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Preservice Teacher Perceptions of Climate Change

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Abstract
Climate change has been increasingly become a debated topic among the public, scientists and educators. Terminology, politics, and misconceptions can bias perceptions. This study examined climate change perceptions of approximately 40 future elementary and middle school science teachers enrolled in a south Texas university. Data included pre- and post-tests tests and open-ended interviews. Results showed a significant change in perceptions regarding the reality and the causes of climate change. The following describes a climate change inquiry lesson plan that changed perceptions for future science teachers.

Introduction
The regard for the potential seriousness of climate change is dependent on the beliefs of the audience in question. Brody, Zahran, Vedlitz & Grover (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. Geographic factors, such as low elevation and distance from the coast, can be instrumental when influencing public recognition of the conceivable negative impacts caused by climate change (Brody et al., 2008).

Extensive data regarding climate change can be found in books, dedicated websites and various types of articles. Because of this, average temperature figures can often lead researchers to very contradictory conclusions due to uncommon weather anomalies. For example, the United Nations' Intergovernmental Panel on Climate Change (IPCC, 2014) and the Nongovernmental International Panel on Climate Change (NIPCC, 2016) 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. The IPCC (2014) regularly publishes assessments containing contributions from the scientific community on climate change, the most recent being in 2014. According to Idso et al. (Idso, Carter, & Singer, 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 (2016), for example, was created to discredit to some extent or to simply downplay the claims that organizations like the IPCC continue to make. Therefore, the purposes of this study are to research and ascertain how perceptions can influence beliefs relating to climate change and to contribute to the field of geoscience education.

Politics and Climate Change

In 2010, Cooney's research spoke to the vast difference in opinion between the scientific community and its overseeing policymakers (Cooney, 2010). Climate change is also used by politicians and other decision-making individuals to influence public opinion. 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 may be distrustful of the scientific community. While there are some politicians that believe in climate change, they may not necessarily believe it is manmade or feel it is a pressing problem (Idso et al., 2016).

Villar and Krosnick (2011) questioned if political party affiliations could predict the preference in terminology. While climate change, global warming, and global climate change basically have the same definition or interpretation, the difference in terminology the two previously stated studies show how the public see climate change as a less severe way of saying global warming and global climate change. Public perceptions will continue to be driven by the politicizing of climate change (Howard, 2009).

Misconceptions Regarding 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 (Caldeira, 2016). 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. 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. Changing public perception through either an informal or formal method of education will need to occur for any of the suggestions to be accepted and practiced.

Depending on their own personal biases, teachers can influence student perceptions through their curriculum (Lambert & Bleicher, 2013). Teachers may not realize they are subconsciously passing on their beliefs to their students during instruction (Shiyu, 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.

Public perception, political views and misconceptions regarding climate change led to investigating the following research questions. First, what are pre-service teachers' beliefs concerning climate change? Second, do pre-service teachers feel concerned enough about climate change to change their behaviors? And third, how did the pre-service teachers' beliefs and perceptions change after a climate change lesson?

Research Methods

During the 2017 academic year, this study was conducted at a regional university located in south Texas designated as a Hispanic Serving Institution (HSI). Forty undergraduate pre-service teachers preparing to teach Kindergarten to 8th grade level (K-8) are enrolled in a required life science pedagogy and content course. The ethnicity of the participants was 20-Hispanic, 19-Anglo American, and 1-African American pre-service teacher. 93.5% of the participants were female, while 6.5% were male.

A mixed methods approach (Johnson, Onwuegbuzie, & Turner, 2007) included quantitative data collected from Likert scaled pre- and post- tests that included responses ranging from strongly disagree (1) to strongly agree (5). Surveys, adapted from Christensen and Knezek

(2015), contained fifteen questions directly related to climate change. The pre-tests were distributed during class approximately a month before the participants were given the climate change lesson that followed with post-tests. Qualitative data were collected from the face to face open-ended interviews and will be reported in a separate paper.

