CLIMATE CHANGE EDUCATION IN THE UNITED STATES:

AN ANALYSIS OF CLIMATE SCIENCE INCLUSION IN

K-12 STATE SCIENCE STANDARDS

by

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ABSTRACT

Climate Change Education in the United States: An analysis of climate science inclusion in K-12 state science standards

Madeline Goodwin

“Climate change is the defining issue of our time.”
~Ban Ki-Moon, Secretary-General, United Nations, 2015

Climate change represents perhaps the greatest global issue of the 21st century, but the United States does not include this issue in its national science standards, leading to very low climate literacy among teenagers. Given the 97% public school enrollment rate in the U.S., incorporating climate change into state science standards could prove an effective education mechanism. The Next Generation Science Standards (NGSS) include climate change, but only 18 states and the District of Columbia have adopted these optional standards. My research used text analysis and surveys to determine the most important climate change concepts for K-12 students to understand and the extent to which state science standards include these concepts. I found that most non-NGSS standards do not include climate change, and even fewer include the priority concepts identified in the survey; these top concepts focused on the impacts of anthropogenic climate change, a politically controversial topic, explaining why they are often absent. To address this gap in students’ education, I recommend nation-wide adoption of the NGSS. For states which prefer not to adopt NGSS, revision of state standards to incorporate climate change should occur as quickly as possible.

Executive Summary

Table of Contents

List of Figures

List of Tables

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1. Introduction

Native Alaskans relocate their entire tribes as the permafrost under their towns melts and their buildings sink unevenly, breaking apart. Severe storms ravage the Northeast, while the Southwest struggles to cope with droughts and wildfires. Coastal communities nationwide watch oceanfront properties become ocean, and snow-melt-dependent regions like the Pacific Northwest face problems relating to changing water availability. The Great Plains and Southeast witness record-breaking heat waves that, coupled with water shortages, create agricultural and health struggles.

These examples from a 2014 government report show us what climate change looks like right now (GlobalChange.gov, 2014). They do not come from models forecasting fifty years down the road—these examples come from reports of *today*. With these effects already being felt, the need for action on climate change gains a new perspective—and urgency.

Action on climate change could come about in two ways. A bottom-up approach depends on individuals changing their actions and behaviors to more environmentally friendly choices, such as changing light bulbs from fluorescents to LEDs, carpooling, or investing in energy-efficient appliances. Either alternatively or concurrently, a top-down approach would include governments regulating carbon emissions and promoting renewable energy sources and energy efficiency, likely using a monetary incentive such as a carbon tax or appliance rebates.

Both of these options, however, rely on a public that makes climate action taken on their own or by their elected officials a top priority. Right now, individuals and smaller groups work for changes too insufficient to make a long term difference, and in order for politicians to push forward would require a more forceful impetus, one that can win out over the myriad of other issues they must juggle. A Yale study from 2015 showed that while 63% of American adults believe that climate change is happening, only 48% believe human activities are the primary driver, while 34% of Congress denies the modern occurrence of climate change at all (Herzog, 2016; Leiserowitz et al, 2015). These numbers pose real challenges for any sort of top-down change, and could potentially impair the efforts of any sitting president to enter into international cooperative agreements. The Paris Climate Accord, the international climate change agreement resulting from the 2015 Conference of Parties, was written to be non-binding to circumvent the possibility of the United States facing a Congressional override, and it could prevent the implementation of regulations proposed in agreements with China and Canada on joint carbon emissions reductions and methane regulations, respectively (White House Press Secretary, 2014; White House Press Secretary, 2016). Given that most of these actions have taken place in the past several years, their current or future impact can only be estimated.

Although working in the short-term requires persuading voting adults of the necessity of climate action, long-term action and future adaptation demands educating the next generation as well. With these obstacles, education becomes a priority in order to combat the inertia of ignorance (Kenyon, 2016). Approximately 97% of American children receive their education in public school classrooms, making the public school system a highly efficient mechanism for climate change science education (Public School Enrollment, 2013).

Additionally, beliefs developed as children and teenagers have staying power: if teachers present climate change as fact to youth now, those youths will become adults who continue to accept climate change as fact (Bloom and Weisberg, 2007). This holds for children as young as late elementary school age: a 2014 study using a storybook designed by the researchers on natural selection showed that second- and third-grade students can comprehend much more complex concepts than expected (Kelemen, 2014). Similarly, young children may also be able to comprehend climate change, allowing them to engage and apply the concept throughout their education and lives.

Unfortunately, this classroom education on climate change—and the science behind it—does not appear to be occurring. A recent survey of U.S. science teachers showed that 70% of middle school science teachers and 87% of high school biology teachers incorporate at least an hour of climate change education into their lesson plans (Plutzer et al., 2016). However, 30% of teachers primarily teach the role of natural causes in climate change. Of the teachers who do teach the science of human-driven climate change, 31% teach both the consensus on the human drivers of climate change and the claim that many scientists believe natural factors drive modern-day climate change. While Plutzer et al. present several explanatory variables, they highlight misperception of the scientific consensus as the primary factor: only 30% of middle school and 45% of high school science teachers knew that more than 80% of climate scientists perceive human activities as the primary driver of global warming. Encouragingly, the teachers seemed to recognize their own ignorance: two-thirds of those surveyed indicated a desire for continuing education on the subject, including half of those who believed climate change was due to natural causes (Plutzer et al,, 2016).

Incorporating climate change into state science standards would be one highly effective way to address the lack of climate change in classrooms. Already the Next Generation Science Standards (NGSS), published in 2013, have been adopted by eighteen states and the District of Columbia. However, the optional nature of NGSS, combined with the politicized nature of climate change, has left many states with standards which fail to adequately cover the subject, if they do so at all (Kliegman, 2015; NYT Editorial Board, 2015).

In this thesis, I ask: *To what extent do state science standards for United States K-12 education include climate change?* I assess this with three sub-xs: *Which states include climate science concepts in their science standards? What do science education professionals consider the three to five most important concepts about climate change for high school students to understand?* And *Are these concepts included in state science standards? If so, in which states?* In answering these questions, I seek to provide an overview of the current state science standards and their inclusion or lack thereof of climate change and related science concepts. I identify standards with room for improvement, and suggest steps for improvement based on my research. I will conclude with an exploration of the implications, potential applications, and areas for future research that this research project provides.

2. Problem Statement

Climate change threatens the entire planet, but greenhouse gas emissions predominantly come from industrialized countries, especially China and the United States

(Boden, Marland, & Andres, 2016). Implementing change means collective agreement to move towards renewable energy sources, but at present, this momentum does not exist in the United States. A large part of this inertia results from ignorance and contrarianism: Only 52% of adults over 18 years of age in the United States accept anthropogenic climate change; it logically follows that the remaining 48% would be disinclined to take action to prevent a threat they do not acknowledge (Leiserowitz et al., 2015). Because public schools teach 97% of school-aged children in the United States, including climate change in the standards would mean educating millions of future voters (Public School Enrollment, 2013). At present, however, most state science standards do not adequately teach climate change (Table 1). Combined with the proclivity for teachers to "teach to the test," this results in most students not being taught climate change in their classrooms (Goodwin & Gustavson, 2013).

Part of this problem comes from the state science standards and curricula adoption decision-makers: groups which rarely include teachers, yet often include politicians or special interests who may have ulterior motives or other agendas (NYT Editorial Board, 2015). The lack of understanding of climate change by teachers also poses a severe challenge, since imparting knowledge requires having that knowledge in the first place (Plutzer et al., 2016). Addressing the problem will require a multi-faceted approach and demands the statistics and information provided in this research.

3. Literature Review

3.1 Introduction

Originally a purely scientific concept, climate change has moved into the policy arena and is becoming a facet of everyday life. Social researchers have long recognized science education as important for participation in modern society: “science, technology, and society,” the term used for the interaction between these topics, has played a prominent role in discussions regarding 21st century education. We build mental frameworks based on our experiences, and science and technology have become essential parts of these frames (Hodson, 2003). The next logical step would be to integrate climate science in these mental frameworks, recognizing its importance to today’s younger generations. Instead, resistance to policy change means climate change receives little coverage within the curriculum unless the teacher makes the effort to include it (Sharma, 2012).

