PERCEPTIONS AND MISCONCEPTIONS REGARDING CLIMATE CHANGE:

POLITICS VERSUS EDUCATION

A Thesis

by

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BS, Texas A&M University-Corpus Christi, 2014

Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Science

in

Environmental Science

Texas A&M University-Corpus Christi
Corpus Christi, Texas

August 2017

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This thesis meets the standards for scope and quality of
Texas A&M University-Corpus Christi and is hereby approved.

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ABSTRACT

Climate change has been increasingly becoming a commonly debated topic among the public (Lambert & Bleicher, 2013). This is especially true with scientists and educators (Cooney, 2010). Terminology, politics, and misconceptions can bias perceptions. Scientists also tend to disagree over the cause of climate change and the data resulting from different studies (Idso, Carter, & Singer, 2016). The pilot study was conducted to examine perceptions of preservice teachers regarding climate change. There were forty participants, comprised of twenty Hispanic, nineteen Anglo American, and one African American, enrolled in a required course for future science educators in a medium-sized south Texas university. The pilot study included pre- and post-tests distributed to all of the participants and one on one interviews with three randomly selected pre-service teachers. The post-test results showed a significant difference in statements about the belief that climate change is real, about there being enough scientific evidence to prove the climate is changing, and the belief we are experiencing an extinction event due to climate change. While one lesson on climate change may not prove to be enough to change all of the participants' perceptions, there were some pre-service teachers who did begin to think differently about the impact of human activities and became more aware of climate change issues. The findings from this research show how beneficial a lesson on climate change can be to the future careers of science educators and in turn contribute considerably to the education of future students.

DEDICATION

This thesis is dedicated to my sons David and Jacob Garza. I love you both more than

you know. Y también dedicado a mi madre Maria. Con mucho amor y cariño, gracias por todo.

ACKNOWLEDGEMENTS

There are many people who I would like to acknowledge for providing their help and support throughout this long and tedious process. First of all, my family who supported me with patience and understanding. Thank you to my nieces Cristina and Liliana for helping me out during my field camp course and my sister Araceli for always being there when I needed you. Without all of you, the completion of this thesis would not have been a possibility.

Secondly, I would like to thank everyone who played a role in my academic accomplishments. Special thanks go to my committee chair, Dr. Cherie McCollough, for her continuous help and encouragement throughout this whole process. To my committee members Dr. Jennifer Smith-Engle and Mr. Tony Wood, thank you both for your advice and guidance. I could not have done this without all of you.

I would also like to thank all of the student volunteers that assisted with my research. And finally, another special thanks to my geology professors, especially to Dr. Tania Anders. Thank you for taking an interest in my future and helping me get started in this endeavor.

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CHAPTER I

Introduction

The purpose of this study is to research and ascertain how perceptions can influence a person's beliefs relating to climate change and to contribute to the field of geoscience education. Geoscientists study important problems concerning the environment and are instrumental in finding solutions to these problems. Studies in the field of geoscience have significantly increased in the last few decades due to the seeming intensification of natural disasters and controversial topics such as climate change. Learning about climate change is relevant to society today, however public perception can pose obstacles when it comes to this particular heated issue (Cooney, 2010).

Perception can be defined as an assumption resulting from an understanding (Merriam-Webster.com, 2016). Public perception, often leading to the unconscious materializing of opinions, depends on a variety of factors. Education, common misconceptions, and even belonging to a specific political party are a few of the factors that can have an effect on public perception. In a constantly changing world, perceptions can be very important. Science and technology are advancing at such an accelerated rate and it can be difficult to keep up with the latest research. Geoscience research may not be considered the most entertaining or the easiest to understand, so instead, the public counts on their previous experiences to influence them one way or another.

The regard for the potential seriousness of climate change is dependent on the beliefs of the audience in question. Brody, Zahran, and Vedlitz (2008) described public perception of risk as being drastically different than the scientific perception of risk due to an individual's own perceived personal risk. The authors concluded that geographic factors, such as low elevation

and distance from the coast, were instrumental when influencing public recognition of the conceivable negative impacts caused by climate change (Brody et al., 2008). This can certainly lead to presumptions regarding climate change.

Terminology may also be important when discussing bias. The public may perceive "global warming" as being more severe than "climate change", resulting in the terminology of choice having an influence on perception (Villar & Krosnick 2011). Another study regarding terminology was done where respondents were asked what phrasing they prefer, whether it was global warming, climate change, or global climate change (Akerlof & Maibach, 2011). The majority of participants in the Akerlof and Maiback (2011) study showed no preference in terminology overall, but global warming seemed to be the diverging and preferred term among citizens in Michigan already concerned with the concept.

According to scientific literature, climate change can be described as the large scale modifications occurring in the Earth's climate over time (Simon, 2010). While it has become a point of serious debate and discussion with the public in the past few years, it has remained an important topic among the scientific community for the past few decades (Cooney, 2010). Extensive data can be found on the subject in everything from books to dedicated websites and various types of articles, although some may be misinterpreted. As a result of this, average temperature figures can often lead researchers to very contradictory conclusions due to weather anomalies which may not be uncommon. For example, the United Nations' Intergovernmental Panel on Climate Change (IPCC) and the Nongovernmental International Panel on Climate Change (NIPCC) are two very conflicting organizations formed by scientists that have differing views on the data relating to climate change. The suggestion that the climate is rapidly changing

on a global scale, as well as the conclusion that humans are most likely the cause has remained a common working theory within the IPCC scientists and researchers.

As climate change becomes a larger issue in the eyes of the policymakers and scientists, organizations are formed with the sole intention on publishing scientific data and educating citizens on current and future potential impacts of climate change. The IPCC regularly publishes assessments containing contributions from the scientific community on climate change, the most recent being in 2014 (Rockström, 2014). According to Idso et al. (2016), there are scientists who disagree with the IPCC's assessments and claims regarding the working hypothesis that humans are the main cause of climate change. The organization NIPCC, for example, was created to discredit to some extent or to simply downplay the claims that organizations like the IPCC continue to make.

<center>*The Terminology of Climate Change*</center>

In a study by Akerlof and Maibach (2011), respondents were asked about preferred terminology regarding climate change. The options offered to the respondents were global warming, climate change, and global climate change (Akerlof & Maibach, 2011). Global warming is identified as "an increase in the [E]arth's atmospheric and oceanic temperatures widely predicted to occur due to an increase in the greenhouse effect resulting from pollution" (Merriam-Webster.com, 2017), climate change as "changes in the Earth's weather patterns" (Merriam-Webster.com, 2017), and global climate change as "a change in the world's climate" (TheFreeDictionary.com, 2017). Climate change and global climate change are often described as having the same definition. The idea behind the study was that different perceptions can alter preferences in terminology commonly used by the general public (Akerlof & Maibach, 2011). The authors found that the preference in terminology was likely associated with the approximate

<center>3</center>

residential location of the respondents with the respondents in certain areas using the same terms (Akerlof & Maibach, 2011).

Another study done by Villar and Krosnick (2011) also made a similar claim that words with interchangeable definitions may not be so to the general public. The research pair grouped the respondents by six categories: the Alarmed, the Concerned, the Cautious, the Disengaged, the Doubtful, and the Dismissive (Villar & Krosnick, 2011). The Alarmed group was found to prefer the global warming terminology, as opposed to the Dismissive, which did not (Villar & Krosnick, 2011).

Students are exposed to the terminology used in their immediate environment by either their parents or by their instructors. Many factors must be taken into consideration in how they perceive the sometimes slightly varied definitions used for climate change.

Politics and Climate Change

In 2010, Cooney's research spoke to the vast difference in opinion between the scientific community and its overseeing policymakers. Climate change is also used by politicians and other decision making individuals to influence public opinion. Stating their unwavering scientific beliefs as part of a political strategy is a common and proven technique used to persuade the public to vote one way or another. Climate change "deniers" are the individuals who basically refuse to believe the climate is changing in a more rapid manner than in previously observed years. Politicians, who may be distrustful of the scientific community, will not easily be swayed with climate change data. While there are some politicians that believe in climate change, they may not necessarily believe it is manmade or feel it is a significant enough problem that needs to be dealt with as soon as possible (Idso et al., 2016). Either way, policymakers should be aware of

where they are receiving scientific information from and what political affiliations those scientists may have (Idso et al., 2016).