The Biological Sciences Curriculum Study (BSCS) 5E Instructional Model was designed and includes five phases in the research-based model: engagement, exploration, explanation, elaboration, and evaluation (Bybee, 2014). The engagement phase used a demonstration to obtain the students' attention and engage them in the lesson. The second phase was the exploration phase and included an activity or activities where students used a hands-on approach. The third phase, the explanation phase, used different types of media to help guide students through the explanation process. The fourth phase was the elaboration phase. During this phase, students are not only encouraged to work in groups, but were also introduced to new situations where they were required to apply the concepts they just learned in the previous phases. The fifth phase, the evaluation phase, included an assessment where students provided evidence of learning to the instructor.

A 5E Instructional Model worksheet on melting ice and rising sea levels served as an important supplement to the lecture which clearly outlined the student objectives and had each phase/section underlined. The engagement activity required participants to add water and sand to a container, and then to measure the initial depths and temperature of the water, recording data on the data sheet. Participants then answered what they thought could cause the temperature of the water to rise. The exploration phase had participants add a small piece of ice to the water and measure the depth. The participants then took the temperature of the water every thirty minutes. They also predicted the temperature of the water throughout the experiment. For the third explanation phase, the participants described 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 regarding sea level rise. Participants 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. A short video titled "Rising Sea Levels" on the NBC Learn (2011) website was used to explain some of the global-scaled impacts resulting from climate change and a worksheet included nine questions addressing information from the video.

Data Analysis

The data pre- and post-tests were analyzed by using a paired t-test. 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 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 illustrate graphically the mean and standard deviation for the pre- and post-tests with confidence intervals.