3.2 Climate Change

Since the industrial revolution, developed nations have pumped billions of tons of carbon dioxide into the atmosphere, increasing atmospheric CO_2 levels from 285 ppm in 1850 to approximately 400 ppm in 2015 (Tans & Keeling, 2015). Scientists have identified a link between this increase and the 1°C increase in global average temperatures that occurred in the past 125 years (Lewis, 2015). The Intergovernmental Panel on Climate Change (IPCC) projects that, assuming “business as usual” emissions, climate change impacts will only get worse, with temperatures continuing to increase and weather events becoming more unusual and unpredictable, and a potential acceleration in effects. Even with extreme mitigation efforts, IPCC scientists anticipate at least 2°C of warming before 2100 (IPCC Core Writing Team, 2014). As these dangers move from future to present, the threat to human life becomes an ever-greater concern (IPCC Press, 2014).

Scientists have established with a high degree of certainty a causal relationship between anthropogenic carbon emissions and significant global climate change (IPCC, 2014). While scientists cannot establish direct links between a given weather event and climate change, the increased frequency of extreme weather events suggests that many locations worldwide already feel the effects of climate change (Geo. Soc. of Amer., 2015; NOAA, 2015; U.C. Santa Barbara, 2015; Wuebbles et al., 2014). In the United States, potential economic costs of a changing climate include, but are not limited to, damage to communities and infrastructure from storms, sea level rise, and wildfires; reduced agricultural production from drought and floods, changing precipitation patterns and increased pest prevalence; more airplane delays due to visibility issues and severe weather conditions; and increased need to transport water and other goods due to shifting precipitation patterns (Karl, Melillo, & Peterson, eds., 2009). Environmental damages include more extreme weather events, changing patterns of precipitation and rainfall, destabilizing pollinator-plant and predator-prey relationships, and species extinctions (IPCC, 2014). Wu et al. estimate that in the eastern United States, heat-wave-related mortalities will increase by several thousand by the late 2050s; already, public health records show an increase in asthma linked to climate change (D’Amato et. al., 2015; Wu et al., 2014).

The United States emits a significant portion of global greenhouse gas emissions, but despite overwhelming consensus among climate scientists regarding anthropogenic global warming, only 52% of the American public accept the existence of anthropogenic climate change, including just 21% of all Republicans, compared to 45% of self-described "moderates" and 63% of those identifying as Democrats (Anderson, 2015; Leiserowitz et al., 2015). Multi-faceted opposition to the implications of the science has caused governmental gridlock at multiple levels, often preventing enactment of the type of government reforms necessary to mitigate and adapt to climate change, such as placing limits on power plant emissions (Anderson, 2015). These obstacles have been overcome in some locations, including the nine-state Regional Greenhouse Gas Initiative (RGGI, pronounced "reggie") on the East Coast and the various emissions reductions efforts in California (California Air Resources Board, n.d.; RGGI, 2007). Nevertheless, many other states have taken steps in the opposite direction, such in Florida, North Carolina, Pennsylvania, and Wisconsin, where bans have been enacted on using climate change vocabulary in state communications, papers, or websites (Lehmann, 2015; Williams, 2015).

As the children of today become the adults of tomorrow, they will be faced with a multitude of decisions which climate change will influence directly or indirectly, including parenthood, health, housing, work, social services, economic investments, and transportation (Barreca, Deschenes, & Guldi, 2015; CIEH, 2015; Martin et al, 2013; NAIC & CIPR, 2015; SaferSmarter, 2015; Stern, 2006; U.S. EPA, 2015). Some of these adults will run for public office, and make choices that affect both their communities and people they may never meet. Even local actions can have a global impact (Jaeger, 2015).

The better the coming generation understands climate change—the causes, the consequences, and how to mitigate the effects—the better they will be able to adapt in the future (Narula, 2013).

3.3 Action and Gridlock

While everyone from the president to comic strip artists have called for action in the name of current and future generations, there remain powerful and outspoken naysayers (Lewis 2015; White House Press Secretary, 2013; Trudeau, 2015). Thus, a great deal of controversy surrounds the issue, creating obstacles to educating today's youth about this critical threat to the planet and modern society (NCSE, 2012).

Whereas public opinion polls indicate a gradual increase in climate change acceptance within the American public, those who deny climate change and oppose climate action have the fortunes of fossil fuel barons on their side (Brulle, 2013; Leiserowitz, 2015). Money from the fossil fuel industry and other deniers fund media campaigns in an attempt to sway the public, which, when these campaigns succeed, then elects government officials who will work against climate action and for the fossil fuel industry (Oreskes & Conway, 2010). Psychological research shows that educating people about scientific facts, using persuasive arguments, can be effective in refuting inaccurate claims made in these media campaigns, particularly when these arguments play on a lack of science education and critical thinking skills (Nussbaum, 2006).

Some positive actions have been taken despite both the opposition of those who reject modern climate science, and the absence of climate change in most public education. The implementation of carbon trading programs in the RGGI states and California present two excellent examples of these positive actions. Although some RGGI states have predominantly conservative voters, the market-based design of the program appeals to this voting bloc; the historic background of inter-state cooperation on environmental issues in this region also facilitates the bipartisan cooperation seen in the RGGI program (Silverman, 2013). California has a liberal urban majority, a demographic which tends to accept the science of climate change, and pollution problems that add extra incentive to reduce emissions (Hamilton, 2010). While these circumstances do not exist everywhere, the programs do offer models on which to base future bipartisan legislation, if the impetus to act grows to a sufficient level.

It could be said that legislators in the states just discussed have taken action without any formal public school education on the subject. However, that would assume that education only happens in the classroom. These people may have been fortunate enough to have learned about climate change in a classroom or an informal setting; they may also have simply had the issue thrust upon them and been forced to self-educate. While this may have been sufficient in the past, the increasing severity of climate change means society can no longer take the chance that sufficient understanding will be gained by the general public without some explicit instruction (Parker, Los Santos, & Anderson, 2015; Pidgeon & Fischhoff, 2011). Lawmakers also typically have aides who specialize in more specific or complex topics, including energy and climate change (Sessoms, n.d.).

In the face of political, economic, and ideological opposition to climate change mitigation efforts, several movements have formed around climate action advocating for fossil fuel restrictions, greenhouse gas emission regulations, and increased use of renewable energy and other non-polluting resources. While they often focus on systemic change, these organizations also push for individual action on climate change, especially in three areas of concern: energy use, transportation, and consumer behavior (e.g. CA Air Resources Board, 2014; David Suzuki Foundation, 2014; EPA, 2015; Holzer, 2006; NRDC, 2015; Roser-Renouf, Maibach, & Leiserowitz, 2014; Union of Concerned Scientists, n.d.).

Individual action on climate change has been the subject of some controversy, as Elizabeth Cripps describes in her 2013 book, *Climate Change and the Moral Agent: Individual Duties in an Interdependent World*. On one hand, if many people take the same set of actions, the combined effort may have more visible results. The increasing public support will also likely catalyze larger-scale action by groups, governments, and community organizations, resulting in even more meaningful reductions in carbon emissions and investment in mitigation technology. On the other hand, the actions of one individual have little impact on the overall problem: an extra car ride here and there or a complete switch to biking, walking, and public transit will not do much to affect the global climate (Cripps, 2013).

Research on individual action has mostly focused on how to get more of it, rather than the why of its importance (Whitmarsh, O'Neill, & Lorenzoni, 2013). Much of this research has argued for individual change as a mechanism for systemic change, as described above. In many cases, these calls-to-action overlook the need for voter participation—for citizens to vote based on environmental policies in addition to other issues. However, in a democratic republic such as the United States, taking action on climate change must include electing officials who will pass adaptation policy and work towards global cooperation in cutting carbon emissions (Nussbaum, 2006).