Villar and Krosnick (2011) also questioned if political party affiliations could predict the preference in terminology. The study found that although the overall results showed no preference in terminology being used, the participants more closely associated with the Democratic Party significantly preferred the terminology of global warming than those associated with the Republican and Independent Parties (Villar & Krosnick, 2011). Climate change, global warming, and global climate change basically have the same definition or interpretation, but the difference in terminology the two previously stated studies show how select members of the public see climate change as a less severe way of saying global warming and global climate change.

Yang, Kahlor, and Griffin (2014) mentioned that politicians use social media since it has been consistently becoming more popular with all crowds, especially over traditional media. Social media is also a relatively easy way for the general public to become more informed and to share information with each other (Yang et al., 2014). Politicians are able to use social media to get their message across, which includes how they feel about controversial topics such as climate change. Unfortunately, voters and policymakers are often swayed by opinions relayed by politicians running for office. The politicians are in turn influenced by parties or companies that are interested in funding mutually beneficial political careers, which makes any future policy involving climate change difficult to predict (Selin & VanDeveer, 2007). For example, a company or its executive may provide monetary campaign contributions to a politician who is running for office with the belief that the politician, once elected, will somehow be an advocate for the company or its practices. As challenges relating to climate change and nature disasters

likely increase, the public will continue to look towards the politicians they voted into office for the answers. Their perceptions and how it directly affects them will continue to be driven by the politicizing of climate change (Howard, 2009).

Misconceptions Regarding Climate Change

Depending on their own personal biases, teachers are able to influence student perceptions through their curriculum (Lambert & Bleicher, 2013). In actuality, teachers may not realize they are subconsciously passing on their beliefs to their students during instruction (Liu, Roehrig, Bhattacharya, & Varma 2015). Their perceptions may come from their own misconceptions regarding climate change and may be problematic due to the possibility of passing on incorrect information (Lombardi & Sinatra, 2013). Bias not only affects teachers, but it can also inadvertently affect how scientists explain data. For example, scientists interested in advancing their careers or in applying for specific grants may be more likely to confirm favorable results if it can monetarily benefit them in some way (Idso et al., 2016).

At times, lack of education concerning climate change can make a difference and may be to blame for common misconceptions and overall naïveté of the public. Since a lot of the public does not understand the science behind climate change data, they simply are not able to accept it and the much more likely scenario is for them to revert back to their initial uninformed judgment of the topic (Brody et al., 2008). Climate science is also considered to be an interdisciplinary science and scientists may only be experts in one field of study, leading to a misinterpretation of data and disagreements regarding conclusive evidence pertaining to climate change (Idso et al., 2016).

Changing the public's perception regarding climate change is something scientists struggle with (Cooney, 2010). There are many things the public simply does not understand

about the science that goes into studying and learning about climate change. For example, the public may only associate climate change with sea level rise resulting in them not fully understanding some of the other immediate risks such as the increase in property damage due to escalating coastal floods and storms (Brody et al., 2008; Strauss, Tebaldi, Kulp, Cutter, Emrich, & Yawitz, 2014). Property values along the Texas coastline are estimated to be around ten billion dollars making any damage caused by natural disasters very costly (Strauss et al, 2014). Understanding this can help the science community educate and help improve public perception with regard to climate change.

There are several misconceptions regarding energy sources and climate change. One is the belief that alternative energy sources are not a viable or adequate option (Sklar, 2016). This belief is due to lack of proper education and possibly insufficient technology available. Although solar, wind, and geothermal energy are usually adequate options with minimum emissions, it is remains more expensive to generate energy than to simply save it (Sklar, 2016). In 2016, Caldeira discussed his struggle with and his attempts to help with climate change impacts. His suggestion for the public to be able to have affordable and dependable energy with almost no emissions, as well as a research and development program responsible for developing better energy and transportation systems may be a far reach. The author mentions the recent affordability of solar and wind energy, but rightfully remains concerned with the lack of dependability.

Caldeira (2016) also discussed recent research related to reducing emissions by combining wind and solar energy with a large scale electric grid and a natural gas power plant as a backup. He referenced research he is currently involved in regarding the difficulty in removing carbon from the atmosphere and the toxicity of releasing it can be. Specific suggestions resulting

from his research were to reduce emissions of black carbon and methane, slow and reverse deforestation, and increase the use of electric vehicles, and building solar, wind, and nuclear plants (Caldeira, 2016). Understanding that the suggested changes will not be an easy transition, Caldeira realized many of them were not considered to be cost effective with recent technology. Changing public perception through either an informal or formal method of education will need to occur in order for any of the suggestions to take form.

Another option discussed by Caldeira (2016) is using incentives for the use of more environmentally friendly energy systems. Incentives are often used by companies to entice their customers or the general public into trying something that was previously unfamiliar to them. Using incentives may be a more innovative method in helping convince the public to be more open to learning about climate change, which will in turn change their previous perceptions. Incentives could be an advantage when educating Americans since Christensen and Knezek (2015) found that they were more apprehensive than citizens of other countries when it came to worrying about the long terms effects of climate change.

Risk and vulnerability for the public may also lead to a strong opinion of climate change (Brody et al 2008). Farmers, for example, are more likely to believe the possibility of a warming climate. They are also more directly affected by the changing weather patterns than those living in suburban areas and therefore are more likely to have a higher concern (Goebbert, Jenkins-Smith, Klockow, Nowlin, & Silva, 2012). Farmers who own or work in more arid areas have a higher risk of the possibility of rain droughts and can expect to pay for water deliveries. This will cause the cost of crops to rise.

Public perception, political views and misconceptions regarding climate change led to this study investigating the following research questions:

RQ1: What are pre-service teachers' beliefs concerning climate change?

RQ2: Do pre-service teachers feel concerned enough about climate change to change their behaviors?

RQ3: How did the pre-service teachers' beliefs and perceptions change after a climate change lesson?

CHAPTER II

Methods

Study Site

A pilot study was conducted in an indoor classroom environment in a regional university located in south Texas that has been designated as a Hispanic Serving Institution (HSI). The selected participants for the study were a small group of forty undergraduate pre-service teachers attending the South Texas University (STU). The university offers more than eighty different undergraduate and graduate degree programs and has a current enrollment of about 12,000 students. It is located along the Gulf of Mexico and is close to several major cities.

All participants of the pilot study were aspiring future Kindergarten to 8th grade level (K-8) science educators enrolled in a life science pedagogy and content course. This course is a requirement for all future K-8 science educators. 87% out of the forty-six pre-service teachers enrolled in the course participated in this study, leaving a sample size of forty individuals. The ethnicity of the participants was twenty Hispanic, nineteen Anglo American, and one African American pre-service teacher. 93.5% of the participants were female, while 6.5% were male.

Definitions

The following terms have been defined for the purpose of this manuscript:

A. *Climate:*

Climate change: changes in the Earth's weather patterns (Merriam-Webster.com, 2017).

Global climate change: a change in the world's climate (TheFreeDictionary.com, 2017).

Global warming: an increase in the [E]arth's atmospheric and oceanic temperatures widely predicted to occur due to an increase in the greenhouse effect resulting from pollution (Merriam-Webster.com, 2017).

Greenhouse effect: a phenomenon in which the atmosphere of a planet traps radiation emitted

by the sun, caused by gases (i.e. carbon dioxide, water vapor, and methane) that allow

incoming sunlight to pass through but retain heat radiated back from the planet's surface

(Merriam-Webster.com, 2017).

B. *Research:*

Perception: an assumption resulting from a previous understanding (Merriam-Webster.com,

2017).

Mixed methods research: mixing both quantitative and qualitative methods in a single study

(Creswell, 2015).