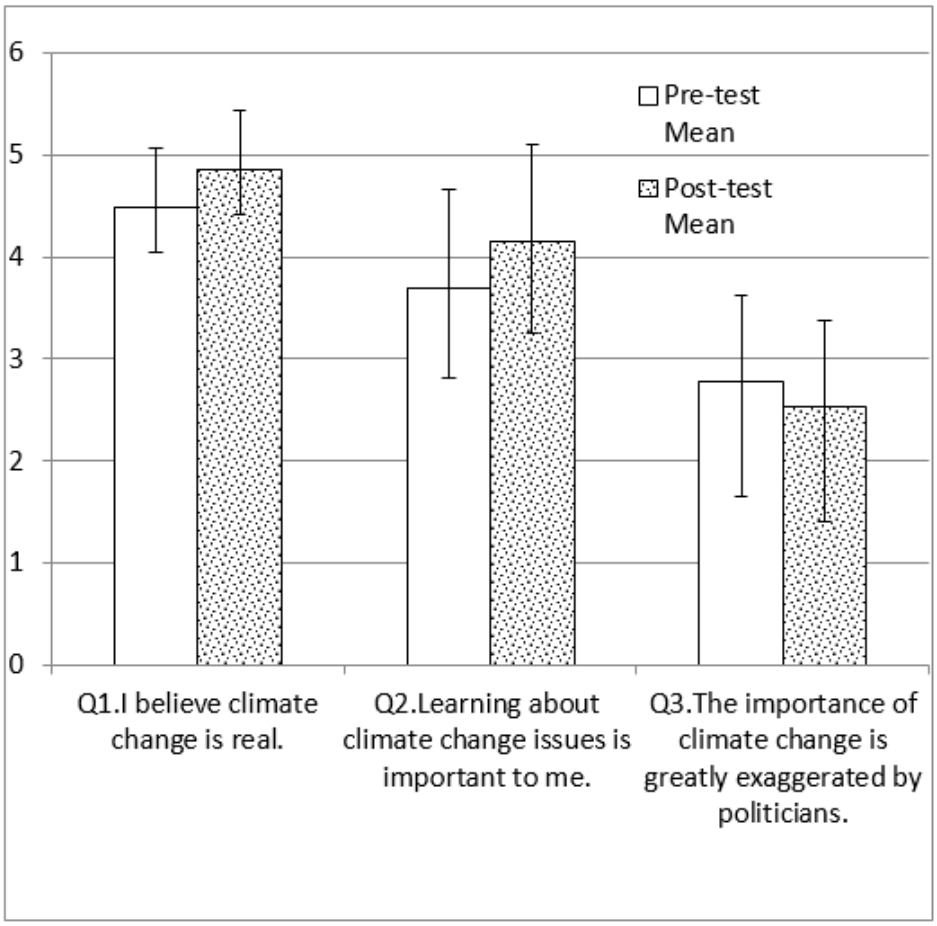

Figure 1: Questions 1-3 Pre- and Post-test Mean & Standard Deviation

Question 1 asked students to indicate whether they thought climate change was “real” and as indicated in Table 1, there was a significant increase in those that did think that climate change was a reality following the lesson ($p=0.0002$). Question 2 also had significant changes in student perceptions regarding the importance of climate change where significantly more students believed it is an important issue ($p=0.0107$). In question 3, less students thought that the importance of climate change is greatly exaggerated by politicians but not by a statistically significant difference than before the lecture ($p=0.2151$) (Figure 1).

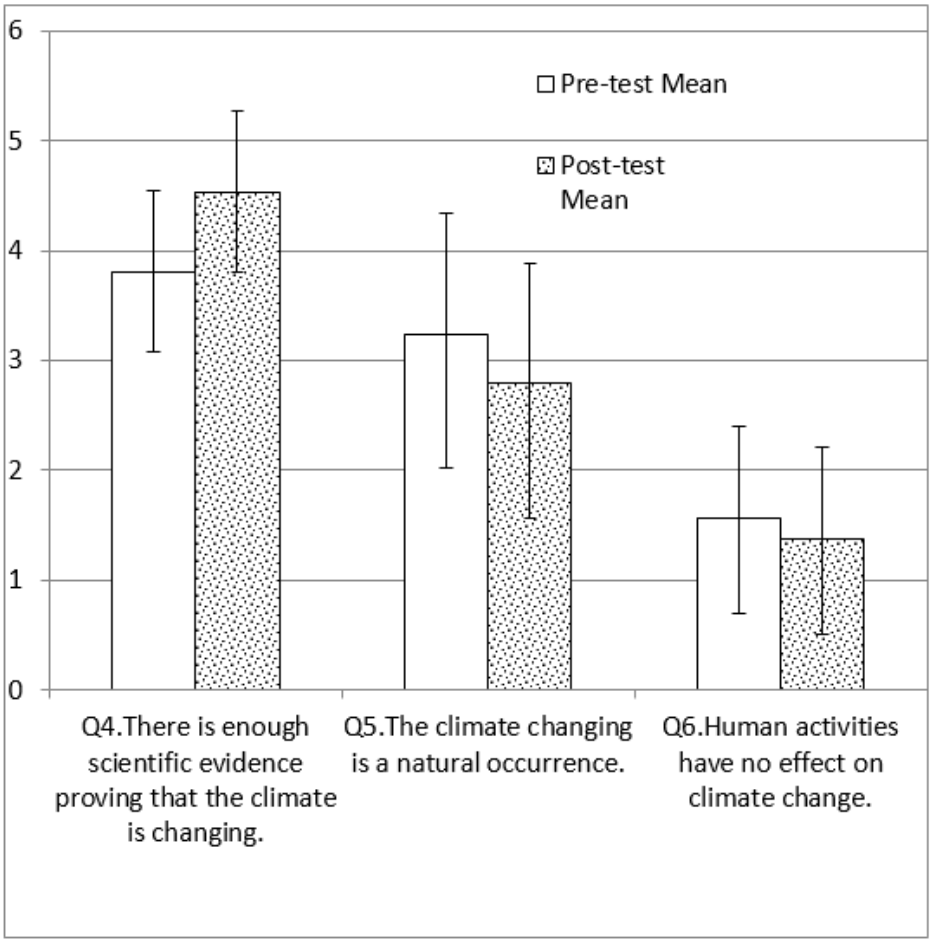

Figure 2: Questions 4 – 6 Pre- and Post-test Mean & Standard Deviation

Question 4 had a significant difference in students thinking there is enough evidence supporting the fact that the climate is changing with more thinking that there is enough evidence after the lesson than before the lesson ($p=0.0001$). Questions 5 and 6 did not have significant differences but indicated less preservice teachers thought that current climate change is a natural occurrence (Q5) and that human activities had no effect on climate change (Q6) after the lesson than before the information was presented (Figure 2).

