can usually deal with complaints without too many issues.

Similarly, events like the omission of global warming or the removal of the term evolution from the state standards hardly leads to many teachers' erasure of the concepts from classroom teaching. After all, one teacher described, "How can you teach biology without talking about evolution?" Another teacher joked (about evolution pushback by parents) saying, "The state standards require teaching evolution, but don't use the "e" word. This seems to work [in the face of classroom pushback]."

In some cases, the intensity and frequency of pushback faced by teachers is mediated by the religious beliefs of communities and/or by teachers' own coinciding or conflicting religious beliefs. In this, while discussing strategies for teaching science, several teachers explained the rhetoric of local religious groups as irrational, "Church pastors are very outspoken and aren't able to discuss facts but only opinion, doctrine." Another teacher realized school policies were directly mediated by community values by explaining, "[My school] would not discuss the origin of life because all scientific proposals at this time are speculative, and we would not discuss human evolution due to pressure from local churches."

In addition to community norms, mediated national discourses also seem to influence pushback from parents and, in one case, even led to school policy reform about how to introduce controversial science topics. For example, parental pushback about the screening of the popular Al Gore movie, *An Inconvenient Truth*, resulted in formal training for all science staff at one school:

> I created an assignment that included the movie *Inconvenient Truth*. A parent complained (without having read the assignment). It resulted in the entire science department having to attend 1st Amendment training!

Similarly, after receiving complaints from parents about the teaching of evolution, another teacher described how she learned about a standard disclaimer she was asked to deliver when discussing controversial science topics in the classroom:

> The principal escorted me to the superintendent's office. I was informed in very specific terms if I planned to be back next year . . . I would make a *disclaimer* speech that students are free to believe what they want why they want. "They can believe whatever they like and it will not change their grade in any way. However, this is a science class and in class they are expected to be able to tell me what science says and why science says it.

In order to negotiate these contestations about what and how science should be taught, some teachers emphasize the difference between scientific knowledge and religious beliefs during student instruction. One teacher explains a strategy for making such distinction:

> I explain that scientific theories are not about beliefs, they are simply tools that offer the best explanation for events that we can observe and measure. For example, if you don't believe in gravity, does that affect what happens if you push a book off the table?

The nature of pushback motivated by religious concern is comical to one teacher, who reported, "I have been called an atheist. I assure [parents and students] that science cannot answer every question." Another teacher describes the negotiation of religious belief and science education in the face of misinformed students:

> I had students approach me after a unit on fossils and evolution. They were concerned about saving my soul. I explained that the function of science is to answer 'quantitative' questions: how long, how many, how much, etc. The questions of why and by whom are not questions addressed by science.

Other teachers create classroom space for student religious beliefs. For example, "I have addressed [student concern about evolution] by stating there are many theories on creation of the earth and its inhabitants. This gives us a moment to share and respect each other's beliefs. Then, I explain that the theory of evolution is a scientific one."

Other teachers find ways to integrate their own religious values with their approach to science education. For example, one teacher described how her strong religious beliefs and pre-service teacher training in a religious institution assisted her in the negotiation of the bounds of science and religion in the classroom:

> Most of the pushback comes from my church and family. I am deeply religious, as is my family, but we do not agree on many things such as

> evolution, the geological age of the Earth, and the universe. Luckily, I went to a very good religious university and was able to observe my science professors and how they handled themselves in similar situations. I am able to use what they taught me and to talk to individuals very plainly about my scientific beliefs and how they do not take away from my religious beliefs.

Another teacher approaches the topic of evolution as a theory and justifies the presentation of both evolution and creationism based in his religious values. In this example, teaching both sides allows the teacher to present creationism alongside scientific theory:

> Many of my students and I believe in God's creation of the universe. This is always discussed as a theory, an unproven assumption. I have had 'pushback' about discussing both evolution and creation, but I will continue to teach both so students can research and make their own decisions.

In other cases, teachers and students engage in modes of resistance to tensions between third party religious values and attitudes about science classroom instruction. For example, pushback from parents or community members did not necessarily result in the desired beliefs and actions of students. For example, one teacher described a request from a student to defy the parent's wishes, "A parent said that all her child needed to know about was the Bible. She asked that her child be excused from the unit. The student told me to ignore her mother and [explained] that she would just not talk about it at home."

The degree of parent and student pushback is not necessarily the same. As the teacher explained about the local community, "Three older [male teachers] refuse to teach anything about climate change or evolution, though their children I've taught didn't [resist during the] lessons. Only about 3-5 students, of 140 per year, will write about or discuss their beliefs about the 10,000 year old Earth."

In summary, this analysis provided examples of mixed, hybrid, and even resistant strategies in response to efforts to naturalize the exclusion of controversial science topics in Oklahoma public schools. Religious beliefs and attitudes were by far the most cited reasons for classroom contestations about evolution, the age of the Earth, and climate change. A history of contestations over evolution in science education seems to color teachers' understanding of how to handle controversies about climate change. Exploration in the situated pedagogical knowledge and everyday acts of resistance of science teachers revealed boundary ordering devices intended to bridge skeptical and consensus attitudes. Efforts to negotiate what counts as scientific knowledge vs. religious knowledge function to reinforce the symbolic legitimacy of contested science topics. The next section explores teachers' pedagogical motivations for teaching the controversy to further demonstrate the nature of and reasoning for this boundary-ordering.

On teaching 'both' sides of the controversy

Teachers were surveyed about their attitudes about *teaching or discussing both sides of the public controversy about human-caused global warming* (Wise, 2010). The vast majority (89%) of Oklahoma teachers agreed with teaching both sides of the controversy. For those11% of respondents indicating they did not support teaching both

sides, teachers' reasons included recognition that there is no real scientific controversy (n=6) and limitations to teachers' personal understanding (n=2). Other teachers specifically outlined the use of misinformation or bad science by self-motivated parties (n=5) as a reason not to discuss the public controversy with students.

Teachers' reservations about their own climate change knowledge and the lack of understanding manufactured climate change denial seems to influence this preference for a skeptical rather than consensus-based pedagogy. Open-ended responses from teachers provided the reasons why they did support the teaching both sides of the public controversy (n=109). Rather than coding for indications of range of consensus attitudes (Wise, 2010), this study used grounded theory methods to identify the expected outcomes of this pedagogical strategy on student learning. Open coding revealed three pedagogical outcomes emerging from the reasons provided by teachers for teaching both sides, including: (1) to promote independent decision-making, (2) to employ fair and unbiased classroom management, or (3) to learn about the tentative nature of science. Each of these reasons offer insight to how teach the controversy frames challenge the epistemic linkages between science and science education and challenge the role of science teachers and even students in the coproduction of climate change knowledge (Jasanoff, 1995; Latour, 2005).

Some teachers who support classroom instruction about 'both' sides believed this approach is valuable because it *promotes independent decision-making* in students. For these teachers, the task of researching and forming your own opinion is the primary goal of instruction, "The world is changing and it doesn't look like it's for the better. However, my opinion aside, students need the opportunity to practice making formative

decisions for themselves over a hot button issue." Other teacher responses pointed to student agency as enacted through the critical consumption of information, for example statements like, "Knowledge is power" and "I feel that students need to be able to understand and discuss current science issues."

Across all responses in this category, the teachers generally viewed debate about both sides as a way to increase access to the information necessary to promote independent decision-making. As one teacher explained, "I think our students deserve to be informed about the current science issues. In doing so, students need to know both sides of the issue in order to form their own opinions!" Another teacher acknowledges that there are many sides and applied this hetereogenity to justify the positioning students as agents of knowledge by saying, "It is important to present both sides so that students can make up their minds about this issue." In a similar line of thinking another teacher explained, "It is very controversial. Students should be made aware of the issue, that there are two very different beliefs and a range of opinions in between."

In some cases, climate change instruction is spurred by the rhetorical positioning of global warming position as a controversial topic, because "…the debate is a good example of data vs. money" and "I want students to think for themselves so I teach a few controversial subjects." These responses position debate about climate change as an opportunity for students to form individual opinions and beliefs about scientific controversies. Implicitly, this type of reasoning is defined by a degree of relativism where meaning is determined by the individual and many *truths* about climate change are possible.

Other teachers who support classroom instruction about both sides of the controversy believe this approach exhibits *fair and unbiased classroom management*. Representative of this reasoning are statements like, "If you do not discuss both sides, then you risk alienating the students who need to hear the information the most. Students will close their minds or question [you], if they do not feel that their viewpoint is included." Teachers provided other reasons for why discussions about *both sides* exhibits classroom management practices, including the desire to remain unbiased or avoid indoctrination of a teacher's personal beliefs. As one teacher explained, "There is a disconnect when students are told how to think" and another teacher proposed, "Our job is to teach them how to think, not what to think."

In sum, it seems teacher neutrality in the face of controversial topics is understood as valuable, even a student right. Notably, this type of reasoning also maintains a sense that students are understood as valid decision-makers concerning the causes of climate change. Again, one's right to all available information and one's right to form a personal opinion emerge as important value sets informing classroom pedagogy about controversial topics. Students are active agents in determining the symbolic legitimacy of science.

Other teachers who support classroom instruction about both sides believe this approach is foundational to *understanding the tentative nature of scientific knowledge*. These responses describe the process of debate as a method for reasoning from scientific evidence and thus central to the processes of scientific theory building. As one teacher explains, "Scientific data should be presented and investigations must be conducted by

students to begin to educate our public. If not, the problem will become more severe and affect our lives."

Teacher reasoning based in scientific literacy outcomes involved some complex negotiations between the tentative nature of science and the symbolic legitimacy of climate change science. Discerningly less relativistic, one teacher clarified her role in teaching both sides, "I discuss, but not support a side that doesn't have scientific evidence." Similarly, another teacher viewed himself as a key informant to students who either lack other sources of information or face misinformation at home or in the media, for example:

> I agree [with teaching both sides], but only because of the value of teaching how bias can affect public opinion. The public is generally misinformed when it comes to scientific data. Students need to learn how to wade through propaganda and politics which has nothing to do with actual conservation in the long run.

