Exploring Persistent Climate Change Misconceptions of Environmental Science Majors after Completing a Global Climate Change Course

American Meteorological Society

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Climate Studies Diversity Project

Overview

Presented are the results of the first of many studies that explore the occurrence of conceptual and factual misconceptions about basic meteorology and climate change and how these misconceptions affect the learning processes of Environmental Science majors taking their first Global Climate Change class. Students in the Global Climate Change class each take a survey, composed of questions centered on climate change concepts and facts, on the first day of class, and then take the same survey on the last day of class. The results of their answers to the survey are analyzed for persistent misconceptions. This study is just a small part of a much larger effort to identify both conceptual and factual science related misconceptions students bring into the classroom that may hinder their learning experience, and the persistence of those misconceptions throughout the curriculum. The effectiveness of the learning experience is also explored by comparing the scored versions of the "before and after" survey and subjecting those results to a one sided T-test.

Background

Learning the basic concepts in each STEM discipline (basic sciences), like those taught in BC's new Global Climate Change course, can be difficult due to the conceptual and factual misconceptions a student brings to the learning experience or may even create during the learning experience. This is especially true for Meteorology and Climate Sciences, where what is learned in the classroom collides with years of the student's personal experience with weather and climate. Unlike the other sciences, everyone on the planet experiences and observes weather and climate on a constant basis. "Everyone talks about the weather".

Added to this is that our changing climate has become one of the most important issue of our time, receiving extensive media and political coverage that is loaded with inaccuracies and bad science, greatly influencing what the layperson knows about basic meteorological concepts and beliefs about global climate change (Rappaport 2009). An assessment given at the U.S. Air Force Academy designed to measure the evolution of meteorology knowledge over the course of the required major courses, revealed that misconceptions can still exist even among graduating seniors, demonstrating their exceptional persistence despite years of instruction. To eradicate misconceptions and improve learning, they must be identified and dealt with head-on (Posner et al. 1982). Several science disciplines have had great success toward this end by developing standardized assessments designed to identify common misconceptions for their student populations, including physics (Halloun and Hestenes 1985; Hestenes et al. 1992), astronomy (Zeilik et al. 1997; Hufnagel 2002), biology (Anderson et al. 2002), statistics (Allen et al. 2004), and the geosciences (Libarkin and Anderson 2005).

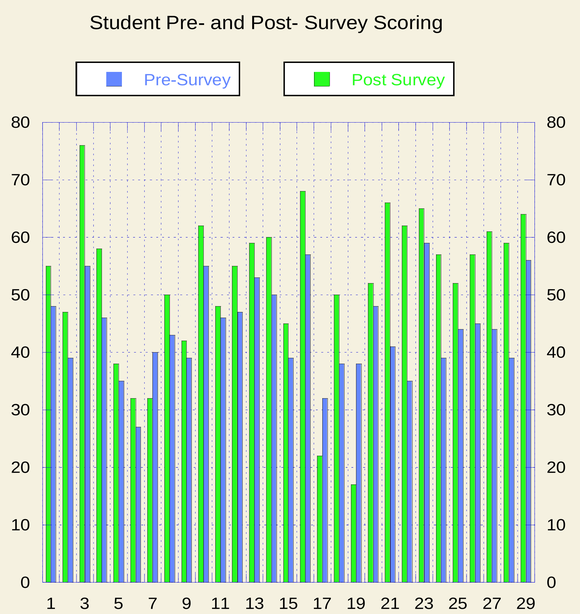
To date, very few broad-reaching assessments exist for the discipline of meteorology, particularly Global Climate Change (*e.g. Global warming and climate change: Common misconceptions about climate change.* Carnegie Mellon University, Department of Engineering and Public Policy. http://www.gcrio.org/gwcc/misconceptions.html). By identifying common meteorology misconceptions, science educators can develop effective instructional approaches in the classroom that best correct these misconceptions and help students attain a more accurate and complete understanding of the science. These results will therefore have broad impact due to the largely unexplored potential of improving student learning in meteorology, climate studies, and climate change.