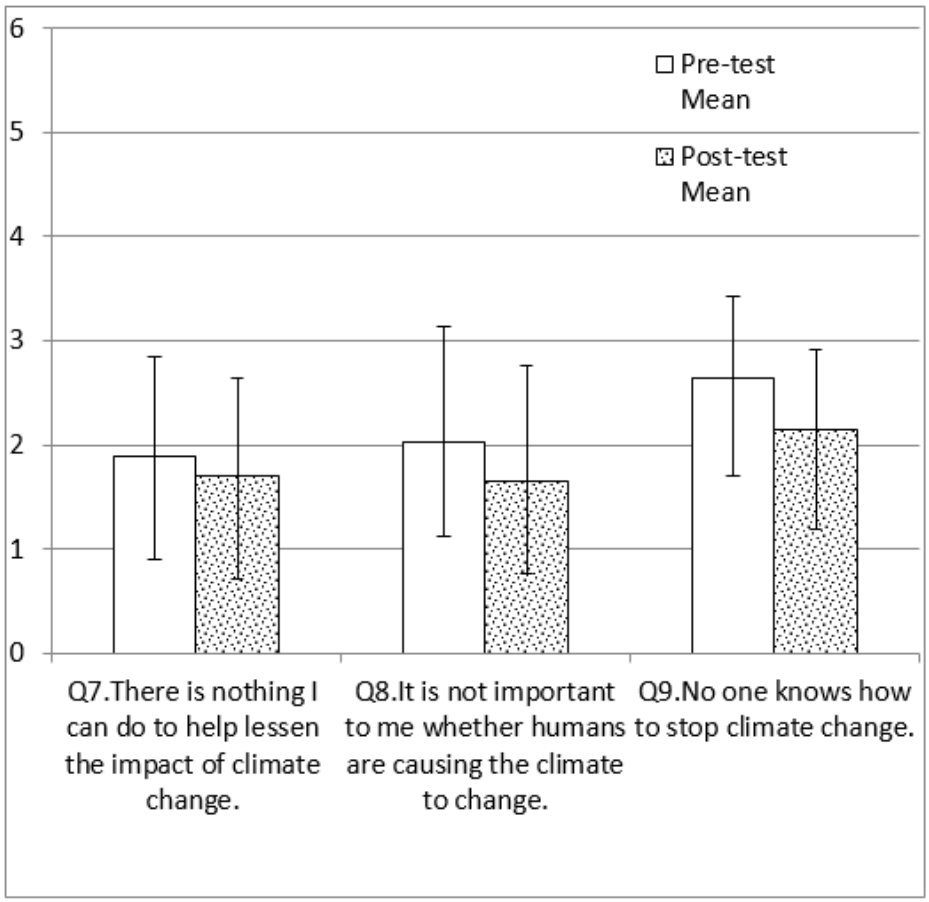

Figure 3: Questions 7 - 9 Pre- and Post-test Mean & Standard Deviation

Question 7 provided no significant change in those that thought there was nothing they could do to help lessen the impact of climate change though fewer did not agree with that statement following the climate change lesson (p=0.3046) (Figure 3). However, questions 8 and 9 did have significant differences between the pre- and post-tests. Question 8 stated that 'it is not important to me whether humans are causing the climate to change" and significantly less students felt that statement was true after the lesson (p=0.0105) (Figure 3). Question 9 also had significantly less students believing that no one knows how to stop climate change after the climate change lesson (p=0.0050) (Figure 3).