Environmental organizations, civil rights groups, and ordinary citizens who may not otherwise see themselves as activists have come together to pressure governments around the world into protecting climate stability. These activists often see themselves as protecting the future—if not for themselves, then for their children and grandchildren (Monstad, 2010; Pedersen, 2010). Rather than passively watching the climate action movement grow in the name of protecting their future, many youth have taken action. The legal organization Our Children's Trust, working with teens from across the country, has filed lawsuits and other legal actions in all fifty states; of these, five states have pending lawsuits (OR, MA, CO, WA, and NC), and courts in six other states have issued developmental decisions. In a significant move in November of 2015, King County (WA) Superior Court Judge Hill ruled in favor of Our Children's Trust and the youth petitioners, ordering the Washington Department of Ecology to account for the effects of climate change in all future environmental rule-making. The probable severity of climate change makes the actions of these youth, and other climate activism, particularly important. By taking these actions, they demonstrate to legislators and others the value current generations place on a stable climate; with their victories, they signal the inevitability of climate action through the legal legitimization of their argument (Our Children's Trust, 2015).

The current generation of children will almost certainly have need of this information; unfortunately, the inclusion of climate science in the public school curriculum has been a slow and contentious process (Beeler, 2015). Making change requires building consensus among the more influential stakeholders as to what should be taught to whom and at what age. The implementation of any new curriculum will likely face challenges from any parties not included in the development process, especially teachers (Jorgenson, 2006). Moreover, these changes must account for political, cultural, religious, and ideological differences, which create different value systems among parents, administrators, and teachers (Lewis, 2015).

3.4 Science Education Policy

A 2015 study shows that most high schoolers fall short of the state and national science literacy expectations, as expressed in the National Science Education Standards (Eberhardt, 2012; Parker, Los Santos, & Anderson, 2015). This lack of scientific understanding translates to an inability to comprehend the urgency posed by the very real threat of climate change (Eberhardt, 2012). Research on climate activists shows that if we want individuals to become engaged and involved in climate action, they must be taught critical thinking and the scientific process, and be exposed to the facts of the subject (Nussbaum, 2006). Persuasive texts and other educational materials have been shown to be effective in providing young people with the information they need to become engaged with climate change, offering a promising approach in encouraging individual action (Sinatra et al, 2011).

U.S. public schools educate approximately 97% of Americans under age 18; almost 50 million children enrolled in the nation's schools in the 2012-2013 school year, the most recent year for which data has been made available (NCES, 2013). To ensure a common educational background for students throughout the nation, the United States federal government first implemented the National Science Education Standards in 1996, which "offer[ed] a coherent vision of what it means to be scientifically literate," although some states have had standards for even longer (National Research Council, 1996). These standards set educational goals for each grade level in these schools (kindergarten through 12th grade, abbreviated as K-12).

Milner et al. note that since the passing of the federal No Child Left Behind Act (NCLB) in 2001, teachers typically spend less time on science, focusing instead on reading and math (Milner et al., 2012). The NCLB legislation raised the stakes on standardized test scores, penalizing schools and teachers if students did not get high enough scores (Swarat, Ortony, & Revelle, 2012). Without climate change concepts in the standards, then, teachers lack incentive to teach them. Alternative approaches to science education, such as environmental education classes and project-based lessons, have been offered, but only a minority of schools have adopted these methods (Goodwin & Gustavson, 2013).

Since NCLB gives students' test scores disproportionate influence in teachers' job evaluations, many have adopted the practice of teaching to the test—teaching specifically the tests' contents, and frequently excluding anything students will not be tested on (Popham, 2001). When teachers teach to the test, their lessons lose content, and students can lose understanding—and thus interest—in the material (Goodwin & Gustavson, 2013; Swarat, Ortony, & Revelle, 2012). Swarat et al. link this loss of interest to a nationwide decline in science literacy, which falls well below the levels set out in the Next Generation Science Standards (Swarat, Ortony, & Revelle, 2012; Parker, Los Santos, & Anderson, 2015). In a 2014 report, the National Science Foundation used

National Assessment of Educational Progress scores to evaluate science literacy in 4th and 8th grade students, and found that while scores did go up, less than a third of all students reached their grade-specific proficiency level. When another test, the Trends in International Mathematics and Science Study, was given in several other countries and jurisdictions, the United States showed no improvement relative to other countries and jurisdictions (NSF, 2014).

With so many U.S. citizens educated in public schools, the education system could act as an effective mechanism for educating a large portion of the public on climate change. Representatives of 26 states and the District of Columbia collaborated with non-governmental organizations, scientists, and education professionals to produce the Next Generation Science Standards (NGSS), which they released in April, 2013, and intend as a gold standard for science education in schools (Achieve, 2013). Unlike previous national standards, the NGSS cover everything from physics and astronomy to chemistry and biology, and emphasize understanding the principles of science rather than memorization of factual knowledge (Poppleton, Carley, & Niepold, 2014; Witte, 2015). In addition, the NGSS include climate change science starting in middle school, the first nationally recommended standards to do so in any significant detail (Poppleton, Carley, & Niepold, 2014).

State implementation of NGSS has only just begun, and thus researchers cannot yet discern outcomes. Additionally, unlike the National Science Education Standards, states have the option to not use NGSS, which could result in limited adoption. In fact, only 18 states and D.C. have adopted NGSS in its entirety since its release, as well as some individual school districts in various parts of the country (Heitin, 2015;

Koronowski, 2015). Given the option, some states, including Oklahoma, South Carolina, and Wyoming, have already rejected NGSS, citing concerns about how the standards handle climate change science (Klein, 2014; Klein, 2015; Strauss, 2014).

3.5 Climate Change Education

Looking back at surveys from previous years, Shepardson et al. found that understanding of climate change among Midwestern secondary students showed that, while comprehension had improved in some ways since previous studies—students no longer confused the greenhouse effect and ozone depletion as much—students made few connections between climate change and their everyday activities (Shepardson et al., 2011). When comparing the climate change knowledge of American teens versus adults, teens scored lower than the adults on the questions about the climate systems and the drivers and results of climate change. However, teens demonstrated a stronger understanding of the key concepts, such as the relationship between anthropogenic burning of fossil fuels and increased atmospheric carbon dioxide (Leiserowitz, Smith, & Marlon, 2011). Combined, these studies show the impact of leaving climate change out of the core curriculum. Some researchers also argue that not only do students not receive an education in these subjects, but they also may not reach the level of scientific thinking necessary to understand the complexity involved (Parker, Los Santos, & Anderson, 2015). Without this comprehension, students may leave school incapable of grasping the impacts of climate change, and without the problem-solving skills to address scientific challenges (Goodwin & Gustavson, 2013).

In looking at climate change in the classroom, Lambert et al. argued that in order to effectively communicate the relevant concepts of climate change, teachers need to better understand the subject themselves. The researchers did a study of pre-service and in-service teachers' understanding of climate change before and after an "instructional intervention," which educated them on subjects relating to climate change. They found that the intervention improved teacher comprehension and teaching of climate change, as measured by their students' scores on a quiz administered by the researchers (Lambert, Lindgren, & Bleicher, 2012). With the introduction of the NGSS, earth sciences teachers will have an even bigger part to play in climate change education. This will require more extensive training for new teachers, along with expanded professional development opportunities and in-service education for current educators. In particular, as more becomes known about how best to teach climate science, this information and the tools to apply it will need to be disseminated (Hestness, 2014).

Fortunately, in light of the dearth of formal climate change curriculum in schools, organizations as diverse as *The New York Times*, the National Center for Science Education, GHF: Gifted Homeschoolers Forum, and the U.S. Environmental Protection Agency offer curricula, online resources for students and for teachers, and training for teachers to use in their classrooms. These opportunities have been designed to help students to better understand earth science, sustainability, and critical thinking skills, which in turn build a foundation for the better understanding of complex climate science issues (Parker, Los Santos, & Anderson, 2015). When students have this understanding, they demonstrate an increased likelihood to take action on climate change (Rickard et al, 2014).

Humanity faces an unprecedented challenge in fighting climate change (United Nations, 2014). By educating the youth of today, we begin to prepare the adults of tomorrow for the world they will live in and the challenges they will face, and empower them to make choices that will help mitigate and adapt to the damage caused by climate change (Holzer, 2006). With 97% of American schoolchildren attending public schools, ensuring their curriculum includes climate change would be an important step in the right direction (Public School Enrollment, 2015).