Responses in this category emphasized the need and importance of scientifically literate students in a contemporary world of politics, business, and even the perils of extreme weather. Here, teachers envisioned students as future citizens, tasked with complex decisions like voting and decoding news media hype.

For other respondents, concerns about teaching the human-causes of climate change are routed in an (mis)understanding that there are natural causes at play as well. From one teacher's perspective, "There is scientific evidence on both sides showing climate change due mainly to human activity and due mainly to natural cycles." One respondent maintains that both human and natural causes should be equitably addressed,

"Students need to be presented with valid points to causes for climate change, so this would include anthropological justification as well as natural cycles and phenomenon that could be large contributors".

Indeed, tropes of scientific uncertainty tropes drive the reason to entertain both sides. Pedagogical knowledge about teaching the tentative nature of scientific knowledge (not attitudes about scientific consensus) informed the logic of teaching both sides for one teacher:

> There would be an injustice in education to the students of Oklahoma to teach just one side of the research pertaining to human activities involvement to global warming. Would you want only the discomforts treated by a medication to be listed on the package for viewing? No you would want to know any possibly occurring side effects. Why teach only partial truth on the matter? That is not what education is.

In sum, teachers' rational for teaching both sides included the following learning objectives: (a) to promote independent decision-making, (b) to employ fair and unbiased classroom management, or (c) to learn about the tentative nature of science. Across all three categories of responses, teachers expressed logic of climate science relativism which grants validity to the idea that there is no fixed consensus, social or scientific, about human-caused global warming. In this way, teaching the controversy frames emerged as boundary ordering devices which, because of their relativism, were use to bridge skeptical and consensus-based attitudes in the classroom.

Summary of Findings

The situated pedagogical discourses of Oklahoma science teachers provided a snapshot of the overlapping and contested terrains which characterize the controversies over climate change education. The overall findings pointed to widespread misunderstanding by secondary science teachers about both manufactured doubt and scientific consensus about climate change. Pervasive in this study is the collective trauma from historical contestations over the presence of evolution in science education which sustains the sense of symbolic power of conservative political and religious values to also regulate climate change education. Teachers' experiences with classroom pushback influences a phenomenological pairing of climate change with other controversial science education topics, namely evolution. While this pairing destabilizes notions of scientific consensus and problematizes climate change education, analyses of teachers situated discourses about classroom pushback suggest that they are engaged in everyday acts of resistance to dominant religious and ideological norms.

This enquiry raised the question, does the pedagogy of 'teaching both sides' render the socio-economic and political forces which resist and deny climate change policies as the norm? Rather than suggesting pathways for productively questioning scientific uncertainty in science classrooms, teachers who profess to 'believe' in climate change while teaching both sides of the controversy seemingly undermine the symbolic legitimacy of climate change consensus (Doyle, 2010). Instead, excavations in the pedagogical strategy of teaching both sides of public controversies about global warming revealed the important role of this boundary-ordering device in bridging both skeptical and adherent classroom discourses (Hoffman, 2011). In short, by teaching climate change

as a controversy, many science teachers in Oklahoma are able neutralize the controversy. Indeed, as a boundary ordering device, the power in the paradox of teaching both sides is the ability to bridge the two social realms (scientific and religious) while also creating the opportunities to construct boundaries between enterprises (Guston, 2001).

Conclusion

This article makes contributions to a critical political ecology of consensus by focusing on the epistemic linkages between science and science education which highlight the role of science teachers in the coproduction of climate change knowledge (Jasanoff, 1995; Latour, 2005). In the face of rapid climate change (long understood as natural or inevitable), critical political ecology provides a necessary mode of examining the influence of climate change discourses centered on scientific consensus norms and highlights the co-production of climate change education in public school classrooms. The biggest implication to this integrated constructivism was to explore the experiences and enactments of teachers on the frontlines of the climate change controversies. Analysis of teachers' views about climate consensus, situated pedagogical knowledge, and reasons for teaching both sides of the controversy informed an understanding of their role in defining: (a) what counts as scientific knowledge, (b) who controls its production, dissemination, and use, and, (c) how actors challenge, reinforce, or reframe the symbolic boundaries of science (Cox, 2006; Forsyth, 2003; Vogel et. al, 2007).

This critical political ecology of consensus introduces a new line of political analysis which accounts for the everyday experiences and individual agency of science teachers in the diffusion of scientific knowledge. A situated science perspective revealed teachers engaged in everyday acts of resistance which restore their symbolical authority

and manage the tensions which emerge in the face of marginalizing classroom pushback. By teaching climate change as a controversy, many science teachers in Oklahoma are able negotiate complex political and religious terrains. While some of these acts may be unintentional and unrecognized by others, they all contribute to the (re)configurations of larger cultural and ideological landscapes. As hidden transcripts, these everyday acts of resistance are powerful symbolic tools for science teachers subordinated by anti-science education contestations because they are largely uncoordinated, incremental and disguised.

Concerns about the linking of climate change and evolution across teach the controversy frames raise important questions about how to manage the climate change education in science classrooms. Contextualizing teachers' reasoning within their experiences of classroom pushback about evolution reveals that such frames actual offer a level of dual interpretation about uncertainty and authority in science. The pedagogical strategy of allowing students' to form their own opinions emerged as a brokering device for teachers managing tensions between political and religious beliefs and scientific knowledge. It is true that teach the controversy frames evoke climate change relativism and capitalize on the inevitability of scientific uncertainty by raising questions about what counts as scientific knowledge and who controls its production and dissemination. However, the situated pedagogical knowledge of teachers' illustrates how such appeals are actually can be used to draw boundaries between scientific and religious knowledge and to negotiate the symbolic legitimacy of scientific consensus. In this way, teach the controversy frames are used to enact resistive agency and negotiate complex political and religious terrains.

Understanding CCE as the simultaneous production of knowledge and social ordering, a situated or hybrid science, allowed us to disentangle public contestations about climate change consensus from teachers' pedagogical reasoning. The hybridization of evolution and climate change controversies emerges from a historical interplay of teach the controversy frames in public education contestations across Oklahoma. By deconstructing the interplay of power relations between anti-science discourse coalitions and science education, the study revealed teachers repurposing teach the controversy frames to negotiate the legitimacy of climate change education in their classrooms. In a landscape of ideological contestations, these findings inform new roles and possibilities for science education in global social change by reminding climate scientists, educators, and policy advocates that all climate change knowledge is co-produced. Educational efforts which remain focused on appeals to scientific consensus will continue to ignore the complex web of relations and historical-interplay which inevitably influence the co-production of climate change politics and science.

CHAPTER V

CONCLUSION

This research set out to investigate the translation of climate change education within and across science education networks. The guiding research question asked*:* *How does manufactured scientific controversy about climate change present specific challenges and characterize negotiations in secondary science education in Oklahoma?* A mixed methods design began with a rhetorical analysis of skeptical media for children, followed by a situated examination of Oklahoma science education networks using key informant interviewees and an on-line survey of secondary science teachers. The results were organized into three distinct manuscripts which are summarized below.

Summary of Findings

The following summaries explain the focus and findings of each chapter article. This is followed by a discussion about the significance of each study, and the dissertation piece as a while, for both theory-driven scholars and applied researchers interested in the intersections of environmental communication, science education, and the politics of climate change consensus.

Chapter Two, titled "Climate change skeptics teach climate literacy? An analysis of children's books," focused on skeptical climate change literature designed for parents and children. Using content analysis procedures developed from previous excavations in

skeptical discourses, the study indentified common forms of climate skepticism, frames for climate change policy making, areas of contested scientific knowledge, and appeals for managing the uncertainty of climate change. The research question answered by this study was: *What rhetorical strategies reinforce the logic of non-problematicity about climate change in skeptical books for children?*

The results suggest that the logic of non-problematicity about environmental problems is bolstered by contradictory forms of climate change skepticism and polarizing social conflict frames. The identified strategies for managing uncertainty complement the logic of non-problematicity across a range of worldviews and sense of agency. The discussion points to the dangers of skeptical media which broker individual decision-making about climate change (over scientific consensus) and undermine environmental concern within dominant narratives of ecological modernization

This research is valuable for educators, advocates, and environmental communication scholars who seek to support learners in developing an improved understanding of climate change amidst widespread manufactured controversy. Strategies for addressing climate change denial rhetoric will need to incorporate learners' worldviews and sense of agency, in addition to addressing widespread scientific misconceptions. Beyond framing, climate change communication scholarship must continue to explore the inventional possibilities, or persuasive rhetorical tools, for responding to climate skeptics who teach climate literacy.

Chapter Three, titled "(un)Doing the NGSS: Possibilities for climate change education in Oklahoma," reported exploratory results about negotiation and translation of climate change education in secondary science classrooms. Applications of Actor-

network Theory (ANT) to educational policy making guided a series of key informant interviewees and an on-line survey of secondary science teachers. The research question answered by this study was: *How does manufactured scientific controversy about climate change present specific challenges to science education in Oklahoma?*

The results revealed the perceived barriers to science education reform faced by educators in Oklahoma. The revisions of state science standards based on NGSS emerged as a possible node of action in the advancement of climate science education in Oklahoma. However, entanglements with historical contestations over evolution characterize the negotiation of standards revisions and suggest that climate change concepts may indeed be erased or muted. Rather than normalize science education, these spaces highlight the provisional and even divergent coalitions supporting climate change education efforts in Oklahoma. Individual science classrooms notably emerged as spaces of negotiation, in the face of prescriptive limitations, where science teachers enact resistive agency through formal and informal CCE lessons.

ANT research is valuable for educational policymakers negotiating the introduction of climate change in states where climate change is highly contested or muted in the state standards texts. A reflexive view of climate change education as co-produced, as both politically constructed and as constructing politics, proved foundational to unweaving the problems with science education in Oklahoma from the problematisation of climate change education. The (un)doing and circulation of climate change education standards modeled along the NGSS will likely re-order science curricula, but the ability for these prescriptions to meet their potentialities in the face of widespread structural and attitudinal barriers remains to be seen.

