

Misconceptions about Climate Change and Ozone Depletion: Textbooks, Instructors and Media Influence on Ghanaian Pre-Service Teachers

Samuel Nyarko¹ and Heather Petcovic¹

¹Western Michigan University

November 23, 2022

Abstract

The need to train a scientific workforce in order to mitigate the impacts of climate change drives an international need for climate change education, including in Ghana. How pre-service teachers understand the concept of climate change, and the often misunderstood relationship between ozone depletion and global warming, critically impacts the students they will teach and the community at large. This mixed-method, descriptive study documents pre-service teachers' climate change and ozone depletion conceptions, and describes the sources of these conceptions. An open-ended and Likert-type questionnaire adapted from Boyes and Groves (1994) was administered to 300 participants from three colleges of education in Ghana. Thirty of the participating pre-service teachers then completed a semi-structured interview. Quantitative data were analyzed using SPSS, and interviews were audio-recorded, transcribed and coded together with the open-ended survey questions. Results of the quantitative analysis suggest that many pre-service teachers hold the idea that climate change results from ozone holes allowing more ultraviolet solar radiation to reach the Earth. Participants understand that ozone is a layer of gas high up in the atmosphere that protects the Earth from ultraviolet radiation, but they lack an understanding of what causes ozone depletion and the consequences of depletion. Participants also identified textbooks (79.9%), instructors (63.5%) and the media/internet (62.1%) as the sources of their ozone layer and climate change knowledge. Qualitative data suggest that participants lack an understanding of the exact position of the ozone layer in the atmosphere, how ozone forms, its relation to ground level UV radiation and natural processes that lead to ozone depletion. Participants also confused climate change with the change in seasons and weather, and could not clearly articulate why they think ozone depletion is linked to climate change. This study adds to existing climate change conceptions literature, identifies new misconceptions held by pre-service teachers and identifies the sources of their conceptions, which provides further information about the learning resources available to students.



WESTERN MICHIGAN UNIVERSITY

MISCONCEPTIONS ABOUT CLIMATE CHANGE AND OZONE DEPLETION: TEXTBOOKS, INSTRUCTORS AND MEDIA INFLUENCE ON GHANAIAN PRE-SERVICE SCIENCE TEACHERS



*Samuel Nyarko & Heather Petcovic

PURPOSE AND GOALS

- The need to train a climate change science workforce, in order to mitigate the impacts of climate change, is driving a need for climate change education in many countries, including Ghana.
- No research has yet been done in Ghana to investigate teachers' knowledge and understanding of climate change concepts including concepts related to ozone depletion.
- The idea that climate change results from ozone holes, by allowing more ultraviolet solar radiation to reach the Earth, is very common among students at all levels (Lambert et al., 2012; Groves & Pugh, 1999; Herman et al., 2015; Arslan et al., 2012; Papadimitriou, 2004).
- This mixed-method, descriptive study documents pre-service teachers' climate change and ozone layer conceptions and the sources of their knowledge.
- This study adds to existing climate change literature, identifies some new sets of misconceptions held by pre-service teachers, and also identifies the sources of their conceptions, which provides further information about the learning resources available to students.

METHODS

PARTICIPANTS

Demographics	Survey N = 255	Interview N = 30
Gender (no. males, % male)	197 (78.8%)	25 (83%)
Age (Range, Mean)	18-29, (22.8)	19-26 (23.6)
Year(s) in program (number of Second years, % of Second years)	139 (57%)	14 (47%)
Description of Hometown (number rural, % rural)	90 (38.3%)	13 (43.3%)
Took Biology (number, %)	133/150 (88.7%)	30 (100%)
Took Chemistry (number, %)	137/149 (91.9%)	30 (100%)
Took Physics (number, %)	124/149 (83.2%)	27 (90%)

DATA COLLECTION & ANALYSIS

The statements in the Ozone Depletion and Climate Change Knowledge Assessment (ODCCCA) instrument was taken from Boyes & Stanisstreet (1994) and Chuckran & Boyes (1993).