Quantitative research: an inquiry approach useful for describing trends and explaining the

relationship among the variables; this method includes narrow questions, uses instruments to

gather data to answer questions and analyze numbers using statistics (Creswell, 2015).

Qualitative research: an inquiry approach useful for exploring and understanding a central

phenomenon; this method includes broad, general questions, collects the detailed views of

participants, and analyzes the information for description and themes (Creswell, 2015).

Research Methods

A mixed methods approach was used for this pilot study (Johnson, Onwuegbuzie, &

Turner, 2007). Quantitative data were collected from pre- and post- tests using a Likert Scale.

The Likert Scale included responses ranging from strongly disagree (1) to strongly agree (5). The

tests, adapted from Christensen and Knezek (2015), contained fifteen questions directly related

to climate change (Appendix A). The pre-tests were distributed during lecture approximately a

month before the participants were given the climate change lesson that followed with post-tests.

The purpose of the pre-tests is to assess the previous knowledge and unbiased opinions of each

participant. Similarly, the purpose of the post-tests is to measure the acquired knowledge of the participants against previous awareness and knowledge while observing if any of the participants' previous views regarding climate change differed in any way after the lesson. Qualitative data were collected from the face to face interviews using an open-ended protocol.

A complete 5E lesson for the participants also accompanied the lecture (Appendix B). The Biological Sciences Curriculum Study (BSCS) 5E Instructional Model includes five phases and is a research-based model that has been around for more than two decades (Bybee, 2014). The phases incorporated in the model are: engagement, exploration, explanation, elaboration, and evaluation (Bybee, 2014). The engagement phase entails the initial part of the demonstration meant to first obtain the students' attention in order to engage them in the lesson. The second phase is known as the exploration phase and includes an activity or activities where students use a hands-on approach. The explanation phase is the third phase and this is where different types of media is often used by instructors to help guide students through the explanation process. The fourth phase in the 5E instructional model is the elaboration phase. During this phase, students are not only encouraged to work in groups, but are also introduced to new situations where they are required to apply the concepts they just learned about in the previous phases. The fifth phase, the evaluation phase, includes a type of assessment where students provide evidence of learning to the instructor. The 5E instructional model was meant to be used as a guide for instructors to create their own lesson plan based on their classroom needs (Bybee, 2014).

The 5E instructional model worksheet on melting ice and rising sea levels (Appendix B) served as an important supplement to the lecture. The goal was for the participants to take part in a hands-on activity in order to become more familiar with climate change. The worksheet was adapted in part by activity worksheets previously created by Kiley (2016) and Phillips and

Jeffrey (2016). The purpose of the worksheet was to keep pre-service teachers engaged in learning and to influence them to think critically, as they needed to reflect and add observations every few minutes (Phillips & Jeffery, 2016). The 5E instructional model worksheet clearly outlined the student objectives and had each phase/section underlined for easier identification. The materials needed for the experiment were also listed and available for the pre-service teachers.

The engagement activity had the participants add the water and sand to the container, and then to measure the initial depths and temperature of the water. The data were recorded on the first data table provided on the worksheet. Participants then needed to answer what they believe could cause the temperature of the water to rise. The exploration phase required that participants add a small piece of ice to the water and measure the depth of it. The participants were then asked to take the temperature of the water every thirty minutes. They were also asked to predict what will happen to the temperature of the water throughout the experiment. For the third phase, the explanation phase, the participants needed to answer what happened to the ice, what caused the change to the ice and if their original prediction was correct or not and why. A second data table was provided for them to continue to document the ongoing measurements. The elaboration phase asked the participants to design their own investigation by first having them write down a testable question they have about sea level rise. Participants then needed to think about how they would set up their experiment including the materials and steps necessary to carry it out. They were also asked to make a prediction about their hypothetical experiment. The evaluation phase was the last phase and participants were asked questions regarding the effects climate change could have on sea level rise and how it could affect the oceans and the coasts. They were also asked how a change in ocean temperature could affect marine animals and why. These questions

were designed for the pre-service teachers to reflect on and discuss what they learned during the lesson.

A short video on the NBC Learn (2011) website was used as part of the lecture as well. The six-minute video, "Rising Sea Levels" explains some of the global-scaled impacts resulting from climate change in terms most participants are able to understand (NBC Learn, 2011). The worksheet (Appendix C) includes ten questions with nine out of the ten questions addressing information from the video. The tenth and last question requires the pre-service teachers to think about what specific, local area would be at risk of rising sea levels and to explain their answer (Texas A&M University Corpus Christi, 2013).

Three randomly selected undergraduate pre-service teachers also from the course were interviewed face to face using an open-ended protocol. Five questions were asked with the sole purpose of obtaining more in-depth answers regarding climate change (Appendix D). The interviews were conducted on a voluntary basis. The interviews were purposely kept relatively short, which was the reasoning for the limited to five questions to maintain the participants' attention span.

Data Analysis

The data were analyzed after the tests were completed by the participants. The data pre- and post-tests were analyzed by using a paired *t*-test quantitative method. The data from the one-on-one participant interviews were analyzed using a qualitative method which included a metric (Creswell, 2015). Each participant response was categorized using a ranking method where 0 meant nothing scientific was stated, a 1 meant a naïve answer was given, a 2 meant a novice answer was given, and a 3 meant an expert scientific answer was given. The responses were

rated by two different reviewers. An inter-rater reliability of 89.7% was reached, providing a

high degree of agreement between reviewers and their ratings (Creswell, 2015).

CHAPTER III

Results

Quantitative Data

Table 1 contains the correlation data from the pre- and post-tests. The table includes the

p-value, the mean, and the standard deviation. A *p*-value <0.05 determined if the difference

between the pre- and post-tests were statistically significant.

Table 1: Pre- and Post-Test Quantitative Data

Variable	*p*-value	*t*-value	df	Standard error of difference	Mean
1. I believe climate change is real.	0.0002**	4.0499	39	0.093	-0.38
2. Learning about climate change issues is important to me.	0.0107**	2.6825	39	0.168	-0.45
3. The importance of climate change is greatly exaggerated by politicians.	0.2151	1.2603	39	0.238	0.30
4. There is enough scientific evidence proving that the climate is changing.	0.0001**	5.4140	39	0.134	-0.73
5. The climate changing is a natural occurrence.	0.0809	1.7930	38	0.243	0.44
6. Human activities have no effect on climate change.	0.1731	1.3878	39	0.144	0.20
7. There is nothing I can do to help lessen the impact of climate change.	0.3046	1.0403	39	0.216	0.23
8. It is not important to me whether humans are causing the climate to change.	0.0105**	2.6874	39	0.186	0.50
9. No one knows how to stop climate change.	0.0050**	2.9772	39	0.168	0.50
10. Extinction of plants and animals is a natural occurrence.	0.0091**	2.7458	39	0.164	0.45
11. Climate change will have no impact on the future.	0.0577*	1.9554	39	0.128	0.25
12. Global climate change is a long term effect that humans should not be concerned with.	0.0114**	2.6555	39	0.132	0.35

13.	Climate change is more likely to affect plants than animals and humans.	0.6857	0.4078	39	0.184	0.08
14.	Climate change is mainly man-made and is not a natural occurrence.	0.3909	0.8677	39	0.144	-0.13
15.	We are experiencing an extinction event due to climate change.	0.0001**	9.4505	39	0.122	-1.15