Chapter Three, titled "Teaching the controversy: The political ecology of consensus", explores the influence of anti-science discourse coalitions seeking to pair climate change in Teach the Controversy campaigns. Critical political ecology guided the interpretive analyses of survey data about teachers' perceptions about the public controversy about climate change and self-reported experiences with pushback in science classrooms in Oklahoma. The research question answered by this study was: What situated knowledge do teachers have about negotiating the symbolic legitimacy of climate change consensus in the face of controversy?

Analyses revealed teachers marginalized by anti-science controversies but engaged in everyday acts of resistance to political, ideological, and religious norms. The practice of teaching both sides was explored as a boundary ordering device bridging convinced and skeptical discourses. The phenomenological pairing of climate change with other controversial science education topics (like evolution and the age of the Earth) both destabilizes notions of scientific consensus and problematizes climate change education. Teachers who profess belief in climate change while teaching both sides of the controversy seemingly undermine the symbolic legitimacy of climate change consensus. However, this research suggests that by teaching climate change as a controversy, many science teachers in Oklahoma are able to neutralize the controversy about teaching climate change; as well as negotiate complex political and religious terrains.

Excavations in the problematization of climate change education reveals socio-historical forms of constraint located and performed across discourses of science teaching and learning. This research contributes to a growing a body of interdisciplinary work

interested in the co-production of science knowledge and the power relations which sustain controversies about the scientific consensus behind global climate change. This study re-conceptualizes the rhetoric of climate change denial within a critical realist perspective and situates the impact of these translations in the daily lives and networks of secondary science teachers. A critical ecology of consensus can be applied to other climate change discourses and inform strategies for future research in the boundaries between science and public policy.

Theoretical and Practical Implications

As a compilation, the dissertation research studies advance an interdisciplinary understanding of the impact and influence of climate change denial as a social problem. Lessons apply to the fields of environmental communication, science education policy making, and cultural and political geography; each interested in the network pathways for the diffusion of climate change knowledge in the face of powerful political and cultural forces. A blended ANT and CPE theorectical framework guided the research question: *How does manufactured scientific controversy about climate change present specific challenges to science education in Oklahoma?* The triangulation of findings reveals two important implications to future research in climate change denial as a social problem.

First, investigations of the circulation of both skeptical media and teach the controversy frames suggests that, in additional to anti-science rhetoric, appeals to independent decision-making over scientific consensus are a powerful brokering devices for mobilizing skeptical discourse coalitions. Contestations over scientific consensus easily translate into contestations about what should be taught in the science classroom. Challenges to science educators include the need to assert scientific authority while also

addressing the tentative nature of scientific knowledge. In practice, Oklahoma science teachers mobilize skeptical pedagogies and appeals to independent decision-making as a method to neutralize classroom controversies and mobilize scientific literacy.

The practical implications of these findings raise questions about the role of research scientists engaged in both formal education and public awareness campaigns. Academic professional demands, and possibly even fear of political retribution, restrict scientist engagements in both educational spheres. Even with increasing scientist involvement, successful responses to widespread climate change denial rhetoric will need to move beyond tropes of scientific consensus to strategies of engagement which develop trust in science and a sense of agency about climate change across diverse social groups. Applied to the context of science education, tapping into alternative cultural narratives about environmental change will be crucial to negotiating the symbolic legitimacy of both climate change science and climate change education efforts. Insights from CPE suggest that scientific literacy efforts should also aim to increase student understanding of the nature of science as tentative and socially constructed.

Next, a complex web of historical, cultural, and political relationships drives the coupling of climate change and evolution by anti-science education discourse coalitions. The symbolic power of this coupling generates a unique form of manufactured controversy which creates a misleading rhetoric-reality gap between perceived contestations and actual engagements in climate change education. While science teachers report experiencing less pushback about climate change, the influence of anti-evolution contestations are materially observable in both science education policy making and the daily lives of teachers in Oklahoma. In short, we cannot ignore the cultural logic

or structural components of climate skepticism within the "social landscape of the debate" (Hoffman, 2011, p. 20).

There are profound theoretical and methodological implications to conceptualizing the logic of non-problematicity about climate change as a broad spectrum of cultural narratives and broker issues rather than simply symptomatic of a logic schism driven by political polarization and manufactured controversy (Shackley & Wynne, 1996). For social scientists, this reconceptualization of the problem with climate change denial as one of translation and negotiation is increasingly important (Nisbet & Scheufele, 2009). An ANT research framework suggests new pathways for researching the echo chamber effects of climate change denial campaigns (McCright & Dunlap, 2011). For science education researchers specifically, conceptualizing the problem as a cultural issue, rather than a knowledge-deficit problem, suggests the need for more research in the teacher pedagogy in addition to content knowledge.

Future Research

This dissertation project and resulting study findings suggest pathways for future research in the construction and translation of climate change knowledge. First, more research is needed in the dissemination of skeptical media designed and targeted for educational contexts. Future research may focus on other identified media (e.g. curriculum/lesson plans, handbooks for punter parents, climate denial apps, and on-line videos) which aim to manufacture controversy about climate change, as well as climate change education. Additionally, research assessing the influence of exposure to skeptical media on teacher, parent, and student attitudes would be valuable to advancing

a better understanding about the actual influence of widespread climate change campaigns.

Next, future research should continue to investigate the complex web of socio-cultural relations which drive the mobilization of climate change denial attitudes. Beyond challenges to scientific consensus, the findings suggest climate change denial is also rooted in the anti-regulatory discourse of ecological modernization, democratic appeals to free speech, conservative political platforms, and even socio-religious values. Within Oklahoma, future cultural landscape research could explore how perceptions about drought influence individual worldviews and general understanding about the causes and impacts of climate change. Other case studies in the negotiation and implementation of NGSS (and other climate change education reform policies) in states with prominent anti-science education campaigns would also provide valuable comparative research.

Finally, future research is needed to assess the influence of manufactured scientific controversy within the contexts of climate change education. More research in the linking of climate change to anti-evolution campaigns should begin to tease out the complex layering of religious values, conservative politics, and anti-science attitudes. Deeper analysis of teacher content knowledge will advance a better understanding of teacher skepticism about climate change consensus. Additionally, research might explore the influence of Oklahoma's prominent industries, fossil fuels and agriculture, on the public attitudes about climate change and brokering of the boundaries between science and policy-making.

In conclusion, this research contributes to a very important and contemporary area of human-environment research. The impacts of current and impending global environmental change will affect all humans. In the evolution of environmental movement, this research points to a new paradigm focused on meeting the need for improved communication and coordination between science and society. While efforts to advance human resiliency and adaptation will be interdisciplinary and diverse, integration of climate change education in secondary science education can play an important role in increasing public understanding about the consequences of and solutions to these changes. However, science education alone is not enough to mobilize public concern and action in the face of rapid change. Research in environmental communication will be vital to understanding how the social construction of climate change problems and solutions informs or inhibits our collective action.

REFERENCES

Al Sonja Schmidt on Fox Business (2008). Retrieved from https://www.youtube.com/watch?v=WdqQH9JWfrE

Alcadipani, R., & Hassard, J. (2010). Actor-Network Theory, organizations and critique: towards a politics of organizing. *Organization, 17*(4), 419-435. doi: 10.1177/1350508410364441

Antilla, L. (2005). Climate of scepticism: US newspaper coverage of the science of climate change. *Global Environmental Change, 15*(4), 338-352. doi: 10.1016/j.gloenvcha.2005.08.003

Arslan, H. O., Cigdemoglu, C., & Moseley, C. (2012). A three-tier diagnostic test to assess pre-service teachers' misconceptions about global warming, greenhouse effect, ozone layer depletion, and acid rain. *International Journal of Science Education, 34*(11), 1667-1686. doi: 10.1080/09500693.2012.680618

Backstrand, K., & Lovbrand, E. (2007). Climate governance beyond 2012: Competing discourses of green governmentality, ecological modernization and civic environmentalism. In M. Pettenger (Ed.), *The Social Construction of Climate Change*. (pp. 123-147). Placed published: location.

Baxter, J., & Eyles, J. (1997). Evaluating qualitative research in social geography: establishing 'rigour'in interview analysis. *Transactions of the Institute of British Geographers, 22*(4), 505-525.

Bedford, D. (2010). Agnotology as a teaching tool: Learning climate science by studying misinformation. *Journal of Geography, 109*(4), 159-165. doi: 10.1080/00221341.2010.498121

Bedford, D., & Cook, J. (2013). Agnotology, scientific consensus, and the teaching and learning of climate change: A response to Legates, Soon and Briggs. *Science & Education, 22*(8), 2019-2030. doi: 10.1007/s11191-013-9608-3

Bedford, R.D. & Snow, D.A. (2000). Framing process and social movements: An overview and assessment. *Annual Review of Sociology 26*, 611-639. doi: 0.1146/annurev.soc.26.1.611

Bell, F. (2010). *Network theories for technology-enabled learning and social change: Connectivism and actor network theory.* Paper presented at the Networked Learning Conference 2010: Seventh International Conference on Networked Learning.

Besel, R. D. (2011). Opening the "black box" of climate change science: Actor-Network Theory and rhetorical practice in scientific controversies. *Southern Communication Journal, 76*(2), 120-136. doi: 10.1080/10417941003642403

Bishop, A. P., Van House, N. A., & Buttenfield, B. P. (2003). *Digital library use: Social practice in design and evaluation*: MIT Press.

Blaikie, P. (2012). Should some political ecology be useful? The inaugural lecture for the Cultural and Political Ecology Specialty Group, annual meeting of the

Association of American Geographers, April 2010. *Geoforum, 43*(2), 231-239. doi: http://dx.doi.org/10.1016/j.geoforum.2011.08.010

Blaikie, P., & Brookfield, H. (1987). *Land degradation and society*. Methuen:Routledge.

Bozdogan, A.E. (2011). The effects of instruction with visual materials on the development of preservice elementary teachers' knowledge and attitude towards global warming. *Turkish Online Journal of Educational Technology, 10*(2), 218-233.

Brown, S. D., & Capdevila, R. (1999). Perpetuum mobile: substance, force and the sociology of translation. In J. Law & J. Hassard (Eds.), *Actor network theory and after* (pp. 26-50). Oxford: Blackwell.