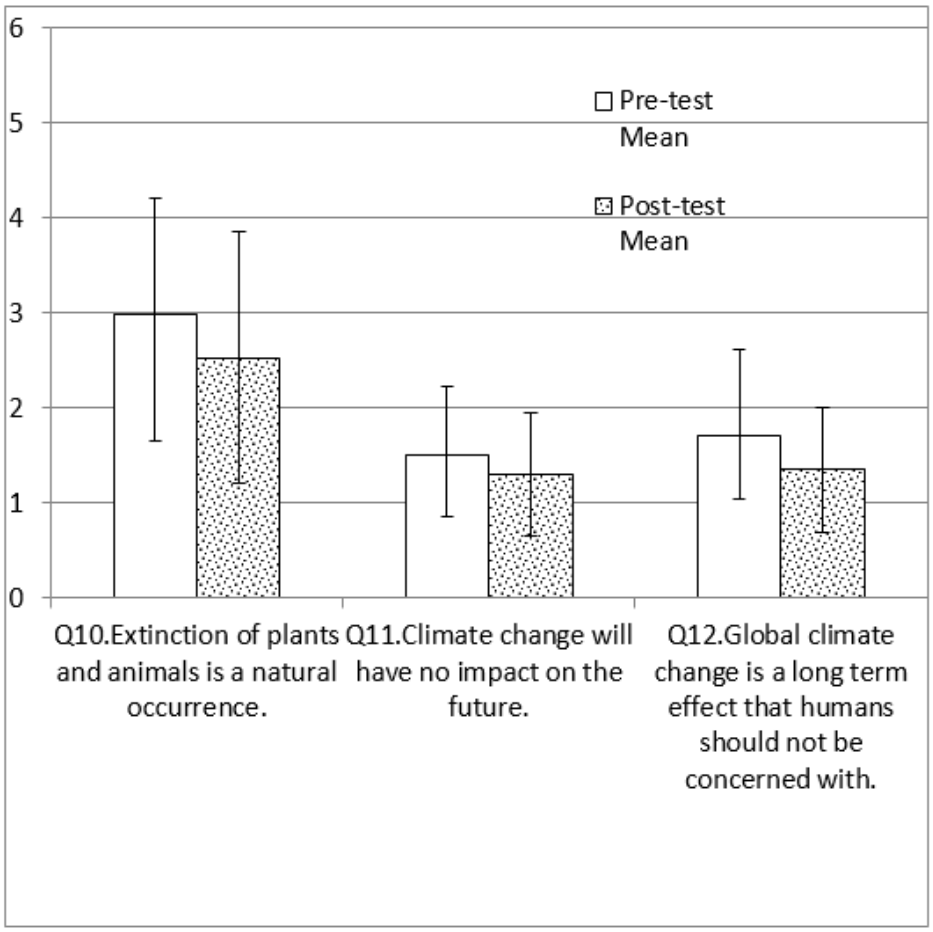

Figure 4: Questions 10- 12 Pre- and Post-test Mean & Standard Deviation

Questions 10, 11 and 12 all had significant differences before and after the classroom lesson (Figure 4). Question 10 stated that the extinction of plants and animals is a natural occurrence. Significantly fewer students agreed with this statement after the lesson ($p=0.0091$). Question 11 stated that climate change will have no impact on the planet and again, significantly fewer students agreed with this statement after the exam ($p=0.0114$) as did question 12 which stated that climate change is a long-term effect that humans should not be concerned with ($p=0.0114$) (Figure 4).