The instrument was peer reviewed by research group members to check for understanding and provide feedback. Feedback from research group members was used to make corrections on the wording and clarity of the statements and then sent to a climate expert for review to ensure content validity.

We then conducted a pilot study to test for cultural understanding of the instrument with Ghanaian students studying educational programs in US colleges and universities. The feedback obtained from the pilot study was used to make additional modifications to the instrument to ensure the cultural relevance of the wording, understanding and articulation of the statements for the main study.

255 pre-service teachers from 3 colleges of education were selected to complete the ODCCCA survey. A subset of 30 pre-service teachers were selected for an interview.

Survey responses were scored as correct or wrong for each participant and analyzed using SPSS to determine the frequency of correct and wrong responses.

Authors independently applied codes to the same sample of 3 transcripts, compared results, discussed disagreements and refined the coding scheme until a final coding scheme was agreed upon.

The first author selected relevant passages from a sample of 5 same transcripts and coded these. The second author independently coded each passage to measure intercoder agreement. A mean 87.92 agreement was achieved. All disagreements were discussed and resolved to reach 100% agreement.

This poster focuses on our analysis of ideas from key themes: 2 codes within the ozone layer theme; 2 codes within the climate change theme; relationship between climate change and ozone layer theme; and 2 codes within the source of knowledge theme.

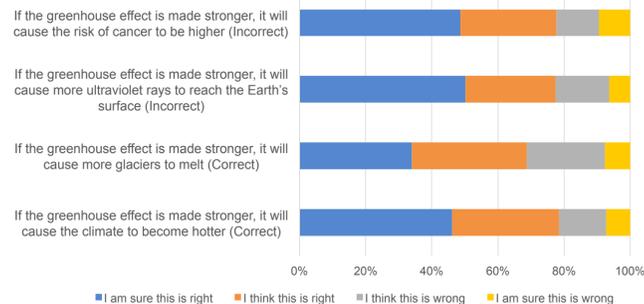
Interview audios were transcribed by authors. Authors independently read through the same 3 interview transcripts and generated potential codes. Codes were compared and consolidated. 4 themes; ozone layer knowledge, climate change knowledge, relationship between climate change and ozone layer, and knowledge sources were identified.

The first author identified relevant passages and applied the finalized coding scheme to the full set of 30 interview transcripts using NVivo 12.0.

Coded text segments were compiled using NVivo 12.0

RESULTS FOR PRE-SERVICE TEACHERS OZONE LAYER CONCEPTIONS

Pre-service Teachers Conception about the Composition, Location And Function of the Ozone Layer



Composition and location of ozone layer

The ozone layer it is this kind of gases in the atmosphere and they are a net-like gases found in the atmosphere. I think the ozone is found should I say just in the atmosphere, but I think its in the second layer (stratosphere) – Chief

The ozone layer is the gas layer in the stratosphere of the Earth – Mack

It is a layer that is beneath the earth and it contains the heat that we produce here on earth. It is beneath the earth layers of the earth – Harlem

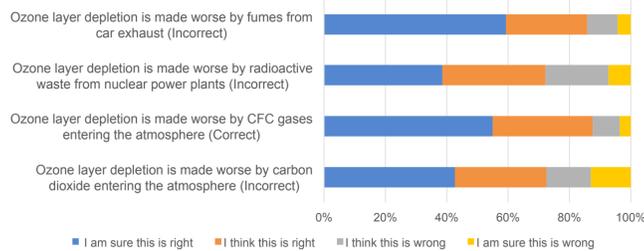
Formation of ozone layer

Its formed from three atoms of oxygen – Abe

It is formed from accumulation of air – Espel

The ozone layer is formed from human activities. We have something called the chlorofluorocarbons and through pollutions and other things like the burning and the sea breeze and other things will move to the sky and it will lead to the formation of the ozone layer – Mack