Buizer,M., Arts, B. & Kok, K. (2011). Governance, scale, and the environment: The importance of recognizing knowledge claims in transdisciplinary arenas. *Ecology and Society, 16*(1), 21. Retrieved from http://www.ecologyandsociety.org/vol16/iss1/art21/

Buttel, F. H. (2000). Ecological modernization as social theory. *Geoforum, 31*(1), 57-65. doi: 10.1016/S0016-7185(99)00044-5

Buttel, F. (1996). Environmental and resource sociology: Theoretical issues and opportunities for synthesis. *Rural Sociology, 61*(1), 56-75. Retrieved from http://core.ecu.edu/soci/juskaa/buttel.htm

Callon, M. (1986). *Some elements of a sociology of translation*: Cambridge, MA: The MIT Press.

Callon, M. (1995). Four models for the dynamics of science. *Handbook of Science and Technology Studies, Revised Edition.* (pp. 29-64). Thousand Oaks, CA: SAGE Publications, Inc.

Carolan, M. S. (2005). Realism without reductionism: Toward an ecologically embedded sociology. *Human Ecology Review, 12*(1), 1-20.

Ceccarelli, L. (2011). *Shaping science with rhetoric*. Chicago: University of Chicago Press.

Ceccarelli, L. (2011). Manufactured scientific controversy: Science, rhetoric, and public debate. *Rhetoric & Public Affairs, 14*(2), 195-228. Retrieved from http://search.proquest.com/docview/872028786?accountid=4117

Center for Research on Environmental Decisions. (2009). *The psychology of climate change communication: A guide for scientists, journalists, educators, political aides, and the interested public*. New York:CRED.

Clarke, A. (2005). *Situational analysis: Grounded theory after the postmodern turn*. Berkley, CA: Sage.

Cook, J. & Lewandowsky, S. (2011). *The debunking handbook.* St. Lucia, Australia: University of Queensland. Retrieved from http://sks.to/debunk

Cook, J. (2009). *A scientific guide to the Skeptics Handbook: The evidence that humans are causing climate change.* Retrieved from http://www.skepticalscience.com/docs/ScientificGuideSkepticsA5.pdf

Cooper, C. B. (2011). Media literacy as a key strategy toward improving public acceptance of climate change science. *Bioscience, 61*(3), 231-237. doi:10.1525/bio.2011.61.3.8

Corbett, J. B. (2006). *Communicating nature: How we create and understand environmental messages*. Washington: Island Press.

Cox, J. R. (2010). Beyond frames: Recovering the strategic in climate communication. *Environmental Communication, 4*(1), 122-133. doi: 10.1080/17524030903516555

Cox, R. (2010). *Environmental communication and the public sphere* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Creswell, J. W., & Plano Clark, V. L. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA.: Sage Publications.

Deacon, R. (2006). Michel Foucault on education: a preliminary theoretical overview. *South African Journal of Education, 26*(2), 177-187.

Demeritt, D. (2006). Science studies, climate change and the prospects for constructivist critique. *Economy and Society, 35*(3), 453-479. doi: 10.1080/03085140600845024

Doyle, J. (2011). *Mediating climate change*. Great Britian: Ashgate.

Dunlap, R.E. & McCright, A.M. (2011). Organized climate change denial. In J.S. Dryzek, R.B. Norgaard, & D. Schlosberg (Eds.), *The Oxford handbook of climate change and society* (pp.145-160). Oxford: Oxford University Press.

Dunlap, R.E. & McCright, A.M. (2010). Climate change denial: Sources, actors, and strategies . In C. Lever-Tracy (Ed.), *Routledge handbook of climate change and society* (pp. 240-259). Abingdon, UK: Routledge.

Dunlap, R.E. & McCright, A.M (2008). A widening gap: Republican and democratic views on climate change. *Environment, 50* (5), 26-35. doi: 10.3200/envt.50.5.26-35.

Fenwick, T. (2010). (un)Doing standards in education with actor-network theory. *Journal of Education Policy, 25*(2), 117-133. doi: 10.1080/02680930903314277

Fenwick, T., & Edwards, R. (2010). *Actor-network theory in education*. Florence, KY: Routledge.

Forsyth, T. (2003). *Critical political ecology : the politics of environmental science*. New York: Routledge.

Fox, S. (2000). Communities of practice, Foucault And Actor-Network Theory. *Journal of Management Studies*, *37*(6), 853-868. doi: 10.1111/1467-6486.00207

Fretwell, H. (2007). The *sky's not falling! Why it's OK to chill about global warming.* New York, NY: Kid Ahead Books.

Fretwell, H. (2009). Environmental education: The science of fear. *PERC Reports*. Retrieved from http://perc.org/articles/environmental-education-science-fear

Freudenburg, W. R. *Social Constructions and Social Constrictions: Toward Analyzing the Social Construction of 'the Naturalized' as Well as 'the Natural'.* . London: SAGE Publications Ltd.

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory*. Chicago: Aldine Publishing.

Grandy, R.E. (1998). Constructivism and objectivity: Disentangling metaphysics from pedagogy. In M.R. Matthews (Ed.), *Constructivism in science education: A philosophical examination* (pp. 113-123). Boston: Kluwer Academic Publishers.

Grimm, J. (2009). "Teach the Controversy" the relationship between sources and frames in reporting the intelligent design debate. *Science Communication, 31*(2), 167-186. doi: 10.1177/1075547009335346

Gross, P., Buttry, D., Goodenough, U., Koertge, N., Lerner, L., Schwartz, M., & Schwartz, R. (2013). Final Evaluation of the Next Generation Science Standards. Retrieved from http://www.edexcellence.net/publications/final-evaluation-of-NGSS.html

Guston, D. H. (2001). Boundary organizations in environmental policy and science: an introduction. *Science, technology, and human values*, 399-408.

Hajer, M. A. (1995). *The politics of environmental discourse: ecological modernization and the policy process*. Oxford: Clarendon Press

Harper, D. (2013). State Superintendent Barresi grilled by audience members at Common Core forum, *Tulsa World*. Retrieved from http://test.serve.tulsaworld.com/site/printerfriendlystory.aspx?articleid=20130811_11_A15_CUTLIN684194

Harrington, J. (2008). Misconceptions: Barriers to Improved Climate Literacy. *Physical Geography*, *29*(6), 575-584. doi: 10.2747/0272-3646.29.6.575

Hendrickx, M. (2008). *We're not scared anymore Mr. Gore. A climate change story for little skeptics.* Little Skeptics Press: ISBN 978-0-9805943-1-7

Hoffman, A.J. (2011). Talking past each other? Cultural framing of skeptical and convinced logics in the climate change debate. *Organization & Environment, 24* (1), 3-33.

Hollander, J. A., & Einwohner, R. L. (2004). Conceptualizing resistance. *Sociological Forum, 19*(4), 533-554. doi: 10.1007/s11206-004-0694-5

Hulme, M. (2010). *Why We Disagree About Climate Change*. Cambridge: Cambridge University Press.

Inman, M. (2012). Schools of thought. *Nature Climate Change, 2*(5), 303-305. doi: 10.1038/nclimate1494

Jacques, P.J., Dunlap, R.E., & Freeman, M. (2011). The organization of denial: Conservative think tanks and environmental skepticism. *Environmental Politics, 17*(3), 349-385. doi:10.1080/09644010802055576.

Jasanoff, S. (1995). *Handbook of science and technology studies*. Thousand Oaks, CA: Sage.

Johnson, R. & Holzer, M. (2011). Climate change education in K-12: Teacher preparation, understanding, needs and concerns. Executive Summary: NESTA. Retrieved from http://www7.nationalacademies.org/bose/1CCEW2_Roberta_Johnson.pdf

Kahan, D., Jenkins-Smith, H. & Braman, D. (2011). Cultural cognition of scienitific consensus. *Journal of Risk Research, 14(*2), 147-174.

Lambert, J.L., Lindgren, J., & Bleicher, R. (2012). Assessing elementary science methods students' understanding about global climate change. *International Journal of Science Education, 34*(8), 1167-1187.

Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. New York: Oxford University Press.

Latour, B. (1997). The trouble with actor-network theory. *Soziale Welt, 47,* 369-381.

Law, J., & Hassard, J. (1999). *Actor network theory and after*. Oxford: Blackwell.

Lee, C. R., Levine, T. R., & Cambra, R. (1997). Resisting compliance in the multicultural classroom. *Communication Education, 46*(1), 29-43. doi: 10.1080/03634529709379071

Lerner, L. S., Goodenough, U., Lynch, J., Schwartz, M., & Schwartz, R. (2012). The state of State science standards, 2012: Thomas B. Fordham Institute. Retrieved from http://www.edexcellence.net/publications/the-state-of-state-science-standards-2012.html

Masys, A. J. (2009). *'World Views' on impacts and responses to climate change: An actor network theory perspective.* Paper presented at the IOP Conference Series: Earth and Environmental Science.

Matkins, J.J. & Bell, R.L. (2007). Awakening the scientist inside: Global climate change and the nature of science in an elementary science methods course. *Journal of Science Teacher Education, 18*(2), 137-163. doi: 10.1007/s10972-006-9033-4

McBean, G. A., & Hengeveld, H. G. (2000). Communicating the science of climate change: A mutual challenge for scientists and educators. *Canadian Journal of Environmental Education (CJEE), 5*(1), 9-25.

McCaffrey, M.S., & Buhr, S.M. (2008). Clarifying climate confusion: Addressing systemic holes, cognitive gaps, and misconceptions through climate literacy. *Physical Geography, 29*(6), 512-528.

McCright, A.M., & Dunlap, R.E. (2010). Anti-reflexivity: The American conservative movement's success in undermining climate science and policy. *Theory, Culture, & Society, 27*(2-3), 100-133. doi: 10.1177/0263276409356001

McCright, A.M., & Dunlap, R.E. (2003). Defeating Kyoto: The conservative movement's impact on US climate change policy. *Social Problems, 50*(3), 348-373. doi: 10.1525/sp.2003.50.3.348

McCright, A.M., & Dunlap, R.E. (2000). Challenging global warming as a social problem: An analysis of the conservative movement's counter-claims. *Social Problems 47*(4), 499-522. doi: 10.2307/3097132.