3.6 Significance

I will be doing a comparative analysis of state science standards across all fifty U.S. states, specifically looking for the inclusion of climate change and related concepts. Despite the extensive literature previously discussed, no comprehensive reviews of state science standards and their incorporation of climate change in science standards have been performed. This research will fill that gap. In addition to adding to the literature, this research will also serve broader uses. This research project will provide states with data regarding climate change content in their science standards, and the impact of adopting the NGSS on student climate change education outcomes. Primary research will identify the most important climate change concepts students should know by the time they graduate high school, and compare the content of each state's science standards to those concepts. Organizations advocating for climate change education may also use the findings to target their efforts towards states which do not adequately include the subject in their standards.

4. Findings

The findings discussed below suggest the demonstrated lack of knowledge about climate change among high school students stems from a systemic absence of climate science in K-12 classrooms. Teachers would like to teach more about the subject, but given their propensity for teaching to the test, the state science standards must be changed and the tests updated to incorporate their feedback. I present this feedback, along with my other findings, in the sections below. Details on my methodology can be found in Appendix A.

4.1 Current Curriculum

At present, 18 states and Washington, D.C., have adopted the Next Generation Science Standards in full (Heitin, 2016). These standards cover all of the 15 climate science concepts I identified in my research, and can thus be considered, for the purposes of this thesis, the “gold standard” for science standards. Of the other 32 states, three included 13 or 14 of the concepts, falling into the “High Performance” category. Four states scored 11 or 12, categorized as “Acceptable,” and another four scored 9-10, “Inadequate.” The remaining 21 scored between 1 and 8, “Poor Performance” (Table 4.1-1). Note that these numbers have changed even since this research began, with three states adopting NGSS since December 2015 (Heitin, 2016).

Table 4.1-1 States according to concept scoring category.

Category	**Number of Concepts**	**States**
Gold Standard	15	AR, CA, CT, DE, HI, IL, IA, KS, KY, MD, MI, NV, NJ, OR, RI, VT, WA, WV, D.C.
High Performance	13-14	ID, MA, SC
Acceptable	11-12	AL, CO, GA, OH
Inadequate	9-10	AZ, MN, OK, UT
Poor Performance	1-8	AK, FL, IN, LA, ME, MS, MO, MT, NE, NH, NM, NY, NC, ND, PA, SD, TN, TX, VA, WI, WY

In a survey of science education professionals, discussed in more detail in the next section, participants voted on which five concepts out of the fifteen studied they believed most important for students to learn by the time they graduated high school. The three highest-ranking concepts, winning across age, gender, political orientation, and educational background categories, were "Impact of human activities on the global climate," "Impact of climate change on earth systems," and "Impact of climate change on living organisms."

By awarding extra points to state standards with these top concepts, some standards with fewer concepts scored higher. Using these revised scores, states also fell into high, medium, and low priority groups for revision. NGSS "Gold Standard" states were excluded from this grouping; they could also be considered "lowest priority." Of the 32 other standards, 11 scored between 1 and 7, and should be considered high priority. The 13 medium priority standards scored 8-14 points; apart from the NGSS standards, only 8 scored 15 or higher, indicating low priority (Table 4.1-2). This indicates that most standards need revision to include climate science concepts.

Table 4.1-2 States according to priority for review and revision.

Priority Group	Scores	States
Low priority	15+	AL, CO, GA, ID, MA, OH, OK, SC
Medium priority	8-14	AK, AZ, FL, LA, MN, MS, MT, NC, NM, TN, TX, UT, VA
High priority	1-7	IN, ME, MO, NE, NH, NY, ND, PA, SD, WI, WY

4.2 Survey Results

Average votes for each of the 15 concepts ranged from 2.2 to 3.8. Four concepts received average votes above 3 points: “Impact of human activity on the global climate” (3.8 points), “Impact of climate change on living organisms” (3.5 pts), “Impact of climate change on earth systems” (3.3 pts), and “Relationship between energy flows and the global climate” (3.2 pts). Interestingly, this last concept received relatively few votes, indicating that the votes it did receive gave it high priority (Table 4.2-1).

Table 4.2-1 Average votes and raw number of votes for each concept in the survey.

Concept	**Average Vote**	**Number of Votes (unweighted)**
Climate consequences of burning fossil fuels	2.6	36
Difference between weather and climate	2.8	30
Effect of oceans on the global climate	2.2	10
Geographical distribution of climate zones	2.7	13
Greenhouse gas effect	2.5	24
Impact of climate change on earth systems	3.3	54
Impact of climate change on living organisms	3.5	52
Impact of climate change on risk from natural hazards and disasters	2.9	22
Impact of human activity on the global climate	3.8	63
Interpretation of climate models	2.2	13
Natural causes of climate change	2.2	25
Ocean acidification	2.3	11
Relationship between energy flows and the global climate	3.2	29
The carbon cycle	2.6	23
The history of Earth's climate	2.9	23

The top-scoring concept was “Impact of human activity on the global climate” (a.k.a. “anthropogenic global warming” or AGW), with 14.5% of the total votes and 18.4% of the points. “Impact of climate change on earth systems” (CCES) received 12.6% of the total votes and 13.9% of the points, tying with “Impact of climate change on living organisms” (CCLF), which received 12.1% of the total votes and 14.2% of the points (Figures 4.2-1 and 4.2-2).

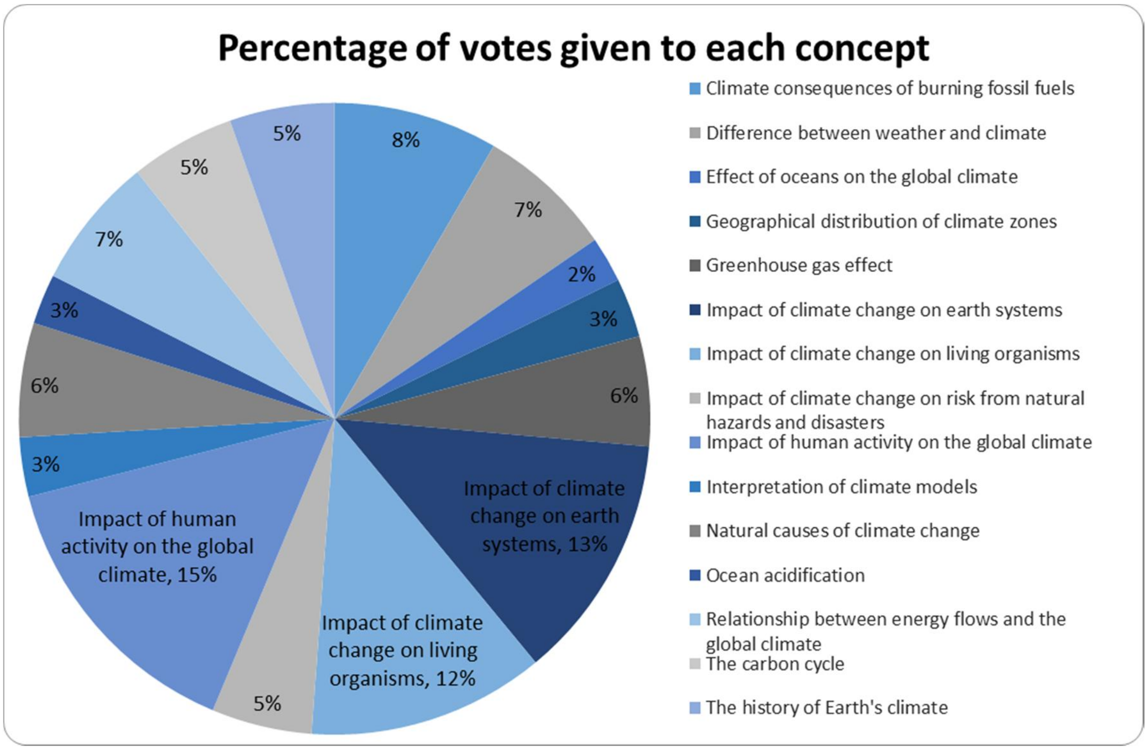

Figure 4.2-1 Percentage of overall votes survey respondents allotted to each concept.