Pre-service Teachers Conception about the Causes of Ozone Depletion



Anthropogenic Causes of Ozone depletion

So for deforestation you know plants absorb carbon dioxide so when there are no maybe with the cutting down of trees there will not be enough plants to absorb carbon dioxide so its going to affect the ozone layer. It creates holes in the ozone layer – Jozy

Burning a lot of coal. That is smoke from industries or burning like fossil fuels – Espel

When using refrigerators and other electrical appliances, these chemicals (CFCs) are in it so automatically because its denser than air it is going to be displaced on top of the air and automatically rise into the atmosphere. But I don't know what actually happen there – Frodo

So these smokes in the atmosphere when the sun shines it take them into the atmosphere which also go back and go and condense with the atmosphere that is the ozone layer which will deplete it over there – Nana

Natural Causes of Ozone depletion

I don't know and No idea – majority of participants

Excess carbon dioxide from breathing. When the carbon dioxide gets into the atmosphere it causes penetration into the ozone layer – Gina

Something like the sun and the ultraviolet rays and things they can lead to ozone depletion – Harlem

Actually the sea breeze. Because during the sun's scorch on the sea, the breeze that will evaporate from the sea it is going to form clouds so that rain will fall but through that it is going to lead to ozone layer depletion – Mack

RESULTS FOR PRE-SERVICE TEACHERS CLIMATE CHANGE CONCEPTIONS

Pre-service Teachers Definition of Climate Change

Short-term weather change

Its temporal weather condition within a particular area of time – Frodo

When there is a change in weather – Jozy

Climate change is for example we have the hot and the cold so maybe when we are in the hot, when it changes to become cold – Mayor

Short-term weather change

When we say climate change we are talking about the long-term manifestation of weather within a particular time at a geographical area – Alaska

It is the change in the weather of a particular geographic area over a long period – Cozy

Climate change occurs over a longer time – IceT

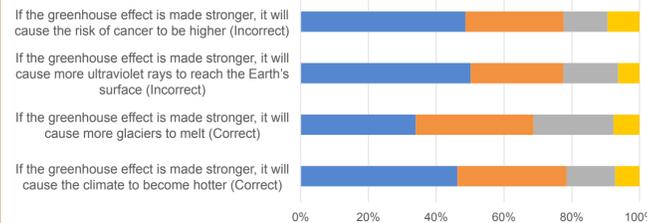
Change in seasons

The climate we have it there already and there are some seasons we are already expecting and waiting for it to occur but when there is deviation between those seasons they are supposed to occur – Ascor

You know we have two climatic changes. We have the rainy season and we have the dry season also – Gaza

climate change is the change in the dry and rainy season – Shaitor

Pre-service Teachers Conception about the Causes of Climate Change



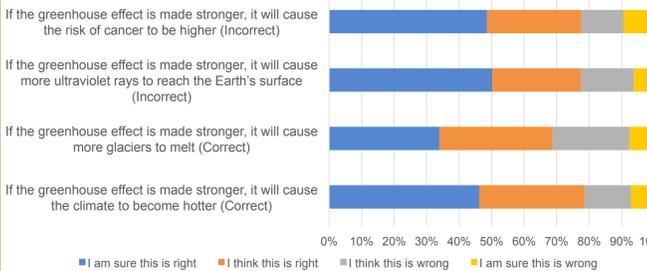
Causes of climate change

The moment we burn the things we are changing the climate. We the humans are causing it by burning or producing the gas and the climate will change – Pep

Climate change is a natural thing so we don't have to worry about it. That is how God created it to be – IceT

You know, greenhouse causes the global warming – Frodo

Pre-service Teachers Conception about the Consequences of Climate Change



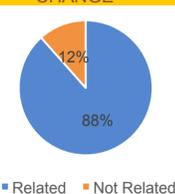
Consequences of climate change

As we are currently experiencing in Ghana, we have some of the months that we are expecting rain but the rain didn't come. It is later that the rain started pouring. So, it means that it has affected those farmers who were expecting the rain to come – Ascor