**Indicates significant results at *p<0.05*
*Indicates trend

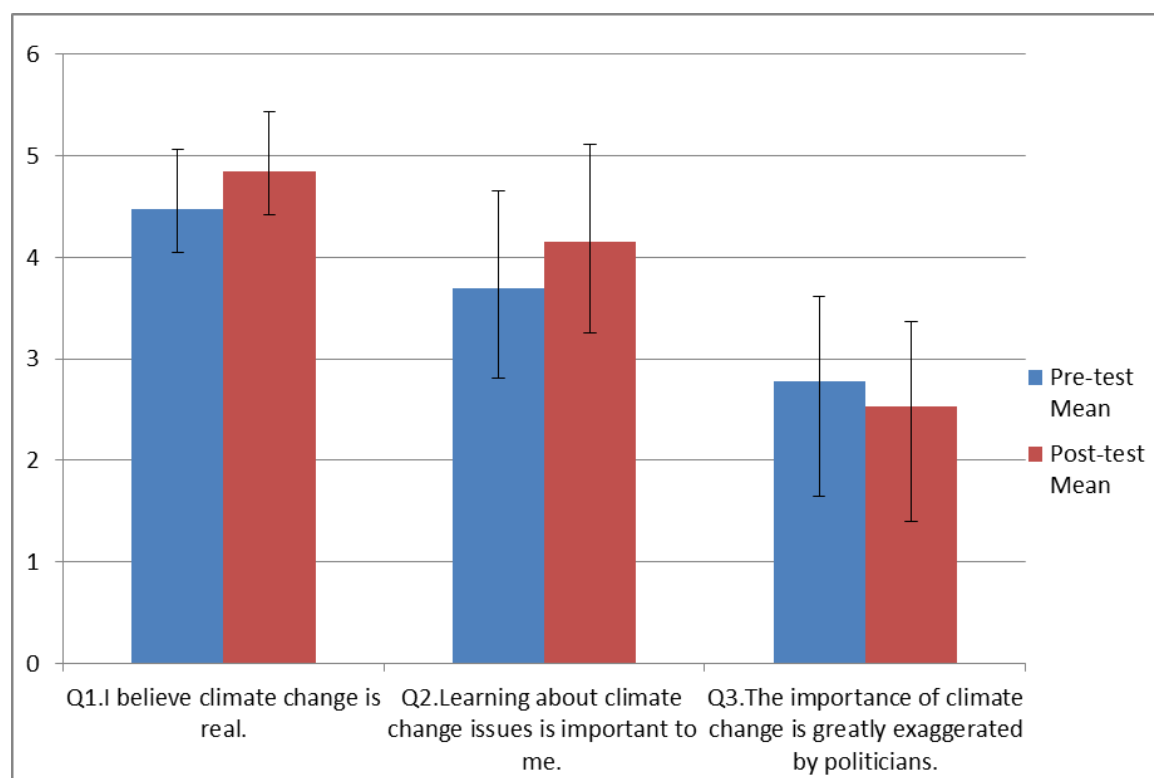Figures 1 to 5 are graphs containing the mean and standard deviation for the pre- and post-tests.

Figure 1: Pre- and Post-test Mean and Standard Deviation. The vertical scale of responses range from "strongly disagree" (1) to "strongly agree" (5).

Figure 2: Pre- and Post-test Mean and Standard Deviation. The vertical scale of responses range from "strongly disagree" (1) to "strongly agree" (5).