Methodology

In 2010, the study "*American's Knowledge of Climate Change*" was conducted by the Yale Project on Climate Change Communication (YPCCC) and funded by NSF, as part of the Communicating Climate Change Initiative. A nationally representative survey of 2,030 American adults aged 18 and older was sample weighted to correspond with US Census Bureau demographic and Gallup political party identification parameters for the United States, and a survey was given to them. The survey is comprised of questions aimed at assessing the knowledge of the respondents about how the climate system works, specific knowledge about the causes, consequences, and potential solutions to global warming, contextual knowledge of human caused global warming in a historical and geographic perspective, and practical knowledge of individual and collective social action. This study included measures related to each of these key dimensions, along with other measures such as public desire for more information, trust in a variety of information sources, climate change risk perceptions and policy preferences.

I have slightly modified the survey so that it can be easily scored. The questions in the survey remain essentially the same, encompassing the same parameters as the original YPCCC survey. I am using this survey because it covers everything needed for in this preliminary investigation, and since it is nationally representative of our population and sample weighted as of the last Census, as well as broadly encompassing most aspects of climate science, including scientific, social, and political, any current or future data collected can then be compared to YPCCC national results.

In this study, a of 31 students pursuing their B.S. degree in Environmental Science at Broward College was given the *modified* version of the YPCCC assessment on the first day of their Global Climate Change (GLY4746) class. There are 98 survey questions, although only 86 are scored. The questions are multiple choice style with a few T/F questions. This same assessment was given to the same students on the last day of the semester long Global Climate Change class. Two students did not finish the class. The results of the "before and after" semester *survey/assessment* taken by Broward College Environmental Science students enrolled in GLY4746 are evaluated to elucidate the occurrence of common weather, climate, and climate change misconceptions that persist even after taking the Global Climate Change course. Identifying these misconceptions and developing effective teaching methods to address each misconception is key to building a strong climate change course and ensuring the effectiveness of student climate change learning and comprehension. This is expected to be an ongoing project, with data collected and synthesized with each GLY4746 class offered during the next several years.



T-Test for Pre and Post Survey Scores

	Group 1	Group 2
Count	29	29
Mean	52.1034	44.0345
Variance	185.953	63.0345
Std. Dev.	13.6365	7.93943
Std. Err	2.53223	1.47431

Mean Difference	8.06897
Degrees of Freedom	28
t Value	4.3831
t Probability	0.0001493

ES = 0.72

Instructional Materials

1) Global Climate Change. Kitchen, D. 2014. Ch 1 – 6
2) *Explaining Climate Change: Visualizing and Understanding the Science of Climate Change*: International Union of Pure & Applied Chemistry (IUPAC), King's Centre for Visualization in Science (Canada), Royal Society of Chemistry (UK), American Chemical Society (ACS), http://www.explainingclimatechange.ca
3) Gateways to Glaciations: Ocean Drilling Program interactive CD, Joint Oceanographic Institution/US Science Support Program (2002 – 2009)
4) AMS Climate Studies Diversity Project *Our Changing Climate*, 2014
5) TASA Graphics Earth Science Animations (Prentice Hall)
6) *Experimenting on a Small Planet*. Hay, W., 2013

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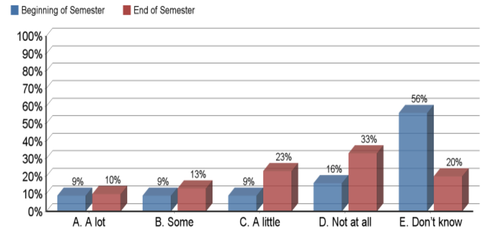
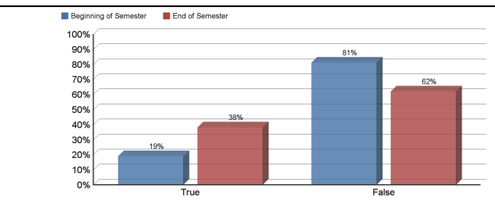
Results from a Comparison of the Before and After Semester Scored Surveys that Suggest Persistent Misconceptions Based on Response Pattern

Q 19. How much can phases of the moon affect the average global temperature of the Earth?