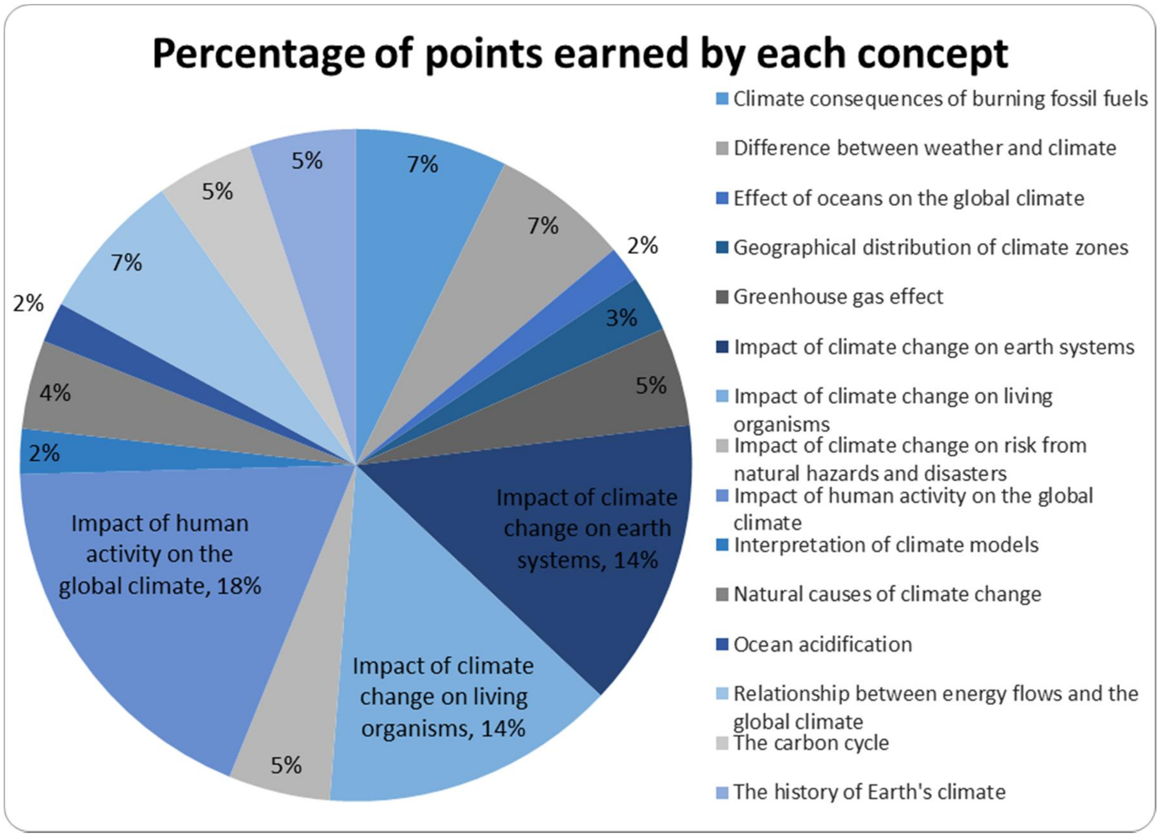

Figure 4.2-2 Percentage of total points allocated to each concept by survey respondents.

Despite the high scores on importance, however, CCLF only appeared in 17 state standards (out of 33, including NGSS), AGW appeared in 16, and CCES was found in a mere 14, out of the same 33 (Table 4.2-2). Eight states did not have any of these three, and only five had all three. While exact percentages varied, these three concepts achieved double-digit vote percentages throughout every subcategory, including age, certification status, political orientation, type of school where they taught, and belief regarding the causes of modern-day climate change. This indicates universal consensus surrounding the need for these three concepts to be taught, irrespective of sociopolitical, educational, and other factors.

On the opposite end of the spectrum, the carbon cycle (CC) received only 5.4% of the votes and 4.7% of the points, but was found in 28 standards—more than any other concept. The effect of oceans on the global climate (EOC) and the relationship between energy flows and the global climate (CEF) received similarly low scores (2.3% and 6.8% of votes and 1.7% and 7.2% of points, respectively), but were included by 22 standards (see Table 4.2-2). A chi-squared test of the relationship between a) the presence of a concept in a standard, and b) the number of votes that concept received from educators subject to that standard, had a p-value of <0.01 and a test statistic of 41.53, well above the 14 df critical value of 23.68. This indicates a correlation between the respondent being required to teach a concept and the respondent voting for the concept.

Table 4.2-2 Proportions of raw votes versus number of points awarded to each concept, and the number of standards which include each concept.

Concept	**% of votes**	**% of points**	**Number of standards including concept**
Climate consequences of burning fossil fuels	8.4%	7.3%	11
Difference between weather and climate	7.0%	6.6%	20
Effect of oceans on the global climate	2.3%	1.7%	23
Geographical distribution of climate zones	3.0%	2.7%	20
Greenhouse gas effect	5.6%	4.7%	13
Impact of climate change on earth systems	12.6%	13.9%	13
Impact of climate change on living organisms	12.1%	14.2%	18
Impact of climate change on risk from natural hazards and disasters	5.1%	4.9%	4
Impact of human activity on the global climate	14.7%	18.4%	17
Interpretation of climate models	3.0%	2.2%	10
Natural causes of climate change	5.8%	4.3%	19
Ocean acidification	2.6%	1.9%	7
Relationship between energy flows and the global climate	6.8%	7.2%	23
The carbon cycle	5.4%	4.7%	28
The history of Earth's climate	5.4%	5.1%	13

These results can be interpreted in two ways. First, the respondents could be voting for things they would like to see *added*, and felt no need to vote for concepts already included. Conversely, they could be voting for concepts they would like to see *replace* current requirements, and did not vote for currently included concepts because the the respondents do not feel they should be taught. The first interpretation both seems more likely than teachers not wanting a subject taught, and provides a more effective starting point for future research; therefore, I will adopt it for the purposes of this thesis.

Interestingly, 76% of teachers said they taught climate change, when only 28% said they were required to. Indeed, more than half (64%) said they were *not* required to teach climate change to their students. Since 63% of respondents were public school teachers and thus subject to state science standards, these statistics reflect teachers' desire for climate change education in the classroom. It should be noted that, while I use the phrase "climate science" when discussing the concepts, the survey and its questions were, with the exception of the rankings, about climate change specifically.

To recap: "Impact of human activity on the global climate," "Impact of climate change on living organisms," and "Impact of climate change on earth systems" received the most votes across all sociopolitical, educational, and demographic categories, contrary to expectation and previous surveys of the general public (Leiserowitz et al, 2015). However, these concepts appeared in relatively few standards. Conversely, some of the lowest-voted concepts appeared most frequently. A chi-squared test revealed a correlation between an educator being required to teach a concept and the educator voting for that concept. Although these results can be explained in two ways, it seems most likely that teachers preferred to vote for concepts they would like to see added instead of choosing concepts they already have to teach. These results should be considered a starting point for future research, and particularly for a repeat survey with a larger, more randomized sample.

4.3 Recommendations for Improvement

Based on the Literature Review performed for this thesis and the results of this research just presented, I recommend that when making changes, lawmakers take into account the preferences of the teachers. Since part of this means ensuring the inclusion of teachers in the revision committees, this would require a change in long-standing structures that may not be politically feasible. My survey presents an intermediary step: current committees implementing teachers' climate science priorities. Ideally, this would involve each state performing its own survey; however, as this would mean spending time and money that may not be available, my survey results can be used instead.

Of the 15 climate science concepts listed in the survey, the top three were all related to climate change. This survey included a cross-section of the U.S. political spectrum, including conservatives, moderates, and liberals; the strong conservatives and liberals were insufficiently represented to be analyzed individually. Interestingly, although studies have shown political identification to be one of the strongest indicators for whether a person believes in climate change, this study showed that some agreement exists on which concepts should be prioritized in the classroom.

The data from section 4.2.1 show the need to increase climate science concepts in science standards. However, when considering the most important aspect of climate science, teachers prioritize climate change above other, more scientifically fundamental concepts such as the relationship between energy flows and the global climate. My results show that three concepts scored highest across every measurement and every demographic subset: "Impact of human activity on climate change," "Impact of climate change on earth systems," and "Impact of climate change on life forms."