McGinnis, J. R., Breslyn, W., Hestness, E., & McDonald, C. (2013*). Climate change education teacher professional development in MADE CLEAR: A research brief.* University of Maryland: Climate Change Learning Sciences Network.

Meehan, C. R. (2012). *Global Warming in Schools: An Inquiry about the Competing Conceptions of High School Social Studies and Science Curricula and Teachers.* University of Wisconsin-Madison. Retrieved from http://depot.library.wisc.edu/repository/fedora/1711.dl:OQUU3BY4BGAVO8B/datastreams/REF/content

Monroe, M. C., Oxarart, A., & Plate, R. R. (2013). A role for environmental education in climate change for secondary science educators. *Applied Environmental Education & Communication, 12*(1), 4-18. doi: 10.1080/1533015X.2013.795827

Moser, S. C. (2010). History, challenges, process and future directions. *Wiley Interdisciplinary Reviews – Climate Change* 1(1), 31-53. Retrieved from http://www.susannemoser.com/documents/Moser_WIRE_2010.pdf

Mulcahy, D. (2007). Managing spaces:(re) working relations of strategy and spatiality in vocational education and training. *Studies in Continuing Education, 29*(2), 143-162. doi: 10.1080/01580370701403266

National Center for Science Education (NCSE) (2012). Climate change denial is affecting education. Retrieved from http://ncse.com/climate/denial/denial-affecting-education

National Center for Science Education. (2013). NGSS Adoption Update. Retrieved Feburary 24, 2014, from http://ncse.com/news/2013/07/ngss-adoption-update-0014887

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, D.C.: The National Academies Press.

Nicholls, N. (1999). Cognitive Illusions, Heuristics, and Climate Prediction. *Bulletin of the American Meteorological Society, 80*(7), 1385-1397. doi: 10.1175/1520-0477(1999)080<1385:CIHACP>2.0.CO;2

Nisbet, M.C. (2009). Communicating climate change: Why frames matter for public engagement. *Environment: Science and Policy for Sustainable Development, 51*(2), 12-23. doi: 10.3200/envt.51.2.12-23

Nisbet, M. C., & Mooney, C. (2007). Framing Science. *Science, 316*(5821), 56. doi: 10.2307/20035941

Nisbet, M.C. & Scheuffele, D.A. (2009). What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany, 96*(10), 1767-1778. Retrieved from http://www.jstor.org/stable/27733515 .

Norton, T., Sias, P., & Brown, S. Experiencing and managing uncertainty about climate change. *Journal of Applied Communication, 39*(3), 290-309. doi: 10.1080/00909882.2011.585397

Nova, J. (2009). *The skeptic's handbook*. Retrieved from http://ncse.com/climate/denial/denial-affecting-education

OETA (Writer). (August 10, 2012). School Funding Flap. Retrieved from http://www.oeta.onenet.net/video/category/oklahoma_news_report/its_your_government.html

Oreskes, N., & Conway, E. M. (2010). *Merchants of doubt: how a handful of scientists obscured the truth on issues from tobacco smoke to global warming*. USA: Bloomsbury Publishing.

Ortner, S. (1995). Resistance and the problem of ethnographic refusal. *Comparative studies in society and history, 37*(1), 173-193. doi: 10.1017/S0010417500019587

Peterson, T. C., Connolley, W. M., & Fleck, J. (2008). The myth of the 1970s global cooling scientific consensus. *Bulletin of the American Meteorological Society, 89*(9), 1325-1337. doi: 10.1175/2008BAMS2370.1

Petrinjak, L. (2011). Elementary teachers getting less time for science. *NSTA Reports, 17*.

Proctor, R., & Schiebinger, L. L. (2008). *Agnotology: The making and unmaking of ignorance.* Standford: Stanford University Press.

Pruneau, D., Gravel H., Bourque W., & Langis J. (2003). Experimentation with a socio-constructivist process for climate change education. *Environmental Education Research, 9*(4), 429-446. Retrieved from http://www8.umoncton.ca/littoral-vie/articles/Jeunes%20visionnaires%20anglais2003.pdf.

Rahmstorf, S. (2004). The climate skeptics. In Munich Re (Ed.), *Weather catastrophes and climate change: Is there still hope for us?* (pp. 76-83). Retrieved from http://www.pik-potsdam.de/~stefan/Publications/Other/rahmstorf_climate_sceptics_2004.pdf

Reardon, S. (2011). Climate change sparks battles in classroom. *Science, 333*(6043), 688-689. doi: 10.1126/science.333.6043.688

Robbins, P. (2012). *Political ecology: A critical introduction* (2nd ed.). Singapore: Wiley-Blackwell.

Rocheleau, D. (2008). Political ecology in the key of policy: From chains of explanation to webs of relation. *Geoforum, 39*(2), 716-727. doi: 10.1016/j.geoforum.2007.02.005

Rocheleau, D., & Roth, R. (2007). Rooted networks, relational webs and powers of connection: Rethinking human and political ecologies. *Geoforum, 38*(3), 433-437. doi: 10.1016/j.geoforum.2006.10.003

Saldanha, A. (2002). Review essay:Actor-network theory and critical sociology. *Critical Sociology, 29*(3), 419-432. doi: 10.1163/156916303322591130

Schmidt, A.S. (2008). *Deb and seby's real deal on global warming*. Bloomington, ID: Authorhouse.

Schneider, S. H. (1993). Degrees of certainty. *Research and Exploration, 9*(2), 173-181.

Scott, E. C. (2013). What's wrong with the "teach the controversy" slogan? *McGll Journal of Education*, *42*(2), 307-316. doi: 10.1016/S0169-5347(03)00218-0

Scott, E. C., & Branch, G. (2003). Evolution: what's wrong with 'teaching the controversy'. *Trends in Ecology & Evolution, 18*(10), 499-502. doi: 10.1016/S0169-5347(03)00218-0

Scott, J. (1986). Everyday forms of peasant resistance. *The Journal of Peasant Studies, 13*(2), 5-35. doi: 10.1080/03066158608438289

Shackley, S., & Wynne, B. (1996). Representing uncertainty in global climate change science and policy: Boundary-ordering devices and authority. *Science, Technology & Human Values, 21*(3), 275-302. doi: 10.1177/016224399602100302

Sharma, A. (2012). Global climate change: What has science education got to do with it? *Science & Education, 21*(1), 33-53. doi: 10.1007/s11191-011-9372-1

Sheehan, R. (2011). Actor-network theory as a reflexive tool:(inter) personal relations and relationships in the research process. *Area, 43*(3), 336-342. doi: 10.1111/j.1475-4762.2011.01000.x

Sobel, D. (1996). *Beyond ecophobia: Reclaiming the heart in nature education*. Great Barrington, MA: Orion Society

Summers, M., Kruger, C., & Childs, A. (2001). Understanding the science of environmental issues: development of a subject knowledge guide for primary teacher education. *International Journal of Science Education, 23*(1), 33-53. doi: 10.1080/09500690116990

Taber, F., & Taylor, N. (2009). Climate of concern-a search for effective strategies for teaching children about global warming. *International Journal of Environmental & Science Education, 4*(2), 97-116.

Vogel, C., Moser, S. C., Kasperson, R. E., & Dabelko, G. D. (2007). Linking vulnerability, adaptation, and resilience science to practice: Pathways, players, and partnerships. *Global Environmental Change, 17*(3), 349-364. doi: 10.1016/j.gloenvcha.2007.05.002

Warriner, K., Goyder, J., Gjertsen, H., Hohner, P., & McSpurren, K. (1996). Charities, no; Lotteries, no; Cash, yes. Main Effects and interactions in a Canadian Incentives Program. *Public Opinion Quarterly, 60*(4), 542-562. doi: 10.1086/297772

Washington, H. (2013). *Climate change denial: Heads in the sand*. USA: Taylor & Francis.

Watts, M. (2000). Political ecology. In T. J. Barnes (Ed.), *A companion to economic geography* (pp. 257-274). Padstow: Blackwell.

Weart, S. (2011). Global warming: How skepticism became denial. *Bulletin of the Atomic Scientists, 67*(1), 41-50. doi: 10.1177/0096340210392966

We are not scared anymore Al Gore (2008). Retrieved from http://www.youtube.com/watch?v=DW9_RkHlz2Q

Wise, S. B. (2010). Climate change in the classroom: Patterns, motivations, and barriers to instruction among Colorado science teachers. *Journal of Geoscience Education, 58*(5), 297-309. doi: 10.5408/1.3559695

Yanow, D. (2000). *Conducting interpretive policy analysis (Vol. 47).* Thousand Oaks, CA: Sage

APPENDIX A

IRB Approval Letters

Oklahoma State University Institutional Review Board

Date:	Tuesday, March 12, 2013
IRB Application No	GU136
Proposal Title:	Climate Change Actor-Networks in Oklahoma Secondary Science Education
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 3/11/2014

Principal Investigator(s):

Nicole Marie Colston	Toni Ivey	Julie Thomas
245 Willard	226 Willard	245 Willard
Stillwater, OK 74078	Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

X The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI, advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Cordell North (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

Appendix A- Key Informant Interview Schedule

Key informant interview protocol (60 minutes total)

Welcome Message

Thank you for agreeing to do this interview. As you know, my name is Nicole Colston and I am interested in climate change education practices in Oklahoma. My research is focused on the experiences of science teachers in Earth Science, Environmental Science, and Biology classrooms.

As ___(insert affiliation/ role)___, you have been identified as a stakeholder in (science/climate change) education in Oklahoma. Thank you for agreeing to share your experiences and perspective on science education practices in Oklahoma.

The purpose of this interview today is to learn more about the actors, networks, and practices influencing classroom implementation of climate science education. I will ask questions to learn more about:

1) trends in science education in Oklahoma,
2) current climate change programming, curriculum, and stakeholder networks,
3) challenges or resistance to climate change education implementation in science classrooms.

This interview should last about 1 hour.

**If you have not already, will you please read and sign the consent form? Do you have any questions?*

Ground rules

Everything you tell me will be confidential. To protect your privacy, I will not connect your name with anything that you say.