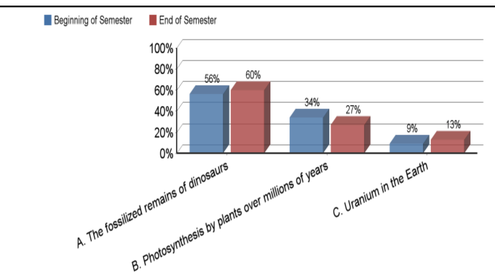
46% of students (after taking the class) believe that the phases of the moon have some affect on Earth's average global temperatures. Prior to taking the class, only 27% of the class believed this. The result is puzzling and will be further explored.

Q44. Wood is a fossil fuel.



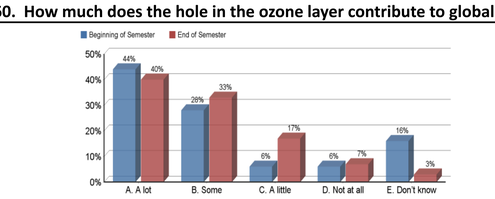
The number of students who think that wood is a fossil fuel doubled in the survey taken by students at the end of class, possibly indicating a mis-interpretation of some concepts in the learning process. Furthermore, in Q45. and Q46 (see attached survey results)., there is essentially no change in the number of students who think that hydrogen and solar energy are fossil fuels (13% and 10% respectively). Although a simple concept, the pattern of responses in these three questions point to some misconception on what is a fossil fuel.

Q47. The energy in fossil fuels originally came from:



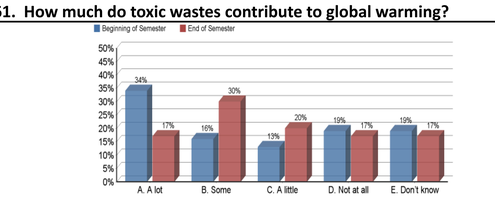
Prior to taking the class, 56% of the class thought that fossil fuel energy came from fossilized remains of dinosaurs. After taking the class, this figure rose to 60%. Clearly this is a significant persistent misconception. Contrary to what many people believe, fossil fuels are not the remains of dead dinosaurs. Misconception may have had its beginnings in 1933, when Sinclair Oil Corp. sponsored a dinosaur exhibit at the Worlds Fair on the premise that oil reserves formed during the Mesozoic Era, which is the Age of the Dinosaurs. Only 10 years ago, Exxon was running a commercial with a cartoon dinosaur and the quote "this dinosaur gave its all" to become part of the oil pumped from the ground. Oil deposits are products of marine phytoplankton that have been deposited and undergone a process of maturation.

Q60. How much does the hole in the ozone layer contribute to global warming?



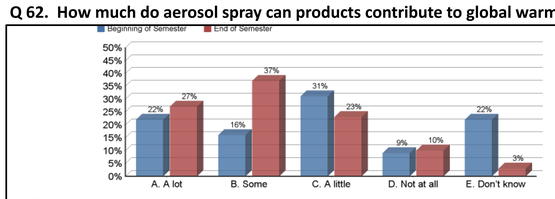
This is one of the quintessential climate change misconceptions: the hole in the ozone layer and its contribution to global warming. Before taking the class, 78% of the students thought that the ozone hole contributes to global warming. After taking the class, 90% of the students believed that the ozone hole contributes to global warming to some degree. Because our atmosphere is one connected system ozone depletion and global warming are related in other ways. Climate change may contribute to the thinning of the ozone layer, however the ozone hole is not a mechanism of global warming. This misconception will be explored further.

Q61. How much do toxic wastes contribute to global warming?



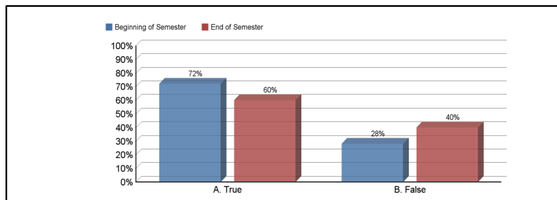
Before taking the class, 63% of students believed that toxic wastes contribute to Global warming. After taking the class, that number increased to 67%, indicating a persistent misconception with this concept. Perhaps the student is linking the production of methane in garbage landfills and other non toxic waste deposits. The fate of toxic waste and impact to the environment is significant, however, toxic wastes are not a mechanism of global warming.