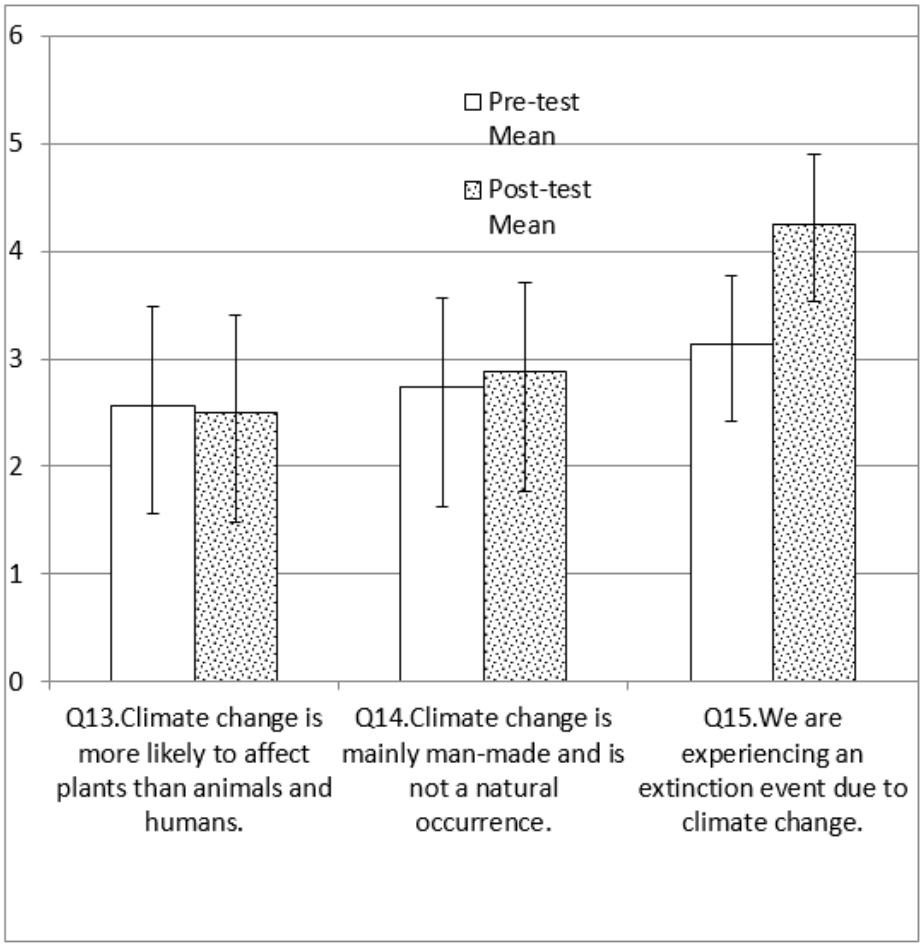

Figure 5: Questions 13-15 Pre- and Post-test Mean and Standard Deviation

Question 13 (Figure 5) stated that climate change is more likely to affect plants than animals and humans. There was no significant difference (p=0.6857) as students felt about the same before and after the classroom lesson, with only slightly less thinking that climate change is more likely to affect plants than animals and humans. Question 14 had little change in pre- and post-tests as only slightly more students thought climate change is mainly man-made and not a natural occurrence following the lesson (p=0.8677) (Figure 5). However, question 15 also had significantly more students thinking that they are experiencing an extinction event due to climate change following the lesson (p=0.0001) (Figure 5).

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 several significant findings in the responses. The question asking participants if they believe climate change is real had a highly significant difference in their responses (Q1). 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 (Q4). 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 (Q15) with significantly more participants believing we are experiencing an extinction event following the lesson than before the lesson. 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 (Q2), if it is important to them whether humans are causing the climate to change (Q8, if no one knows how to stop climate change (Q9), if the extinction of plants and animals is a natural occurrence (Q10), if climate change will have no impact on the future (Q11), and if global climate change is a long term effect that humans should not be concerned with (Q12). The fact that 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 (Q11) 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, global climate change is a long-term effect that humans should not be concerned with (Q12) resulted in significant responses indicating preservice teachers were concerned with long term effects of climate change. Clearly, there was some confusion in these responses that may be related to the way the questions were posited.

Conclusions

The contrasts in the pre-service teachers' responses between the pre- and post-tests answered the research question regarding how the pre-service teachers' beliefs and perceptions changed after a single climate change lesson. The responses also showed that one lesson may 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. Data indicate that 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.

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 proven challenging to interpret. 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 (2016) is in the process of being widely distributed to 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. 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 (2016), and is also the funder supporting past attempts to refute secondhand smoke health risks and NIPCC recent attempts to deny human emissions are the leading cause of

climate change. Notably, 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, 2011).

Locating unbiased publications can be a significant obstacle when conducting research regarding climate change. Statistical rigor could be increased by increasing the sample size of 40 subjects will lead to more generalizable results. 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.

Teacher educators becoming more familiar with pre-service teachers' misconceptions regarding climate change and political views may be the key to future educational approaches to planning instruction. Examples such as articles and assessments published by organizations like the IPCC (2014) and the NIPCC (2016) 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.

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