At any time during our conversation, please feel free to let me know if you have any questions or if you would rather not answer any specific question. You can also stop the interview at any time for any reason.

**Is it OK if I audiotape this interview today? [Turn on recording equipment.]*

(start at _____)

Appendix B- Recruitment Message

Dear _____,

My name is Nicole Colston and I am a PhD candidate in Environment Science at Oklahoma State University. I am contacting you as a potential key informant in research on the state of climate change education in Earth Science, Environmental Science, and Biology classrooms in Oklahoma. I would like to interview because of your ties to (insert specific science education and/or climate change network) in Oklahoma.

The general purpose of this interview would be to gather your perceptions of trends in Oklahoma Earth Science education, including the implementation of climate change education. The information I collect will be used to identify the actors, networks, and practices supporting and opposing climate change education in Oklahoma. My specific goal is to use key informants, like you, to inform the development of a state-wide survey for middle school and high school science teachers.

The interview should take about an hour and I would gladly meet you at a time and location that is convenient to you. I would like to audio record the interview with your permission. All the information I collect will be kept in confidence and all identifiable material will be removed from the final reports and archived data.

Please see the attached "Informed Consent to Participate in Research" form. Please read this form in its entirety and respond to this email by stating that you either (1) consent to the research study and will like to schedule a meeting or (2) do NOT consent to the research study and will NOT participate in an interview.

Please contact me if you have any questions about this research. The best to contact me is by email at Nicole.colston@okstate.edu.

Sincerely,

Nicole Colston

245 Willard Hall, OSU
Stillwater, OK 74078
Nicole.colston@okstate.edu
(405) 744-8018 (office)
(828) 773-7662 (cell)

Appendix C- Informed Consent to Participate in Research

Informed Consent to Participate in Research

OKLAHOMA STATE UNIVERSITY

Title: Climate Change Education Actor-Networks in Oklahoma Secondary School Science

Investigator: Nicole M. Colston, PhD. Candidate in Environmental Science, Oklahoma State University, College of Education-STCL

Purpose: The purpose of the research study is to identify trends in science education in Oklahoma, including the practice of climate change education and possible controversy surrounding its implementation. Data collected from key informant interviewees (like you) will be used to identify the actors, networks, and practices supporting and opposing climate change education in Oklahoma. I expect these results will also inform the future development of a state-wide survey for middle school and high school science teachers.

What to Expect: An interview will take about an hour and I would gladly meet you at a time and location that is convenient to you. I would like to audio record the interview with your permission. I will ask questions about,

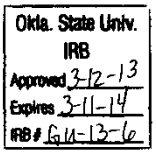
1) trends in earth science and climate change education in Oklahoma,
2) current climate change programming, curriculum, stakeholder, and networks,
3) challenges or resistance to climate change education implementation in science classrooms.

Risks: There are no risks associated with this project which are expected to be greater than those ordznarily encountered in daily life.

Benefits: I expect this research to provide needed information about science and climate change education practices in Oklahoma. I hope this research will inform the future development of climate change education practices and policies in Oklahoma. If you are interested, I will send you a copy of the results when the study is complete.

Your Rights: Your participation in this research is voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time, without penalty.

Confidentiality: All information about you will be kept confidential and will not be released. Specifically, participant confidentiality will be assured and maintained in final reporting by utilizing codes or pseudonyms. Interviewer data will be stored in a secure office location in a locked filing cabinet for 5 years.



Your personal information and consent form will be stored separately from electronic or hard copies of interview transcripts and researcher notes. The researcher data will be available only to project researchers.

Contacts: You may contact Nicole M. Colston at the following addresses and phone numbers, should you desire to discuss your participation in the study and/or request information about the results of the study: Nicole Colston, 245 Willard Hall, College of Education-STCL, Oklahoma State University, Stillwater, OK 74078, 405-744-8018 (campus office) or 828-773-7662 (cell).

If you have questions about your rights as a research volunteer, you may contact Dr. Shelia Kennison, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu

CONSENT DOCUMENTATION:

I have been fully informed about the procedures listed here. I am aware of what I will be asked to do. Below I have initialed the items to which I consent to participate:

_____ I agree to an interview.

_____I agree to be audio recorded during the interview.

_____,I would like a copy of the executive report of final results of this study. My preferred contact information is: _____

I have read and fully understand this consent form. I sign it freely and voluntarily.

_____
Print Name

_____ Date:_____
Signature

KEEP THIS COPY FOR YOUR RECORDS

Informed Consent to Participate in Research

Title: Climate Change Education Actor-Networks in Oklahoma Secondary School Science

Investigator: Nicole M. Colston, PhD. Candidate in Environmental Science, Oklahoma State University, College of Education-STCL

Purpose: The purpose of the research study is to identify trends in science education in Oklahoma, including the practice of climate change education and possible controversy surrounding its implementation. Data collected from key informant interviewees (like you) will be used to identify the actors, networks, and practices supporting and opposing climate change education in Oklahoma. I expect these results will also inform the future development of a state-wide survey for middle school and high school science teachers.

CONSENT DOCUMENTATION:

I have been fully informed about the procedures listed here. I am aware of what I will be asked to do. Below I have initialed the items to which I consent to participate:

_____ _I agree to an interview.

_____I agree to be audio recorded during the interview.

_____I would like a copy of the executive report of final results of this study. My preferred contact information is: _____

I have read and fully understand this consent form. I sign it freely and voluntarily.

_____
Print Name

_____ Date:_____
Signature

PLEASE RETURN THIS PAGE TO THE RESEARCHER

Oklahoma State University Institutional Review Board

Date:	Thursday, May 16, 2013
IRB Application No	ED1385
Proposal Title:	Tracing the Flow: Climate Change Education Actor-Networks in Oklahoma Secondary School Science
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 5/15/2014

Principal Investigator(s):

Nicole Marie Colston	Toni Ivey	Julie Thomas
245 Willard	226 Willard	245 Willard
Stillwater, OK 74078	Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

X The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI, advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Cordell North (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

Email Recruitment Script

Greetings Middle School and High School Science Teachers!

My name is Nicole Colston and I am a PhD student in Environmental Science at Oklahoma State University. I hope to solicit the participation of **5th-12th grade science teachers in Oklahoma** for my **on-line survey**. This study is part of my dissertation research about science teaching and learning in Oklahoma, titled "Tracing the Flow: Climate Change Education Actor-Networks in Oklahoma Secondary School Science".

The questionnaire will take approximately 30 minutes to complete. You will be asked questions about your personal experiences as a science teacher in Oklahoma, including your access to resources, curriculum choices, and attitudes about science education practices. I am particularly interested in your attitudes and opinions about climate change education in school science.

Your response will be very helpful for the success of this study. Information gathered from teachers across the state could be used to support efforts to improve the experiences of science teachers and learners in Oklahoma schools.

At the end of the survey, the researcher will request your permission to contact you about future research opportunities, including:

1) *a potential* follow-up interview by phone with the researcher
2) *a potential* focus group with other science teachers.

After you complete the survey, you will have the opportunity to enter to win one of five $20 VISA gift cards. This information will be collected via an independent link and will not be connected to your survey responses. However, if you wish to remain anonymous, simply decline to enter your contact information at the end of the survey and decline to participate in the prize drawing.

All respondents personal contact information, questionnaire responses, and name will remain confidential. The data reports will not identify the respondents or release personal information. Research records will be securely stored and only the principal investigator will have access to the records.

For more details, please see the attached Informed Consent and Project Information Sheet.

To participate in this study, please click on the link below:

https://okstatecoe.qualtrics.com/SE/?SID=SV_57iArzW7nMtJqgB

NOTE: This link takes them directly to the Informed Consent Form.

Updated: November, 2012

Informed Consent to Participate
OKLAHOMA STATE UNIVERSITY

(Please read the following and indicate your voluntary participation below).

INVESTIGATOR & PROJECT TITLE: My name is Nicole Colston and I am a PhD student in Environmental Science at Oklahoma State University. I hope to solicit your participation in my on-line survey as part of my dissertation research about science teaching and learning in Oklahoma, titled "Tracing the Flow: Climate Change Education Actor-Networks in Oklahoma Secondary School Science".

THE PURPOSE: The purpose of this research is to identify trends in science education in Oklahoma, including the practice of climate change education and possible controversy surrounding its implementation. Data collected will be used to identify key actors, science education networks, and practices influencing the treatment of climate change education in science classrooms.

WHAT TO EXPECT: The questionnaire will take approximately 30 minutes to complete. You will be asked questions about your personal experiences as a science teacher in Oklahoma, including your access to resources, curriculum choices, and attitudes about science education practices. I am particularly interested in your attitudes and opinions about climate change education in school science.
Your response will be very helpful for the success of this study. Information gathered from teachers across the state could be used to support efforts to improve the experiences of science teachers and learners in Oklahoma schools.

CONFIDENTIALITY: Your responses will be collected by a secure survey program, called Qualtrics, provided by Oklahoma State University. Your participation in this study is voluntary. There is no penalty for refusing to participate and you are free to withdraw your consent and participation at any time during the questionnaire.

At the end of the survey, the researcher will request your permission to contact you about future research opportunities, including:

1) *a potential* follow-up interview by phone with the researcher
2) *a potential* focus group with other science teachers.

After the survey is complete, you can enter to *win one of five $20 VISA gift cards* by drawing. This information will be collected via an independent link and will not be connected to your survey responses.

All respondents personal contact information, questionnaire responses, and name will remain confidential. However, *if you wish to remain anonymous, simply decline to enter your contact information and decline to participate in the drawing.*

All information will remain confidential (or anonymous if you choose not to provide your contact information All information will remain confidential (or anonymous if you choose not to provide your contact information). No one will release information about your individual participation and the data reports will not include specific references to individual names, schools, or communities.

Updated: November, 2012

Research records will be securely stored and only the principal investigator will have access to the records. The complete survey will be stored on the principal investigators computer stored in 245 Willard Hall for five years.