4.4 Recommendations for Future Research

An area of suggested further research would be the presence of teachers on committees that review science standards. In particular, I suggest exploring the relationship between teacher representation on the committees and climate science inclusion in the standards. My research demonstrates a large gap between the most prevalent concepts in state science standards, and the most highly prioritized concepts by my survey respondents. While many factors could account for this discrepancy, including the political pathways to standards adoption, I hypothesize that the level of teacher representation has the greatest effect.

5. Solutions

My findings indicate that state science standards often leave out many climate science concepts, resulting in very poor scores on my assessment. Additionally, most state science standards do not include the concepts educators say should receive priority. The results summarized here clarify the problem and provide some potential solutions focused on adding climate science to state science standards.

As argued in the Problem Statement and Literature Review, climate change should be taught to all students to prepare them for their future. The Findings showed that state science standards often leave out priority climate science concepts, and climate change in particular gets excluded frequently. At the same time, survey respondents expressed a desire to teach climate change, above and beyond their interest in more foundational climate science, a desire reflected by the 76% of survey respondents who said they taught climate change compared to the 64% who said they were not required to. The percentage of respondents who said they did teach climate change exceeded the 63% of the United States population that does believe in climate change (Leiserowitz et al, 2015). These results, along with the concepts rankings, indicate that including teachers to a greater extent in the standards development process would result in climate science standards that look vastly different to the ones we have today.

My findings reinforce previous assessments, which recognize the Next Generation Science Standards as a ground-breaking gold standard for climate science education (Poppleton, Carley, & Niepold, 2014; Branch, 2013). One solution to the absence of climate science in state science standards would be to require the adoption of the NGSS nationwide. Although many people, members of Congress included, have problems with various parts of these standards, national adoption of NGSS would ensure uniform baseline science education within the United States, including addressing the lack of climate science (Branch, 2013).

Political forces make achieving universal climate change education a challenge. Much of the problem stems from the state legislatures which pass state science standards: if politicians do not accept the reality of climate change, then they frequently will not pass standards that include anything to do with climate change or climate science (Bidwell, 2014). Requiring standards to be passed by the legislature politicizes the adoption process, arguably to an unnecessary extent. Changing the process for adoption to give the veto power to state offices, such as Washington state's Office of the Superintendent of Public Instruction, or to teacher's unions, could go a long way to depoliticizing standards content.

Such procedural changes could also accelerate the process. Updates and modifications every 5-10 years simply cannot keep up when new information becomes available on a daily basis. By depoliticizing the standards, revision committees may be able to achieve agreement on the outcomes far more quickly, potentially enabling them to perform updates on a semi-annual or annual basis.

National adoption of the NGSS cannot happen without effort. Other intermediate steps must also be taken. First, states should do their part by adopting the NGSS themselves, or developing alternatives that incorporate my research results (Bagley, 2014). School districts can also individually adopt the standards, if permitted by their state's education laws; this has already been done in several districts in states that have not adopted the NGSS (Heitin, 2015). If enough school districts in a state adopt the NGSS, this could also put pressure on the state legislatures to adopt the standards statewide.

Additionally, professional development opportunities must be made available to teachers. A February 2016 Science article showed that teachers feel woefully unprepared to teach climate science to their students. It does no good to require the teaching of climate science if teachers do not have the ability to comply. Mandating that schools, districts, or states fund professional development training, including time off, registration and travel, and hosting local workshops, would help many more teachers be more effective at their jobs (Plutzer et al, 2016). In a similar vein, curriculum and test development with the primary climate science concepts would help teachers better advocate for inclusion of these concepts in their classrooms.

Other solutions exist. At the state level, groups such as the National Center for Science Education can make the results of my survey and others that follow from it a central part of their climate change lobbying platform, pushing for the top concepts to be included (Branch, 2013). Education committee chairs in state legislatures can set the tone by laying out the importance of climate science for weather forecasting and air and ocean travel. Locally, parents can also get together to lobby for climate change education in their school districts.

Finally, this assessment process should be repeated in 3-5 years' time to evaluate what progress has occurred and where improvements can still be made. While the standards probably will not all be perfect in five years' time, substantial changes to better educate our next generation can and should happen—and sooner rather than later.

6. Conclusion

At the start of this research, I articulated a problem: K-12 students do not receive adequate climate change education. Given the severity of the problem climate change itself presents, I set out to find out why. Through an exploration of climate science content in state science standards, especially the concepts relating to climate change, I found that the standards did not require climate change education. By performing a survey, I discovered that teachers would like to teach climate change in their classrooms, but my literature review showed that teachers often teach to the test. While political forces make climate change education difficult to mandate, I offer several solutions. Finally, I recommend that the Next Generation Science Standards be adopted nationwide immediately. No solution will fix the problem completely, and changes take time, but improvements are possible and should be made sooner rather than later.

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Appendix A. Methodology

In this research, I used four steps. First, I identified climate science concepts, coding the state science standards for recurring themes, a common qualitative research tool (Hays, 2000). Then I surveyed science educators on the relative importance of these concepts. This survey was based in part on the Yale Project on Climate Change Communication public survey, and was designed according to survey research best practices (Borch, 2015). Next, I aggregated my results from the first two steps to determine the relationship between a concept's frequency of inclusion in state standards and the level of priority awarded by the educators. Finally, I used basic statistical analytical techniques in my analysis. These steps are discussed in the sections below.

A.1 Concept Identification and the Survey

I identified six search terms: climate (to include both climate and climatic), fossil fuel, carbon, acidification, warming, and greenhouse. With these, I found fifteen climate science concepts that appeared in at least one state's science standards (for the list, see Appendix B). Using my keywords as my search tool, I reviewed the state science standards for all states that had not adopted the Next Generation Science Standards (non-NGSS states), in addition to the NGSS themselves (links to the standards can be found in Appendix C). In order to determine what the most important concepts were, I surveyed science educators.

Survey participants were identified in two ways. First, I attended the National Science Teachers Association (NSTA) national conference in Nashville, TN, from March 30 to April 3, 2016, where I collected email addresses from people interested in participating. At the conference, on Saturday, April 2, I also made the survey available on a tablet I had with me, so people could respond on-site. Second, I used the internet to reach people who were not at the NSTA conference. This took two forms: I wrote a blog post for GHF: Gifted Homeschoolers Forum, and I did an interview for the weekly STEM Girls column at the Maker Mom blog. The link to the survey was included in both posts, which were shared on the internet without my involvement. My survey did not ask participants to indicate how they heard about my research; the responses cannot be sorted according to recruitment method.

My survey (see Appendix D) presented the fifteen concepts I found, and asked teachers, "Which of the concepts do you believe is (first-, second-, third-, fourth-, fifth-) most important for students to understand before graduating high school?" I also included questions about age, political orientation, whether the respondents had teaching certifications, what type of school they taught at, and what they believed causes modern-day climate change. Age and political orientation have been linked to likelihood of belief in anthropogenic climate change (Leiserowitz, 2015). Teaching certifications require background education that may influence teacher belief and pedagogy; the type of school where a teacher works was hypothesized to have a similar influence. Whether a teacher believes in anthropogenic climate change holds strong influence over whether they teach climate change to their students (Plutzer, 2016).

A.2 Data Analysis

A.2.1 Ranking the Standards

Using my table of concepts found in each state's science standards (Appendix B), I gave states one point for each concept they included, regardless of its ranking. Based on their scores, state standards fell into one of five categories: Gold Standard (15 points), High Performance (13-14 points), Acceptable (11-12 points), Inadequate (9-10 points), and Poor Performance (1-8 points). I gave standards receiving a perfect score their own category because they represent the gold standard for climate science inclusion in state science standards and a goal for other states to aspire to. I based the point distribution on the standard grading system of the United States.

To evaluate the quality of current standards and identify key points for improvement, I awarded additional points for including the impact of human activities on climate change (3 extra points), the impact of climate change on earth systems (2 extra points), and the impact of climate change on living organisms (1 extra point). Thus, states had a maximum score of 21 points (15 for all concepts, plus six bonus points). The additional points were awarded based on the premise that states which already teach the most important standards—regardless of their overall concept inclusion—should be rewarded for being priority concept "early adopters." I then ranked the states according to these scores, and labelled them as high, medium, or low priority for revision based on whether they obtained 1-7, 8-14, or 15 or more, respectively, of available points.