Figure 3: Pre- and Post-test Mean and Standard Deviation. The vertical scale of responses range from "strongly disagree" (1) to "strongly agree" (5).
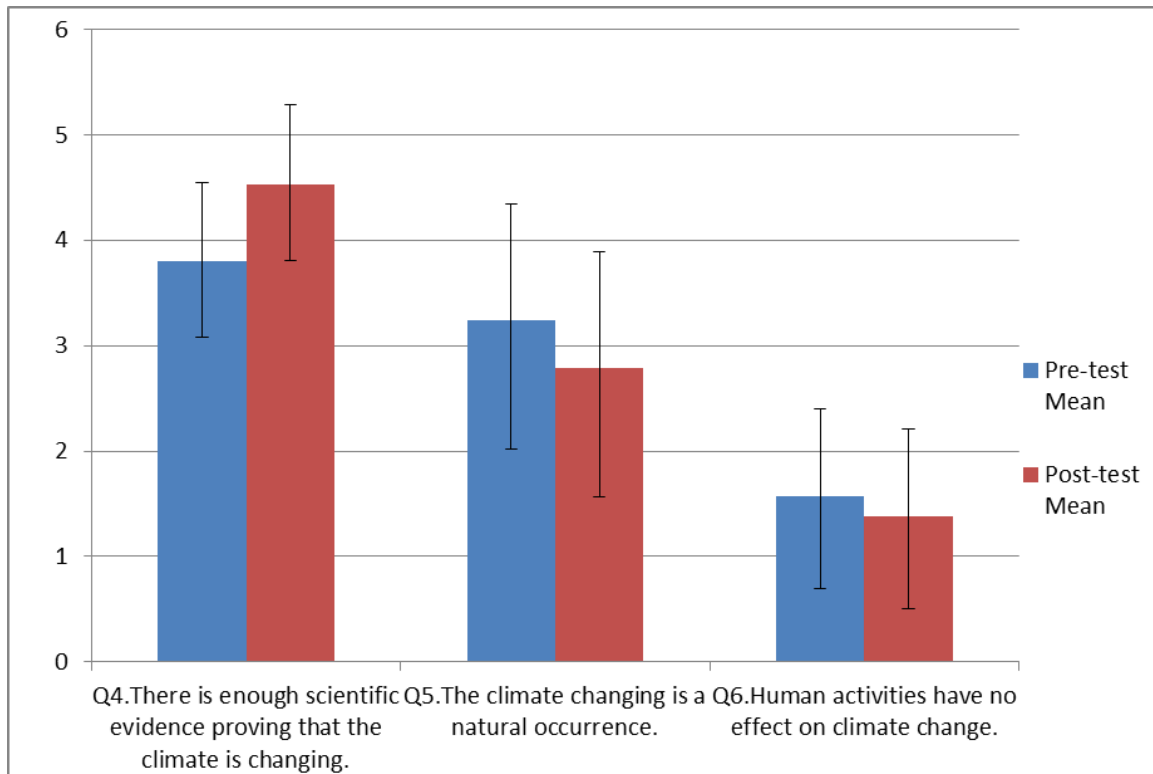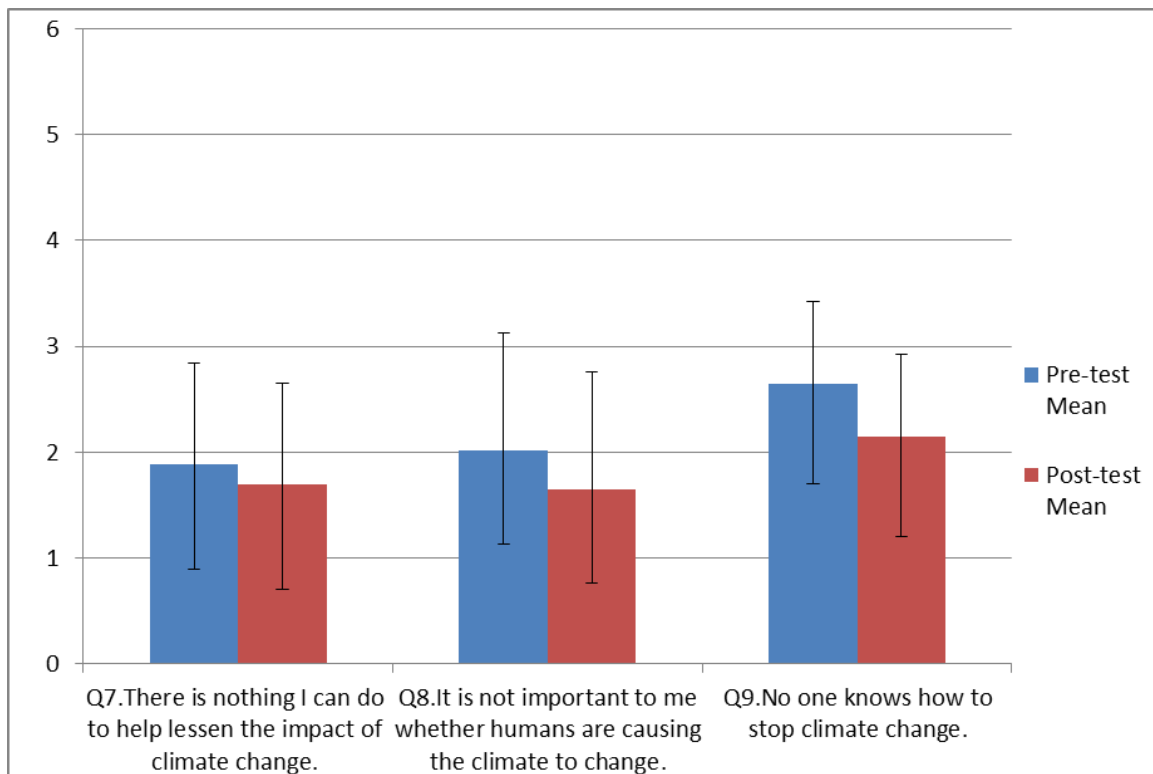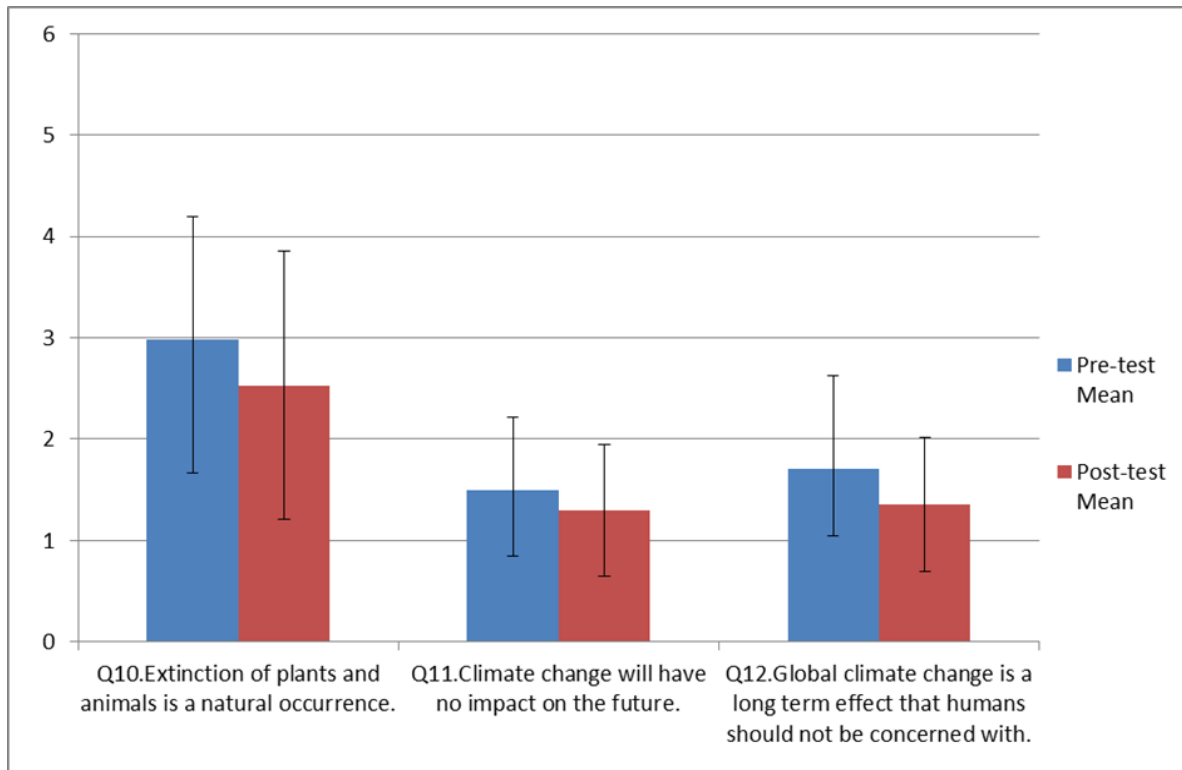
Figure 4: Pre- and Post-test Mean and Standard Deviation. The vertical scale of responses range from "strongly disagree" (1) to "strongly agree" (5).
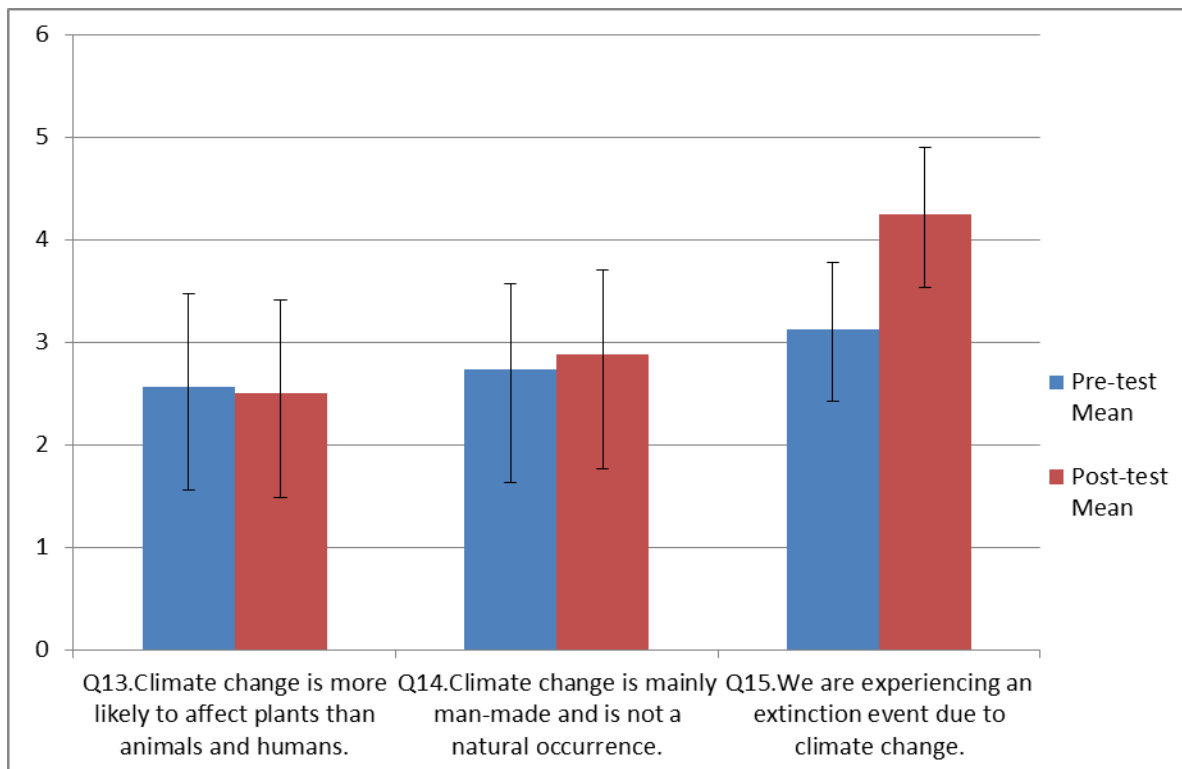

Figure 5: Pre- and Post-test Mean and Standard Deviation. The vertical scale of responses range from "strongly disagree" (1) to "strongly agree" (5).

Case Studies

Three randomly selected pre-service teachers were interviewed regarding their beliefs pertaining to climate change. The oral interviews occurred after the climate change lecture and activity, using the protocol found in Appendix D. For the purpose of this study, the participants will be known as Sue, Rachel, and Terry.

Sue

One of the biggest differences between Sue's pre- and post-test was her belief that there is nothing she can do to help lessen the impact of climate change. She expressed uncertainty on the pre-test and strongly disagreed by the post-test. Another notable difference was whether she agreed or disagreed that the importance of climate change is greatly exaggerated by politicians. She was uncertain during the pre-test and strongly disagreed on the post-test. Sue was also uncertain during the pre-test at the statement that no one knows how to stop climate change. After the lesson on climate change, she strongly disagreed with the statement. She chose uncertain on the pre-test when prompted if climate change is more likely to affect plants than animals and humans. She chose to strongly disagree on the post-test. On the pre-test Sue again chose uncertain for the statement about climate change mainly being manmade and not a natural occurrence and chose to agree on the post-test. Lastly, she chose uncertain on the pre-test for the statement whether we are experiencing an extinction event due to climate change and decided to strongly agree on the post-test.