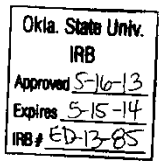
RISKS OF PARTICIPATION: There are no risks associated with this project greater than those encountered in ordinary life. If, however, you experience discomfort or stress in this project, you may end participation at any time.

BENEFITS: There are no direct benefits to you. However, you may gain from the indirect benefits of improved science education practices in Oklahoma.

CONTACTS: You may contact Nicole M. Colston at Nicole.colston@okstate.edu or at the following address and phone numbers, should you desire to discuss your participation in the study and/or request information about the benefits of the study: Nicole Colston, 245 Willard Hall, Stillwater, OK 74078, (405)744-8018 (campus office) or (828)773-7662 (cellphone).

You may contact my advisor Dr. Julie Thomas at Julie.Thomas@okstate.edu or at the following address and phone numbers, should you desire to discuss your participation in the study and/or request information about the benefits of the study: Dr. Julie Thomas, 245 Willard Hall, Stillwater, OK 74078, (405)744-7396 (campus office).

If you have questions about your rights as a research volunteer, you may contact: Dr. Shelia Kennison, IRB Chair, 219 Cordell North Stillwater, OK 74078, (405)744-3377 or irb@okstate.edu .



Updated: November, 2012

APPENDIX B

Key Informant Interview Protocol

Welcome Message

Thank you for agreeing to do this interview. As you know, I am interested in climate change education practices in Oklahoma. **My dissertation research is focused on** the experiences of science teachers in Earth Science, Environmental Science, and Biology classrooms.

As ___(insert affiliation/ role)___, you have been identified as a **stakeholder** in (science/climate change) education in Oklahoma. **Thank you** for agreeing to share your experiences and perspective on science education practices in Oklahoma.

The purpose of this interview today is to learn more about the actors, networks, and practices influencing classroom implementation of climate science education. I will ask **questions** to learn more about:

1) Trends in science education in Oklahoma,
2) Your opinions about climate change education practices,
3) Contestations climate change education implementation in science classrooms.

This interview should last about 1 hour.

**If you have not already, will you please read and sign the consent form? Do you have any questions?*

Ground rules

Everything you tell me will be **confidential.** To protect your privacy, I **will not connect your name with anything that you say**.

At any time during our conversation, please feel free to let me know if you have any questions or if you would rather not answer any specific question. **You can also stop the interview at any time** for any reason.

**Is it OK if I audiotape this interview today? [Turn on recording equipment.]*

Interview Questions

(start at _____)

I'd like to begin by asking some questions about you position. What is your title or position? Can you tell me a bit more about your involvement with science education in Oklahoma?
What are your responsibilities and roles?

How long have you been in your position?

Listen for both past and current experiences related to school science

Trends in science education in Oklahoma (start at _____)

From your experiences, how would you describe the state of science education in Oklahoma?
Where is science education now and where does it need to go?
What do we need to do to make this happen? Are there any efforts to change?
Encourage elaboration on activities related to Earth Science, Environmental Science, and Biology classrooms

How do you and others stay informed about trends and practices in science education?
Who are important actors in your science education network?

Ask about possible email list-servs, social media, websites, newsletters, school or district communication, and other possible communication channels.

How might these communication practices be the same or different than other groups, districts, or regions?

<u>Climate Change Education Practices</u> (start at _____)

What role do you see for climate change education and literacy efforts in school science education?
When you hear "climate change education", what does it mean to you?

Is climate change an important topic for Environmental Science, Earth Science, or Biology?

Do you have any other opinions about the importance of climate change education standards, curriculum guides, and textbook choices are used in educational settings?

Have you encountered any opportunities for climate change education in Oklahoma?
Encourage reflection on both formal and informal science education

Encourage participants to elaborate each climate change education example- who, where, how, why, when.

Ask for elaboration about specific climate change concepts, science classroom practice, and perspective on their success.

Climate Change Contestations (start at _____)

A recent national survey by the National Earth Science Teachers Association (2011) found that "~25% of teachers noted that students, parents, administrators, or community members have argued with them climate change is not happening, or is not the result of human activity". Have you (or anyone you know) ever been involved in a controversy about climate change education?
Please share more about the experience(s).

Why do you think they contested these ideas?

Was the controversy resolved? How might it have been avoided?

In your opinion, what types of climate change education are most effective or appropriate in Oklahoma?

Seek specific details about the reasons, actors, and practices.

Is there anything else that you would like to add about any of the topics that we've discussed or other areas that we didn't discuss but you think are important?

Referral Requests (start at _____)

Can you direct me to other stakeholders in secondary science education or climate change education who might inform this study?

Can you provide me with any information or archival data, perhaps textbooks, curriculum guides, school policies, or state policy briefs that might better inform this study?

Would you be willing to introduce me with science teachers involved in climate change education?

Would you be willing to help promote the distribution of a survey to Earth science, environmental science, and biology teachers?

(end at _____)

Handout for Interviewee

Trends in science education

From your experiences, how would you describe the state of science education in Oklahoma?

How do you and others stay informed about trends and practices in science education?

Climate change education

What role do you see for climate change education and literacy efforts in school science education?

Have you encountered any opportunities for climate change education in Oklahoma?

Climate change contestations

Have you (or anyone you know) ever been involved in a controversy about climate change education?

In your opinion, what types of climate change education are most appropriate for Oklahoma?

Closing

Is there anything else that you would like to add about any of the topics that we've discussed or other areas that we didn't discuss but you think are important?

Would you be willing to direct me to. . Other key informants for interviewee, OK science teachers for survey , Related textbooks, curriculum guides, etc., or School policies or state policy briefs

Ground rules

Everything you tell me will be confidential. To protect your privacy, I will not connect your name with anything that you say. At any time during our conversation, please feel free to let me know if you have any questions or if you would rather not answer any specific question. You can also stop the interview at any time for any reason.

APPENDIX C

Question items found on the on-line survey questionnaire

Q1: Which statement best describes your role in school science education?

a) I teach all or most subjects, including science.
b) I primarily teach science, but I teach other subjects too.
c) The only subject I teach is science.
d) We team teach, and I have primary responsibility for science.
e) I do not teach science.
f) Other, please specify: _____

Q2: What grade level(s) are the students you teach? (*Please select all that apply*)

a) 5th
b) 6th
c) 7th
d) 8th
e) 9th
f) 10th
g) 11th
h) 12th
i) None of these

Q3: What science content or courses do you teach? (*Please select all that apply*)

a) General Science
b) Biology
c) Biology (AP)
d) Chemistry
e) Chemistry (AP)
f) Earth & Space Science
g) Environmental Science
h) Environmental Science (AP)
i) Life Science
j) Physical Science
k) Physics
l) Physics (AP)

Q4: How would you best describe your school?

a) Public
b) Private
c) Charter
d) Parochial
e) Home
f) Other, please specify: _____

Q5: How would you best describe the location of your school?

a) Rural area
b) Urban area
c) Suburban area
d) Other, Please specify: _____

Q6: I primarily rely on the following sources for information about opportunities in science teaching and learning in Oklahoma: (*Please select your 3 primary sources of information*)

a) Other teachers
b) My principal
c) My district curriculum coordinator
d) OK State Board of Education
e) State teacher organizations (e.g., OSTA or NABT)
f) National teacher organizations (e.g., NSTA or NAAEE)
g) Scientific Organizations (e.g., NASA or AGU)
h) Informal education organizations (e.g., OERB or Project WET)
i) Educational vendors (e.g., FOSS or Carolina)
j) Social media platforms (e.g., Facebook or Pinterest)
k) Other, please specify: _____

Q7: My science teaching materials primarily come from:
(*Use your cursor to Click & Drag each item. Rank the resources, with #1 being most utilized and #10 being least utilized resource*)

_____ I create my own lesson plans
_____ Textbook
_____ District Curriculum Guide
_____ State recommended curricula
_____ Teacher Organizations
_____ Informal Education Organizations
_____ Scientific Organizations
_____ Trade books/ Picture books
_____ Educational Vendors
_____ Other, please specify:

Q8: Please choose the answers that best represent your current experiences in science instruction.

Science Lab Resources

	My school has the following available for science instruction. . .		I include these resources in science instruction. . .			
	Yes	No	Never	Rarely	Often	Very often
a) Demonstration lab stations						
b) Student lab stations						
c) Supplies or equipment for science labs						
d) Scientific measurement instruments						
e) Science kits						

Q9: Please choose the answers that best represent your current experiences in science instruction.

Computer and Technology Resources

	My school has the following available for science instruction. . .		I include these resources in science instruction. . .			
	Yes	No	Never	Rarely	Often	Very often
a) Student access to computers for in- class science instruction						
b) Teacher access to computers for science instruction						
c) On-line course management system (for assignments, grades, discussions, etc.)						
d) Science lab computer modules						
e) Graphing calculators						

Q10: Please choose the answers that best represent your current experiences in science instruction.

Other Resources

	My school has the following available for science instruction. . .		I include these resources in science instruction. . .			
	Yes	No	Never	Rarely	Often	Very often
a) Science magazines and trade books						
b) Outdoor classroom facilities						
c) Science kits/modules						
d) Audiovisual material for instruction						
e) Resources for field trips or field experiences						

Q11: Do any of your science textbooks introduce the concept of global climate change?

a) Yes
b) No

Q12: Do you currently teach about or discuss climate change in your science classroom?

a) Yes, formal lessons
b) Yes, informal lessons
c) No

Q13: In your opinion, in which school subject(s) should Oklahoma students learn about climate change? (*Please select all that apply*)

_____ Environmental Science
_____ Earth and space science
_____ Life science
_____ Physical science
_____ Social studies
_____ Geography
_____ Chemistry
_____ Economics
_____ Physics
_____ Language arts
_____ All of the Above

_____ None of the Above
_____ Other, please specify: _____

Q14: Please rank the following according to how important you feel these ideas are to developing student understanding of climate change:
(*Use your cursor to Click & Drag each item. Rank the importance of each strategy, with #1 being most important, #2 as next important, and so on*.)