Q 62. How much do aerosol spray can products contribute to global warming?



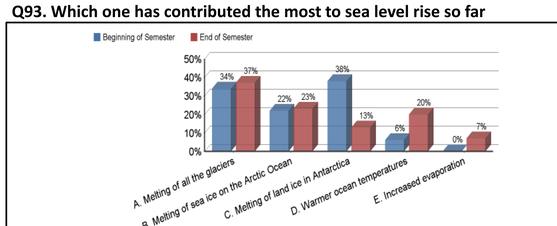
69% of the students at the beginning of the semester thought that spray can products contributed to global warming, increasing to 87% after taking the class. Students were taught in class that aerosols ,"particulate matter in the atmosphere", affect global warming; however, a significant number begin the class linking aerosols, "chloro-fluoro-carbons", from spray cans to the destruction of the ozone layer. Without clear distinction made between these two meanings of the word "aerosol", the misconception arises that spray can aerosols are associated with global warming, and offers one hypothesis as to why there is an 18% increase in students who believe this at the end of class.

Q89. Melting of sea ice on the Arctic Ocean can cause global sea-levels to rise



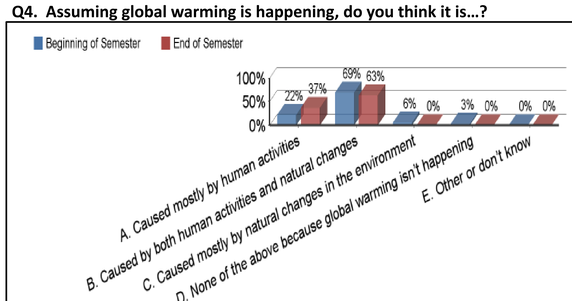
Even though there was a 12% decrease in the number of students who , at the beginning of class believed that melting sea ice will cause a rise in global sea level, the percent of students who believe this to be the case is high at 60%. This is evidence of a persistent misconception as to what causes sea level to rise in the first place. See Q93. Melting sea ice has no impact on sea level rise because it's already floating in the ocean. Like a glass of ice water. as it warms, the ice in the glass melts, but the total volume of water does not change.

Q93. Which one has contributed the most to sea level rise so far



The responses show a broad lack of knowledge on what has contributed the most to the recent rise In sea-level (63% believe it is glacial melting) with only 20% of those at the end of the course knowing the correct answer is warmer ocean temperatures. This misconception most likely stems from the plethora of dire predictions that rising sea level could destroy coastal areas and wipe out hundreds of islands and island nations. Sea level is rising, but the largest contributor to the rise is warmer ocean temperature, causing the water column to expand. The melting sea ice responses (B.) indicate once again that persistent misconception, which has been identified in Q92.

Q4. Assuming global warming is happening, do you think it is…?



Since about 1975, global warming has been caused by mostly human activities. It was expected that a large number of those who chose "B" at the beginning of the semester would have chosen "A" at the end of the semester. However, 63% of students at the end of the semester believe that global warming is caused by both human and natural changes, down only 6% , indicating a persistent misconception in the current cause of most of the warming.

Synopsis

A 98 question scored survey was given to Environmental Science Majors taking their first Global Climate Change course. Students took the same survey on the first and last Day of class. The survey covered basic elements of climate change. Eighty-six questions were scored; those results are displayed with this poster.

Nine common misconceptions about climate and climate change are recognized in the results of the survey. This was done by comparing answers of both surveys to make a determination on whether the pattern of wrong answers suggested persistent misconceptions regarding the scientific concepts or factual information presented in the question. Graphs of the student responses for each of the nine questions are presented and several hypotheses are discussed regarding the persistent misconceptions, opening doors for future exploration.

If a scientifically reliable inventory of Global Climate Change misconceptions is to be fully developed, many more iterations of this type of project needs to be done, each using the same methods of determination. This particular project is simply a pilot study that experiments with one method of used to determine persistent misconceptions and the students scientific knowledge of climate change. The project also surveyed student knowledge of the social and economic impacts of climate change producing data which will be useful for future research.