Question 1: What do you already know about climate change?

Sue explained how familiar she is with climate change. She emphasized her knowledge about the climate changing, ice glaciers shrinking, and the release of trapped greenhouse gases into the atmosphere. She recalled that cows "produce a lot of methane". Sue mentioned the increasing

acidity in the ocean, due to carbon dioxide, being responsible for killing "a lot of plankton and plankton creates oxygen". She also stated that "car, machines, and aerosols" create emissions. Her response was ranked at a 3-expert answer.

Question 2: Are you concerned with the impact of climate change? Why or why not?

Sue discussed her love for "nature and the environment" and how she will "miss all of the things from the natural environment that are going to go away". Sue stated that pollution is "not good to breathe in". She also mentioned the sea level is rising. She expressed sadness when discussing coral bleaching and the potential loss of land in the future due to sea level rising. Her response was ranked at a 2-novice answer.

Question 3: How familiar are you with climate change in south Texas? Is there anything specific that you have noticed?

Sue described noticing the lack of horny toad lizards that she used to see a lot of. She also mentioned the realization that "lots of plants and wildlife" will eventually become extinct. Her response was ranked at a 2-novice answer.

Question 4: How do you feel climate change is portrayed in the media and/or in politics? Give an example.

Sue recalled hearing that "it's a myth and a scam set up by other politicians to take your money". She also expressed her confusion with the newly elected president promising "not to do anything about climate change" and shock at him still getting elected. Her response was ranked at a 2-novice answer.

Question 5: Are you aware of or concerned with your ability to make an impact regarding climate change? Why or why not?

Sue shows her concern by continuing to ride her scooter to and from school, which holds one gallon of gas. When she doesn't ride her scooter, she prides herself on riding the bus. Her purchase of energy saving lightbulbs is another point of pride for her. Her response was ranked at a 3-expert answer.

Rachel

One of the differences between Rachel's pre- and post-tests was her change from uncertain to agreement in the belief that learning about climate change is important to her. Another difference is she chose to agree that the importance of climate change is greatly exaggerated by politicians on the pre-test and became uncertain about the statement on the post-test. Rachel strongly agreed that the climate changing is a natural occurrence on the pre-test, but chose to disagree on the post-test. On the pre-test she agreed that human activities have no effect on climate change and on the post-test strongly disagreed. Rachel chose agree once again with the prompt that there is nothing she can do to help lessen the impact of climate change on the pre-test and changed her mind to uncertain on the post-test. Another notable difference was Rachel agreed on the pre-test that it was not important to her whether humans are causing the climate to change and disagreed on the post-test. On the pre-test she was uncertain that no one knows how to stop climate change and chose agree on the post-test. She chose to agree with the statement that climate change will have no impact on the future on the pre-test and disagreed on the post-test. She was uncertain that climate change is mainly manmade and is not a natural occurrence on the pre-test and chose to agree on the post-test. Lastly, she was uncertain that we are experiencing an extinction event due to climate change on the pre-test and strongly agreed on the post-test.

Question 1: What do you already know about climate change?

Rachel expressed her awareness that climate change is happening and the Earth is getting warmer from the trapping of greenhouse gases. She also discussed a rise in sea level leading to animals possibly losing their habitats. Her response was ranked at a 3-expert answer.

Question 2: Are you concerned with the impact of climate change? Why or why not?

Rachel did not seem to be concerned since she has yet to feel affected by the impact of climate change. Her response was ranked at a 1-naïve answer.

Question 3: How familiar are you with climate change in south Texas? Is there anything specific that you have noticed?

Rachel was not familiar with the possible change in climate in Texas, but felt the weather was either "always really hot or really cold". Her response was ranked a 0-nothing scientific stated.

Question 4: How do you feel climate change is portrayed in the media and/or in politics? Give an example.

Rachel stated how "climate change is portrayed in such a negative way in the media" and "politics and how people are going out of their way to make this a big deal". Her response was ranked at a 1-naïve answer.

Question 5: Are you aware of or concerned with your ability to make an impact regarding climate change? Why or why not?

Rachel stated she was not concerned with her ability to make an impact because she does not consider herself "to be a source that directly affects this cause in a positive way". Her response was ranked at a 1-naïve answer.

Terry

There were many differences between Terry's pre- and post-tests. One of the notable differences was that she agreed that climate change is real on the pre-test and became uncertain

on the post-test. Another difference was she agreed with the statement that learning about climate change issues is important to me on the pre-test, but chose to disagree with it on the post-test. Terry disagreed that the importance of climate change is greatly exaggerated by politicians on the pre-test and agreed on the post-test. She agreed that there is enough scientific evidence proving that the climate is changing on the pre-test and became uncertain on the post-test. Terry was uncertain with the statement that human activities have no effect on climate change on pre-test and agreed on the post-test. She was also uncertain on the pre-test that there is nothing I can do to help lessen the impact of climate change and chose uncertain on the post-test. She agreed that no one knows how to stop climate change on the pre-test and disagreed on the post-test. Lastly, Terry was uncertain with the statement that global climate change is a long term effect that humans should not be concerned with on the pre-test and disagreed on the post-test.

Question 1: What do you already know about climate change?

Terry seemed very familiar with climate change and expressed confidence in knowing that "global warming of two degrees Celsius is our global goal not to surpass due to extreme effects on climate". She has read about the ocean acidification problem and how "coral reefs are dying at an alarming rate". She claimed "the oceans were warming faster than ever in recorded history and the ice caps in the Polar Regions are showing the effects of the warming of the seas". She also mentioned how changes are occurring in human-established environments and global warming is real. She later reflected on the belief that humans can reverse the effects in order to better the future. Her response was ranked at a 3-expert answer.

Question 2: Are you concerned with the impact of climate change? Why or why not?

Terry expressed some confusion with this question. She answered "yes and no" due to her being concerned, but not noticing "much of a change" in her lifetime. Her response was ranked at a 0-nothing scientific stated.

Question 3: How familiar are you with climate change in south Texas? Is there anything specific that you have noticed?

Terry professed her love for science and the environment and considers herself "in the loop when it comes to climate change". She has not, however, noticed anything specific aside from the winters seeming less cold. Her response was ranked at a 1-naïve answer.

Question 4: How do you feel climate change is portrayed in the media and/or in politics? Give an example.

Terry described feeling like climate change is not portrayed well and commented about our newly elected president being uninformed. Her response was ranked at a 0-nothing scientific stated.

Question 5: Are you aware of or concerned with your ability to make an impact regarding climate change? Why or why not?

Terry stated she was aware and concerned but also expressed struggling with the knowledge that "polluting factories being built for the next 20 to 30 years". Her response was ranked at a 1-naïve answer.

CHAPTER IV

Discussion

This research investigated whether factors such as education, political views, and misconceptions regarding climate change can affect the perception of future teachers. The results from the pre- and post-tests showed significant findings in the responses. The statement whether the participants believe climate change is real showed one of the greatest significant differences in their responses. Pre-service teachers were either uncertain how to respond to the statement or simply did not believe in climate change, but changed their mind after the lesson when responding to the same statement on the post-test. Another significant finding was whether the participants believed there is enough scientific evidence proving that the climate is changing. Participants also showed uncertainty or disagreement on the pre-test and seemed to agree after the lesson. The statement whether the participants believed we are experiencing an extinction event due to climate change also showed a significant difference between the pre- and post-tests. Participants again may have been either uncertain how to respond to this statement or disagreed with it before learning more during the lesson on climate change.

Other statements that showed some significance between the pre- and post-tests were the statements assessing if participants believed learning about climate change issues is important to them, if it is important to them whether humans are causing the climate to change, if no one knows how to stop climate change, if the extinction of plants and animals is a natural occurrence, if climate change will have no impact on the future, and if global climate change is a long term effect that humans should not be concerned with. The fact that all of these important statements showed a significant difference in responses shows how even one lesson in climate literacy can help change the views of pre-service teachers.