A.2.2 Survey Data Analysis

My survey received 86 responses, including three homeschoolers (including a former teacher), one international respondent (from Canada), three informal educators, and seven student teachers. For each variable, I looked at response types with at least 15 respondents ($n \geq 15$); this sample size correlates with the 15 concepts on which respondents voted.

I used two methods to determine which were the top-scoring concepts: % of total (unweighted) votes and weighted count. When looking at weighted votes, I made teachers' first-choice votes worth 5 points, second-choice votes worth 4 points, and so on through fifth-choice (1 point). For both methods, I calculated the means, standard deviations, and spreads for both raw and weighted votes. I also calculated the sums of raw and weighted votes for each concept within each subcategory for each variable. Additionally, I counted how many standards included each concept. This allowed me to contrast the ranking of the concept by educators against how widely it was taught. Some survey respondents also provided their location, which enabled a comparison of respondent values against the concepts included in their state's standards.

A.3 Biases

As with all research, this methodology included a set of biases, primarily in the survey. Although care was taken in composing the questions, I did not use a focus group to test them, but went straight to data collection due to time constraints. This introduces the possibility of leading questions, learning on the part of the respondent, and other flaws. In some cases, respondents may answer according to how they want to portray themselves.

Respondents were recruited both in person (at a conference) and online. At the conference, at least one climate science contrarian refused to take the survey. A self-selected, rather than randomized sample, means that the results may not be indicative of all educators; the limited sample size (86 respondents) makes this bias especially possible. The sample could also be biased to give me the data respondents thought I wanted because I appealed to their sympathy towards a graduate student when asking them to take my survey. Additionally, coding brings inherent bias, due to its subjective nature; I did my best to remain objective but may have overlooked or inappropriately included concepts present in some state science standards.

Appendix B. Concepts Used

Concept name	Abbreviation
Climate consequences of burning fossil fuels	FFC
Difference between weather and climate	WvC
Effect of oceans on the global climate	EOC
Geographical distribution of climate zones	SD
Greenhouse gas effect	GHGE
Impact of climate change on earth systems	CCES
Impact of climate change on living organisms	CCLF
Impact of climate change on risk from natural hazards and disasters	CCNH
Impact of human activity on the global climate	AGW
Interpretation of climate models	GCM
Natural causes of climate change	NCC
Ocean acidification	OA
Relationship between energy flows and the global climate	CEF
The carbon cycle	CC
The history of Earth's climate	HEC

Appendix C. Links to the Standards

State	Link
Alabama (AL)	http://alex.state.al.us/staticfiles/2015_AL_Science_Course_of_Study.pdf
Alaska (AK)	https://www.eed.state.ak.us/AKStandards/standards/standards.pdf
Arizona (AZ)	http://www.azed.gov/standards-practices/files/2011/12/sciencestandard.pdf
Colorado (CO)	https://www.cde.state.co.us/sites/default/files/documents/coscience/documents/science_6th_grade.pdf; https://www.cde.state.co.us/sites/default/files/documents/coscience/documents/science_8th_grade.pdf; https://www.cde.state.co.us/sites/default/files/documents/coscience/documents/science_hs.pdf
Florida (FL)	http://www.cpalms.org/public/search/Search
Georgia (GA)	https://www.georgiastandards.org/standards/Georgia%20Performance%20Standards/EarthSystems-Approved2006.pdf; https://www.georgiastandards.org/standards/Georgia%20Performance%20Standards/Ecology.pdf; https://www.georgiastandards.org/standards/Georgia%20Performance%20Standards/EnvironmentalScienceStandards-Approved2006.pdf; https://www.georgiastandards.org/standards/Georgia%20Performance%20Standards/Geology.pdf; https://www.georgiastandards.org/standards/Georgia%20Performance%20Standards/Meteorology.pdf; https://www.georgiastandards.org/standards/Georgia%20Performance%20Standards/Oceanography.pdf; https://www.georgiastandards.org/standards/Georgia%20Performance%20Standards/Environmental-Physics-Standards.pdf
Idaho (ID)	http://sde.idaho.gov/academic/science/files/draft/2015-Idaho-State-Science-Standards.pdf
Indiana (IN)	http://www.doe.in.gov/sites/default/files/standards/science/2010-Science-EarthSpace.pdf
Louisiana (LA)	https://www.louisianabelieves.com/docs/default-source/academic-standards/standards---k-12-science.pdf?sfvrsn=4
Maine (ME)	http://www.maine.gov/doe/scienceandtechnology/standardsinstruction/index.html
Massachusetts (MA)	http://www.doe.mass.edu/frameworks/scitech/2016-01.pdf

Minnesota (MN)	http://education.state.mn.us/MDE/EdExc/StanCurri/K-12AcademicStandards/Science/index.htm
Mississippi (MS)	http://www.mde.k12.ms.us/docs/curriculum-and-instructions-library/earth-and-space-scienceB31028A3D680.pdf?sfvrsn=4
Missouri (MO)	https://dese.mo.gov/sites/default/files/gle-6-8-science.pdf; https://dese.mo.gov/sites/default/files/cle-other-science.pdf
Montana (MT)	http://opi.mt.gov/pdf/Standards/09ScienceELE.pdf
Nebraska (NE)	http://www.education.ne.gov/science/Documents/10-6-10%20Earth%20Science%20Standards.pdf
New Hampshire (NH)	http://education.nh.gov/instruction/curriculum/science/documents/framework.pdf
New Mexico (NM)	http://www.ped.state.nm.us/MathScience/dl08/Standards/ScienceStandardsV2.pdf
New York (NY)	http://static.nylearns.org//content/documents/mststa4.pdf
North Carolina (NC)	http://www.dpi.state.nc.us/docs/acre/standards/new-standards/science/6-8.pdf; http://www.dpi.state.nc.us/docs/acre/standards/new-standards/science/earth-env.pdf
North Dakota (ND)	https://www.nd.gov/dpi/schoolstaff/assessment/unit/
Ohio (OH)	http://education.ohio.gov/getattachment/Topics/Ohios-Learning-Standards/Science/ScienceStandards.pdf.aspx
Oklahoma (OK)	http://sde.ok.gov/sde/sites/ok.gov.sde/files/OAS_Science_Standards_3-2-15.pdf
Pennsylvania (PA)	http://static.pdesas.org/content/documents/PreK-2_Science_and_Technology_Standards.pdf; http://static.pdesas.org/content/documents/Academic_Standards_for_Science_and_Technology_and_Engineering_Education_(Elementary).pdf; http://static.pdesas.org/content/documents/Academic_Standards_for_Science_and_Technology_and_Engineering_Education_(Secondary).pdf
South Carolina (SC)	http://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf
South Dakota (SD)	http://doe.sd.gov/contentstandards/documents/sdSciStnd.pdf
Tennessee (TN)	https://www.tn.gov/education/article/science-standards
Texas (TX)	http://ritter.tea.state.tx.us/rules/tac/chapter112/ch112c.html
Utah (UT)	http://www.schools.utah.gov/CURR/science/Core/Grade912.aspx
Virginia (VA)	http://www.doe.virginia.gov/testing/sol/standards_docs/science/201

	0/complete/stds_all_science.pdf
Wisconsin (WI)	http://dpi.wi.gov/science/standards
Wyoming (WY)	http://edu.wyoming.gov/wordpress/downloads/standards/Standards_2008_Science_PDF.pdf
NGSS States (AR, CA, CT, DE, HI, IL, IA, KS, KY, MD, MI, NV, NJ, OR, RI, VT, WA, WV, D.C.)	http://www.nextgenscience.org/sites/ngss/files/NGSS%20DCI%20Combined%2011.6.13.pdf

Appendix D. Survey

Climate Change Concepts in State Science Standards

By clicking "I agree" below, I hereby agree to serve as a subject in the research project titled "Climate Change Education in the United States: An analysis of climate science inclusion in K-12 state science standards." It has been explained to me that its purpose is to gather data on science teacher opinions about the importance of climate change science concepts. The research activity I will participate in is a survey.