_____ Greenhouse gases and the greenhouse gas effect
_____ Connection between coal and CO2 emissions
_____ Impacts of climate change on Oklahoma and the United States
_____ Impacts of climate change on the rest of the world
_____ Differences between natural and anthropogenic (human-caused) climate change
_____ Scientific evidence and reasoning behind climate change theories
_____ Both sides of the debate over human-caused global warming
_____ Technological innovation and solutions to climate change
_____ Connection between natural gas & oil and CO2 emissions
_____ Connection between land-use, agriculture, and climate change

Q15: Do you think there is public controversy about climate change?

a) Yes
b) No

Q16: Why or Why not?_____

Q17: Please select the option that best represents your opinion: (*Select one oval per line*)

	Strongly Agree	Agree	Disagree	Strongly Disagree
a) Other teachers at my school feel that climate change is inappropriate or too controversial to be taught in the science classroom.				
b) I support increased efforts to include teaching and learning about climate change in the science curriculum.				
c) At my school, I believe that increased efforts to include climate change education in science curriculum might lead to pushback or controversy.				

d) Administrators in my school or district feel that climate change is inappropriate or too controversial to be taught in the science classroom.				

Q18: According to public polls, about 20% of the US population does not think that recent global warming is caused primarily by human activity. In general, do you think Oklahoma science teachers should discuss 'both sides' of this public controversy with students?

a) Yes
b) No

Q19: Why or why not?_____

Q20: Please describe how you incorporate teaching and learning about climate change in your classroom. What topics, strategies, materials, and/or activities do you use?_____

Q21: Which resources do you primarily use to teach about climate change? (*Please select all that apply*)

_____ I write my own lesson plans
_____ Textbook
_____ District Curriculum Guide
_____ State recommended curricula
_____ Teacher Organizations
_____ Informal Education Organizations
_____ Scientific Organizations
_____ Trade books/ Picture books
_____ Educational vendors
_____ Other, please specify: _____

Q22: Approximately, how much classroom time during the school year do you devote to the topic of climate change?

a) Less than 2 hours
b) 2-4 hours
c) 5-10 hours
d) More than 10 hours
e) Other, please specify: _____

IF YES- I teach about or discuss climate change in your science classroom

Q23: Please complete the following phrase: "I teach climate change in my science classroom because. . . "

Q24: How motivated are you by the following reasons for teaching about climate change? (Please rank each item from 0 (not motivated) to 5 (highly motivated))

It is tested on AP exams.
It is a good bridge between subject areas.
It is included in my curriculum guide.
It is included in my textbook.
I feel that it is an important topic.
It has real-world relevance to students.
It is important for the future of Oklahoma.
My students expressed interest in the subject.
I receive encouragement from others.
Other, Please Specify:

Q25: Have you encountered any of these barriers to teaching about climate change in your classroom? (Please select all that apply)

_____ Lack of quality climate science teaching resources
_____ Lack of personal training or professional development around the topic of climate change
_____ Lack of content alignment with state standards
_____ Lack of time
_____ Personal apprehension about the science
_____ Concern over pushback from parents or students
_____ Concern over pushback from adminstrators or co-workers
_____ None of the Above
_____ Other, please be specific: _____

IF NO- I do not teach about or discuss climate change in your science classroom

Q26: Please complete the following phrase: "I do not teach climate change in my science classroom because. . . "

Q27: How motivated are you by the following reasons for NOT teaching about climate change? (Please rank each item from 0 (not motivated) to 5 (highly motivated))

I don't know enough about the topic.
It is not included in the state standards or curriculum guide.
It is not included in my textbook.
I am concerned about objections from others.
I do not feel climate change is an important topic.
I am not sure climate change is happening.
My students expressed disinterest in the topic.
I am not sure whether to teach "both sides" of global warming debate.
I was discouraged from teaching climate change by others.

Q28: Have you encountered any of these barriers to teaching about climate change in your classroom? (*Please select all that apply*)

_____Lack of quality climate science teaching resources
_____Lack of personal training or professional development around the topic of climate change
_____Lack of content alignment with state standards
_____Lack of time
_____Personal apprehension about the science
_____Concern over pushback from parents or students
_____Concern over pushback from adminstrators or co-workers
_____None
_____Other, please be specific: _____

Q29: Which of your classroom science textbook(s) introduce the concept of global climate change?
(*For each, please be specific by indicating the full title, author, year, and publisher*)

Q30: I have experienced pushback concerning my personal approach to teaching about the following topics from the following groups: (*Please select all that apply. Select at least one box for each line*.)

	Please select the source(s) of the pushback							
	Parents	Administrators	Students	Teachers	Family/ Friends	Church	Other	None
Environmental Science								
Evolution								
Climate Change								
Global Warming								
Age of the Earth/ Geological time								
Solar System/ Planet Formation								
Other:_____								

Q31: Please tell us more about your experience(s): What types of pushback did you (or perhaps someone you know) face? How did the disagreement play out? Did the experience change your approach to teaching science?

Q32: Did any of your college or advanced course work place emphasis on the science or theory behind global climate change?

a) Yes
b) No

Q33: In the last two years, have you engaged in any of the following learning experiences about climate change? (Select all that apply)

_____Conference session
_____Professional development workshop
_____School in-service
_____Climate change education specific website
_____Reading a magazine
_____Reading a book
_____None of the Above

Q34: How much had you thought about climate change education in your science classroom before today?

a) A lot
b) Some
c) Little
d) None

Q35: Would you be willing to participate in future learning experiences about climate change in secondary science classrooms?

a) Yes
b) No
c) Maybe

Q36: Why or why not?
Q37: How concerned are you about climate change?

a) Not Concerned
b) Slightly Concerned
c) Somewhat Concerned
d) Very Concerned

Q38: The climate change we are seeing today is primarily caused by...

a) Natural cycles of the Earth
b) Natural cycles of the Sun
c) The ozone hole
d) Human activities
e) Other. please specify: _____

Q39: People have different ideas about how the climate system works. Which statement best represents your views on how the climate system works?

a) *Gradual.* Earth's climate is slow to change. Global warming will gradually lead to dangerous effects.
b) *Fragile.* Earth's climate is delicately balanced. Small amounts of global warming will have abrupt and catastrophic effects.
c) *Stable.* Earth's climate is very stable. Global warming will have little to no effect.
d) *Threshold.* Earth's climate is stable within certain limits. If global warming is small, climate will return to a stable balance. If it is large, there will be dangerous effects.
e) *Random.* Earth's climate is random and unpredictable. We do not know what will happen.

Q40: To what extent do you disagree or agree with each of the following statements:

	Strongly Agree	Agree	Disagree	Strongly Disagree
a) Climate change is a natural process.				
b) Most climate scientists agree about the causes of recent climate change.				
c) The evidentiary basis supporting the theory of global warming is weak and even wrong.				
d) Global warming would be beneficial if it were to occur.				
e) Environmental policies and regulations often do more harm than good.				
f) Recent climate change is happening mostly because of humans.				

Q41: On some issues people feel that they have all the information they need in order to form a firm opinion, while on other issues they would like more information before making up their mind. With regard to global warming, where would you place yourself?

a) I need a lot more information
b) I need some more information
c) I need a little more information
d) I do not need any more information

42: To what extent do you disagree or agree with each of the following statements:

	Strongly Agree	Agree	Disagree	Strongly Disagree
a) A scientific theory that explains a natural phenomena can be classified as a "best guess" or "hunch".				
b) I would teach a theory even if it conflicts with my religious beliefs.				
c) The scientific methods used to determine the age of fossils and the earth are reliable.				
d) The scientific methods use to determine global warming are reliable.				
e) Schools should teach children about the causes, consequences, and potential solutions to climate change.				
f) Schools should teach children about processes and evidence of evolution.				

Q43: Including this school year, how many years of teaching experience do you have?

Q44: What is your gender?

a) Male
b) Female

Q45: What year were you born?

Q46: In the last two years, I participated in the following professional development activities related to the teaching of science: (Please select all that apply)

_____College course
_____Workshop or training session
_____Conference or professional association meeting
_____Observational visit to another school
_____Mentoring or coaching in formal arrangement
_____Committee or task force on curriculum or assessment
_____Regularly schedule discussion or reading group
_____Teacher collaborative or network
_____Independent reading or research
_____Co-teaching/team teaching
_____Consultation with a subject specialist
_____Other, Please specify: _____

Q47: What is the highest academic degree you hold?

a) High-school diploma
a) Associate's degree/vocational certification
b) Bachelor's degree
c) Master's degree
d) Education specialist's or professional diploma
e) Doctorate
f) Professional Degree (e.g. M.D., LL.B., J.D)

Q48: In your undergraduate coursework, did you have a major or minor in any of the following subjects?

	Yes, major	Yes. minor or special emphasis
Biology or other life science		
Physics, chemistry, or other physical science		
Earth or space science		
Mathematics		
Mathematics education		
Science education		
Elementary or secondary education		
Other, Please Specify: ____		

49: In your advanced coursework, did you have a major or minor in any of the following subjects?

	Yes, major	Yes. minor or special emphasis
Biology or other life science		
Physics, chemistry, or other physical science		
Earth or space science		
Mathematics		
Mathematics education		
Science education		
Elementary or secondary education		
Other, Please Specify:		

Q50: Within your science classroom, how much do you focus your science curriculum on preparing for the following types of assessments?

State assessments
District assessments
School assessments
Other, Please specify:

Q51: To what extent do the following entities influence the scope and sequencing of science education in your school?
(*Please select an answer for each item*)

	Not at all	To a small extent	To a moderate extent	To a large extent	Not applicable
a) Individual teachers					
b) In-school curriculum frameworks and standards for learning					
c) Recommendations from school science department					
d) Results from school assessments					
e) District curriculum standards or curriculum guides					
f) Results from state/district assessments					
g) State curriculum standards					
h) Informal education programs					
i) Commercially designed programs					

VITA

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Candidate for the Degree of

Doctor of Philosophy

Thesis: TRACING THE FLOW: CLIMATE CHANGE ACTOR-NETWORKS IN OKLAHOMA SECONDARY SCIENCE EDUCATION

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Education:
Completed the requirements for the Doctor of Philosophy in Environmental Science at Oklahoma State University, Stillwater, Oklahoma in May, 2014.

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