One of the statements that showed a trend was asking whether climate change will have any impact on the future may have caused some confusion among pre-service teachers and may have led to uncertainty in their responses. It is unclear as to why this statement showed a trend rather than a significant change, since the next statement on the pre- and post-test resulted in significant responses. These statements prompted participants to answer whether they believed global climate change is a long term effect that humans should not be concerned with.

The one-on-one interviews helped further clarify the research question on what pre-service teachers' beliefs were concerning climate change. The first interview question inquired about climate change knowledge. All three participants seemed very knowledgeable on the topic and went into great detail regarding what they already knew. The second question delved into the personal concerns of the pre-service teachers with the impact of climate change and led to very dissimilar answers with two of the participants, Rachel and Terry mentioning they did not feel impacted by climate change. The third question inquired about the pre-service teachers' familiarity with climate change in south Texas. Two of the participants, Rachel and Terry, both spoke about the weather in south Texas instead of the climate. The fourth question asked the pre-service teachers how they feel climate change is portrayed in the media and/or in politics. Sue responded with examples of what she has heard from politicians in the media, but Rachel and Terry instead spoke of their disapproval of politics. The fifth question probed participants about their awareness or concern with their ability to make an impact regarding climate change and also helped answer the research question regarding if the pre-service teachers feel concerned enough to change their behaviors. Sue, again, provided in great detail how she actively does her part in lowering her carbon footprint on a daily basis. Rachel did not feel concerned enough

about the future of climate change or about her ability to make an impact. Terry felt concern, but

struggled with finding a positive way to make an impact regarding climate change.

CHAPTER V

Conclusion

The contrasts in the pre-service teachers' responses between the pre- and post-tests, as well as the interview questions, answered the research question about how the pre-service teachers' beliefs and perceptions changed after a climate change lesson. The responses also showed that regardless of the lesson on climate change they were exposed to, one lesson may in fact lead to more confusion or misconceptions. Students are usually not exposed to climate change in their formative years and begin to learn more about it during college, even though state requirements list climate change as a natural process that should be covered in an Earth and Space Science course offered during their junior or senior year (Texas Education Agency, 2009). Some pre-service teachers saw value in the lesson, but changing someone's beliefs and perceptions about climate change may prove to be quite difficult and one lesson may not be enough.

Climate science data are made available for interested parties in a variety of different methodologies and formats. There are several articles and assessments being conducted showing future projections that have proved to be a challenge to interpret. Scientists' observations and opinions will continue to vary when interpreting data. Current literature, such as the book *Why Scientists Disagree about Global Warming*, implies that scientists are unable to agree regarding climate change issues and examines potential biases they may have. This particular book prepared by the NIPCC is in the process of being distributed to all educators, including college science faculty, K-12 teachers, and administrators. Science is constantly changing and publications politicizing climate change issues are becoming an unfortunate consequence of the vast amount of information available.

Implications, Limitations, and Future Directions

Future investigations and research are still required to help further determine how personal experiences and education can affect perceptions of climate change. Currently, there are not many studies similar to this one without some political bias. Political ties, as well as funding sources, can be associated with numerous published articles and books that make every effort to influence policy against scientific research that opposes their interests. For example, the Heartland Institute is responsible for publishing the book by the NIPCC, and is also the think tank behind past attempts to refute secondhand smoke health risks and present attempts to deny human emissions are the leading cause of climate change (Oreskes & Conway, 2012). The Heartland Institute is funded by conservative individuals and foundations that include well-known companies in the oil and gas, insurance, pharmaceutical, and tobacco industry (Oreskes & Conway, 2012). Locating unbiased publications can be a significant obstacle when conducting research regarding climate change.

Limitations to the study included a sample size of forty pre-service teachers. Increasing the sample size will lead to more generalizable results. Testing more than one school would be an additional option to increase statistical rigor. An investigation including multiple schools from different regions could be used to conduct a similar study and would provide a larger collection of participants and data.

Another limiting aspect came with the use of the pre- and post-tests and interview questions. Similar research could include additional interview questions or a different set of questions, depending on the audience. Targeting pre-service teachers from other schools along coastlines or surrounded by land, may result in different outcomes. All of the participants in this study were enrolled in a specific course that is required for future science educators. Conducting

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a study using pre-service teachers enrolled in a different science education course or pre-service teachers that have previously been enrolled in geoscience courses that covered climate literacy education may be another viable option. Educators becoming more familiar with pre-service teachers' misconceptions regarding climate change and political views may be the key to future educational approaches allowing instructors to plan around these factors. Examples such as articles and assessments published by organizations similar to the IPCC and the NIPCC show that many media and political forces are at play in helping persuade educators to provide "alternate views" in the science behind climate change. Further studies regarding perceptions of teachers and students can help scientists and educators better understand public views about climate change.

APPENDICES

Appendix A: Sample Pre-/Post-Test

NAME :
DATE:

PRETEST: CIRCLE YOUR RESPONSE FOR EACH QUESTION	Strongly Disagree		Uncertain		Strongly Agree
1. I believe climate change is real.	1	2	3	4	5
2. Learning about climate change issues is important to me.	1	2	3	4	5
3. The importance of climate change is greatly exaggerated by politicians.	1	2	3	4	5
4. There is enough scientific evidence proving that the climate is changing.	1	2	3	4	5
5. The climate changing is a natural occurrence.	1	2	3	4	5
6. Human activities have no effect on climate change.	1	2	3	4	5
7. There is nothing I can do to help lessen the impact of climate change.	1	2	3	4	5
8. It is not important to me whether humans are causing the climate to change.	1	2	3	4	5
9. No one knows how to stop climate change.	1	2	3	4	5
10. Extinction of plants and animals is a natural occurrence.	1	2	3	4	5
11. Climate change will have no impact on the future.	1	2	3	4	5
12. Global climate change is a long term effect that humans should not be concerned with.	1	2	3	4	5

13. Climate change is more likely to affect plants than animals and humans.	1	2	3	4	5
14. Climate change is mainly man-made and is not a natural occurrence.	1	2	3	4	5
15. We are experiencing an extinction event due to climate change.	1	2	3	4	5

Melting Ice and Rising Sea Levels

Objectives
- Students are introduced to climate change terminology and instruction.
- Students are exposed to the threat posed by melting glaciers.
- Students understand how predictions and observations are formed.
- Students engage in class discussions regarding sea level rising experiment.

Materials:
Container, equal amounts of sand and water, ruler, digital thermometer, piece of ice, timer

Engage
Demonstration activity:
1. Add water and sand to plastic container.
2. Measure depths of water and sand.
3. Take temperature of water.

What could cause the temperature of water to rise?

Explore
1. Add ice to water and measure depth of ice.
2. Take temperature every thirty minutes.

Predict what will happen to the temperature of the water throughout this experiment.

Data Table 1	
Amount of water	
Amount of sand	
Depth of water	
Depth of sand	
Starting temperature of water	
Depth of ice	
Width of ice	
Starting time	

Explain
What happened to the ice?

What caused this?

Was your prediction correct? Why or why not?

Data Table 2	
Depth of water	
Depth of sand	
Ending temperature of water	
Depth of ice	
Width of ice	
Ending time	

Elaborate
Designing your own investigation

What question do you have about sea level rise? Write your testable question below.

How would you design an experiment to test your question?

What materials could you use?

What steps will you follow to carry out this experiment?

Make a prediction. What do you think will be the result?

Evaluate
How do you think global climate change can affect sea level rise?

How would rising sea levels affect the oceans? the coast?

How would a decrease or increase in ocean temperature affect marine animals? Why?

*Borrowed in part from "Northern Nevada Science Teachers Present: Climate Change Activities for the Classroom" and "Patterns of Change: Forces and Motion"

Rising Sea Levels

Watch the video and answer the questions below.

Link: http://www.nbclearn.com/changingplanet/cuecard/53460

Fill in the blanks:

1. _____ of the World's population lives within _____ miles of the coast.