I have been informed that the information I provide will be used in a thesis and public presentations as part of the graduation requirements for the Master's of Environmental Studies program at The Evergreen State College. I also understand that my responses may be reported in the manuscript and presentation, and my identity will be kept confidential and no identifying information about me will be included. Madeline Goodwin has agreed to provide, at my request, a copy of the final draft of her manuscript. Ms. Goodwin has also informed me that the manuscript may also be presented at the National Science Teachers Association (NSTA) regional conference in Portland, Oregon in November 2016, and that the NSTA may also publish it. I understand that the anticipated risks to me are minimal.

I agree to take this survey and have my response recorded and reported as part of the aggregate data. There will be no compensation of any kind available for my participation. I have been told that I can skip any question or stop the survey and withdraw my full participation from the study at any time without penalty. If I have any questions about this project or my participation in it, I can call Madeline at (541) 441-6766 or email her at madeline.goodwin@gmail.com. Likewise, the person to contact if I experience problems as a result of my participation in this project is John McLain, IRB administrator at The Evergreen State College, Library 2211, Olympia, WA 98505; Phone 360.867.6045.

1. **I understand that my participation in this project is completely voluntary, and that my choice of whether to participate in this project will not jeopardize my relationship with The Evergreen State College. I am free to withdraw at any point before or during the interview. I have read and agree to the foregoing.**
   Mark only one oval.

   ◯ I understand and accept the risks presented to me above. I wish to continue with this survey.

   ◯ I do not wish to continue with this survey. *Stop filling out this form.*

Data Collection

Climate change represents perhaps the greatest global issue of the 21st century, but the United States does not include this issue in its national science standards, leading to very low climate literacy among teenagers. The Next Generation Science Standards (NGSS) include climate change, but only 14 states and the District of Columbia have adopted these optional standards. My research will utilize text analysis and surveys to determine the most important climate change concepts for K-12 students to understand, and to what extent state science standards include these concepts. This will provide several benefits: states will have a starting point for improvements in their standards' climate change content; states and teachers will have a prioritized list of concepts to add if they want to make the aforementioned improvements; and parents and informal science educators will have a better understanding of what their students are being taught in school. Thanks for your participation!

2. **Which of the following climate science concepts do you believe is most important for students to understand before graduating high school?**
Mark only one oval.

- ◯ Geographical distribution of climate zones
- ◯ Relationship between energy flows and the global climate
- ◯ Interpretation of climate models
- ◯ Impact of climate change on living organisms
- ◯ Impact of climate change on earth systems
- ◯ Impact of climate change on risk from natural hazards and disasters
- ◯ Impact of human activity on the global climate
- ◯ The carbon cycle
- ◯ Natural causes of climate change
- ◯ The history of Earth's climate
- ◯ Climate consequences of burning fossil fuels
- ◯ Effect of oceans on the global climate
- ◯ Difference between weather and climate
- ◯ Greenhouse gas effect
- ◯ Ocean acidification

3. **Second-most important?**
Mark only one oval.

- ◯ Geographical distribution of climate zones
- ◯ Relationship between energy flows and the global climate
- ◯ Interpretation of climate models
- ◯ Impact of climate change on living organisms
- ◯ Impact of climate change on earth systems
- ◯ Impact of climate change on risk from natural hazards and disasters
- ◯ Impact of human activity on the global climate
- ◯ The carbon cycle
- ◯ Natural causes of climate change
- ◯ The history of Earth's climate
- ◯ Climate consequences of burning fossil fuels
- ◯ Effect of oceans on the global climate
- ◯ Difference between weather and climate
- ◯ Greenhouse gas effect
- ◯ Ocean acidification

4. **Third-most important?**

Mark only one oval.

- Geographical distribution of climate zones
- Relationship between energy flows and the global climate
- Interpretation of climate models
- Impact of climate change on living organisms
- Impact of climate change on earth systems
- Impact of climate change on risk from natural hazards and disasters
- Impact of human activity on the global climate
- The carbon cycle
- Natural causes of climate change
- The history of Earth's climate
- Climate consequences of burning fossil fuels
- Effect of oceans on the global climate
- Difference between weather and climate
- Greenhouse gas effect
- Ocean acidification

5. **Fourth-most important?**

Mark only one oval.

- Geographical distribution of climate zones
- Relationship between energy flows and the global climate
- Interpretation of climate models
- Impact of climate change on living organisms
- Impact of climate change on earth systems
- Impact of climate change on risk from natural hazards and disasters
- Impact of human activity on the global climate
- The carbon cycle
- Natural causes of climate change
- The history of Earth's climate
- Climate consequences of burning fossil fuels
- Effect of oceans on the global climate
- Difference between weather and climate
- Greenhouse gas effect
- Ocean acidification

6. **Fifth-most important?**
Mark only one oval.

- ⬭ Geographical distribution of climate zones
- ⬭ Relationship between energy flows and the global climate
- ⬭ Interpretation of climate models
- ⬭ Impact of climate change on living organisms
- ⬭ Impact of climate change on earth systems
- ⬭ Impact of climate change on risk from natural hazards and disasters
- ⬭ Impact of human activity on the global climate
- ⬭ The carbon cycle
- ⬭ Natural causes of climate change
- ⬭ The history of Earth's climate
- ⬭ Climate consequences of burning fossil fuels
- ⬭ Effect of oceans on the global climate
- ⬭ Difference between weather and climate
- ⬭ Greenhouse gas effect
- ⬭ Ocean acidification

Skip to question 7.

Teaching

Please provide information on the classes and school where you are currently teaching

7. **Years of teaching (e.g. 2010-2012; 2010-present)**

____

8. **Your grade level(s)**

____

9. **Your subject(s)**

____

10. **Type of school**
Mark only one oval.

- ⬭ Public
- ⬭ Private
- ⬭ Charter
- ⬭ Alternative
- ⬭ Montessori
- ⬭ Religious
- ⬭ Other: _______________________________

11. **Name of School**

____

12. **City/State**

____

13. **Do you teach your students about climate change?**
Mark only one oval.
    - ◯ Yes
    - ◯ No
    - ◯ Prefer not to say

14. **Are you required to teach your students about climate change?**
Mark only one oval.
    - ◯ Yes
    - ◯ No
    - ◯ Unsure

15. **If yes, by whom?**

____

Skip to question 16.

Climate Change

Questions in this section are modified from the Yale Project on the Environment's 2014 report titled "Climate Change in the American Mind," which can be accessed at http://environment.yale.edu/climate-communication/article/climate-change-in-the-american-mind-april-2014.

16. **Recently, you may have noticed that climate change has been getting some attention in the news. Global climate change refers to the idea that the world's average temperature has been increasing over the past 150 years, may be increasing more in the future, and that the world's climate may change as a result. Do you think that climate change is happening?:**
Mark only one oval.
    - ◯ Yes
    - ◯ No
    - ◯ Not sure
    - ◯ Prefer not to say

17. **How sure are you that climate change is or is not happening?**
Mark only one oval.

	1	2	3	4	5	
Not at all sure	◯	◯	◯	◯	◯	Very sure

18. **Assuming climate change is happening, do you think it is caused by...**
Mark only one oval.

- ⬭ Human activities
- ⬭ Natural changes in the environment
- ⬭ Both human activities and natural changes in the environment
- ⬭ Neither, because climate change is not happening
- ⬭ Other
- ⬭ Prefer not to say

Demographics

19. **Name**

____

20. **Gender**
Mark only one oval.

- ⬭ Female
- ⬭ Male
- ⬭ Other
- ⬭ Prefer not to say

21. **Age**
Mark only one oval.

- ⬭ 18-24
- ⬭ 25-34
- ⬭ 35-44
- ⬭ 45-54
- ⬭ 55-64
- ⬭ 65+
- ⬭ Prefer not to say

22. **Political orientation**
Mark only one oval.

- ⬭ Very conservative
- ⬭ Conservative
- ⬭ Moderate
- ⬭ Liberal
- ⬭ Very liberal
- ⬭ Prefer not to say

Education

23. **What schools have you obtained degrees from? (School/Year/Degree/Major; reverse chronological order)**

24. **What year did you receive your teaching certification?**

25. **What institution issued your teaching certification?**

26. **Have you participated in trainings or workshops on teaching climate change? If so, please provide details below.**

Interview

27. **Do you wish to participate in a follow-up interview?**
Mark only one oval.

- ⬭ Yes
- ⬭ No

28. **If yes, please provide your name, email address, and phone number**