2. Global sea level rise has accelerated over the past 100 years with a rise of _____ during this time. Models predict a rise of anywhere between _____ and _____ for the next 100 years.

3. List five impacts of rising sea levels, some of which are already being felt around the world.

4. According to scientists, what are the two main causes for rising sea levels? What is their contribution (%) to the rise respectively?

5. What are some of the concerns regarding the melting of marine ice sheets?

6. According to scientists what is currently the greatest threat to rapid sea level rise?

7. According to more recent satellite data, by how much are sea levels currently rising per year on average?

8. What influences local sea level rises in addition to the global changes?

9. How do geologists reconstruct sea level changes of the past?

10. Given what you already know AND after watching this video, what area around here locally do YOU think is at greatest risk of rising sea levels? Briefly explain why you chose that particular area.

Appendix D: Sample Participant Interview Protocol

1. What do you already know about climate change?

2. Are you concerned with the impact of climate change? Why or why not?

3. How familiar are you with climate change in south Texas? Is there anything specific that you have noticed?

4. How do you feel climate change is portrayed in the media and/or in politics? Give an example.

5. Are you aware of or concerned with your ability to make an impact regarding climate change? Why or why not?

LITERATURE CITED

Akerlof, K., & Maibach, E. W. (2011). A rose by any other name ...?: What members of the general public prefer to call "climate change": A letter. *Climatic Change*, *106*(4), 699-710. doi:10.1007/s10584-011-0070-4

Brody, S. D., Zahran, S., Vedlitz, A., & Grover, H. (2008). Examining the relationship between physical vulnerability and public perceptions of global climate change in the United States. *Environment and Behavior*, *40*(1), 72-95. doi:10.1177/0013916506298800

Bybee, R. W. (2014). The BSCS 5E instructional model: Personal reflections and contemporary implications. *Science and Children*, *51*(8). 10-13.

Caldeira, K. (2016). Stop emissions! A climate scientist argues that public attitudes must change so that it is no longer acceptable to dump carbon dioxide in the sky. *MIT Technology Review*, (1). 40-43.

Christensen, R., & Knezek, G. (2015). The Climate Change Attitude Survey: Measuring Middle School Student Beliefs and Intentions to Enact Positive Environmental Change. *International Journal of Environmental & Science Education, 10*(5), 773-788.

Climate change. (2017). *Merriam-Webster.com*. Retrieved June 25, 2017, from https://www.merriam-webster.com/dictionary/climate%20change

Cooney, C. M. (2010). The perception factor: Climate change gets personal. *Environmental Health Perspectives*, *118*(11), A484.

Creswell, J. W. (2015). *Educational research: planning, conducting, and evaluating quantitative and qualitative research* (5th ed.). Pearson.

Goebbert, K., Jenkins-Smith, H. C., Klockow, K., Nowlin, M. C., & Silva, C. L. (2012). Weather, climate, and worldviews: The sources and consequences of public perceptions

of changes in local weather patterns. *Weather, Climate, and Society, 4*(2), 132-144. doi:10.1175/WCAS-D-11-00044.1

Global climate change. (2017). *The Free Dictionary.com*. Retrieved June 25, 2017, from http://www.thefreedictionary.com/global+climate+change

Global warming. (2017). *Merriam-Webster.com*. Retrieved June 25, 2017, from https://www.merriam-webster.com/dictionary/global%20warming

Greenhouse effect. (2017). *The Free Dictionary.com.* Retrieved June 25, 2017, from http://www.thefreedictionary.com/greenhouse+effect

Howard, R. (2009). The politics of climate change. *The Futurist*, (6), 24-27.

Idso, C. D., Carter, R. M., & Singer, S. F. (2016). *Why scientists disagree about global warming: the NIPCC report on scientific consensus*. Arlington Heights, IL: Published for the Nongovernmental International Panel on Climate Change (NIPCC) by the Heartland Institute.

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research, 1*(2), 112-133. doi:10.1177/1558689806298224

Kiley, T., M.S.Ed. (2016). Northern Nevada science teachers present: Climate change activities for the classroom (J. Ewing-Taylor Ph.D., Ed.). Retrieved June 25, 2017, from http://sensor.nevada.edu/Static/Documents/Education/Washoe%20Activities/Reference/EPSCoR%20GCC%20Activity%20Manual.rev6-17.pdf

Lambert, J. L., & Bleicher, R. E. (2013). Climate change in the preservice teacher's mind. *Journal of Science Teacher Education, 24*(6), 999-1022. doi:10.1007/s10972-013-9344-1

Liu, S., Roehrig, G., Bhattacharya, D., & Varma, K. (2015). In-service teachers' attitudes, knowledge and classroom teaching of global climate change. *Science Educator, 24*(1), 12- 22.

Lombardi, D., & Sinatra, G. M. (2013). Emotions about teaching about human-induced climate change. *International Journal of Science Education, 35*(1), 167-191. doi:10.1080/09500693.2012.738372

NBC Learn (Producer). (2011). *Rising Sea Levels* [Video]. Available from http://www.nbclearn.com/changingplanet/cuecard/53460

Oreskes, N., & Conway, E. M. (2012). *Merchants of doubt: how a handful of scientists obscured the truth on issues from tobacco smoke to global warming*. London: Bloomsbury.

Perception. (2016). *Merriam-Webster.com*. Retrieved December 8, 2016, from https://www.merriam-webster.com/dictionary/perception

Phillips, M. & Jeffery, T. D. (2016). Patterns of change: Forces and motion. *Science Activities: Classroom Projects and Curriculum Ideas, 53*(3), 101-111. doi:10.1080/00368121.2016.1188052

Rockström, J., Brasseur, G., Hoskins, B., Lucht, W., Schellnhuber, J., Kabat, P., . . . Arnott, J. (2014). Climate change: The necessary, the possible and the desirable earth league climate statement on the implications for climate policy from the 5th IPCC assessment. *Earth's Future, 2*(12), 606-611. doi:10.1002/2014EF000280

Selin, H., & VanDeveer, S. D. (2007). Political science and prediction: What's next for U.S. climate change policy? *Review of Policy Research, 24*(1), 1-27. doi:10.1111/j.1541-1338.2007.00265.x

Simon, S. (2010). *Global warming*. First edition. New York: Collins.

Sklar, S. (2016). Looking at the World Through One Lens. *Solar Today*, *30*(4), 52-53.

Smith, J. W., Bitsura-Meszaros, K., & Keane, R. (2016). Differences between Conservatives and

    Liberals in Information-Seeking Behavior and Perceived Risks Associated with Climate-

    Driven Changes to Local Forest Conditions. *Weather, Climate & Society, 8*(1), 43-55.

    doi:10.1175/WCAS-D-15-0046.1

Strauss, B., C. Tebaldi, S. Kulp, S. Cutter, C. Emrich, D. Rizza, and D. Yawitz (2014). Texas

    and the Surging Sea: A vulnerability assessment with projections for sea level rise and

    coastal flood risk. *Climate Central Research Report*. pp 1-29.

Texas A&M University Corpus Christi. (n.d.). Retrieved from http://www.tamucc.edu/

Texas A&M University Corpus Christi. (Fall, 2013). *GEOL 1303 Essentials of Geology* [Class

    Handout]. Corpus Christi, TX: Texas A&M University Corpus Christi.

Texas Education Agency. (2009). Chapter 112. *Texas Essential Knowledge and Skills for*

    Science, Subchapter C. High School. Adopted August, 2009.

Villar, A., & Krosnick, J. A. (2011). Global warming vs. climate change, taxes vs. prices: Does

    word choice matter? *Climatic Change*, *105*(1), 1-12. doi:10.1007/s10584-010-9882-x

Yang, Z. J., Kahlor, L. A., & Griffin, D. J. (2014). I share, therefore I Am: A U.S.--China

    comparison of college students' motivations to share information about climate change.

    Human Communication Research, *40*(1), 112-135. doi:10.1111/hcre.12018