In places like the Antarctica we have a lot of glaciers and climate change can melt the glaciers and lead to high sea levels – Gina

When there is climate change, let say harmattan seasons, the sun scorches a lot so it makes plant not to grow well. So there can be scarcity of food and drying of rivers – Espel

RESULTS FOR PRE-SERVICE TEACHERS CONCEPTION ABOUT THE RELATION BETWEEN OZONE LAYER AND CLIMATE CHANGE



Ozone depletion causes climate change

When the ozone layer is depleted it makes the heat of the sun hit the earth more than it should and this leads to climate change – Alaska

If the ozone layer is depleted it means the excess radiation that will come will cause the climate change – Ember

when the ozone is depleted the amount of rainfall will reduce and the time for rainy season may shift backward or forward and that can cause climate change – IceT

Climate change causes ozone depletion

When there is climate change it will definitely affect the ozone layer. When the solar radiation is very high the ozone layer will be depleted and when it is low it won't – Jozy

Like when I was talking about the heavy rains; these heavy rains is due to climate change and these heavy rains can cause depletion of the ozone layer – Pep

For instance when the climate becomes dry we have so many places that get burnt. If you go to the bushes they burn. The burning produces dangerous gases which will go up to deplete the ozone layer – Pojoro

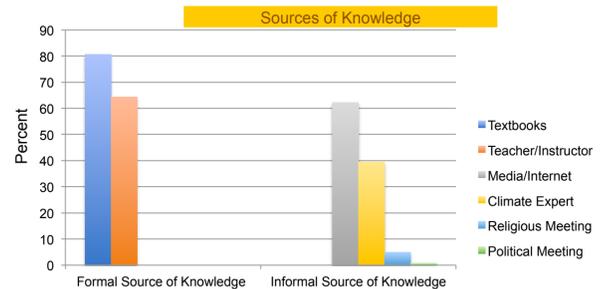
There is no relationship between ozone depletion and climate change

The ozone layer is only a net-like gas in the atmosphere which prevents so much radiations but then climate change is a change in atmospheric conditions – Chief

The ozone layer is just protecting the ultraviolet rays from the sun coming to Earth and climate change is the temperature on Earth in a particular geographic area – Mack

From the two, I don't really know how depletion of the ozone layer tends to affect the climate change. They are not related – Abe

RESULTS FOR PRE-SERVICE TEACHERS OZONE LAYER AND CLIMATE KNOWLEDGE SOURCES



Formal sources of knowledge

I studied them in school. I have the knowledge from my teachers – Espel

First my teacher told me. He introduced us to the topic and I also learned from textbooks – Gaza

I remember back at our high school our teachers used to tell us that when we keep on cutting down trees and some human pollutions, it (gases) will go up to the atmosphere and chop the ozone layer. Let me say my teachers because I was taught from primary to where I am now (college) – Prince

Informal sources of knowledge

From the internet. Sometimes when you are curious about something you go to the internet and search over there – Ascor

I got some through the internet. I also came across some of them in the news, those weather forecasts and other media – Harlem

Recently the Ghana Bishops conference met in Tamale, Ghana and the main aim was to discuss ways of protecting the environment. After their discussions and deliberations they came to my school to educate us on how to maintain the environment. I heard some of the things from them – Cozy

DISCUSSION

Most of the pre-service teachers had a good understanding of the composition, location and function of the ozone layer. However, the majority had misconceptions or did not know about the formation of the ozone layer.

The majority of the pre-service teachers had misconceptions about the causes of ozone depletion. Many of them wrongfully described carbon dioxide emissions, smokes from bushfires, fumes from burning coal and fossil fuels are the causes of ozone depletion.

Most of the pre-service teachers held the correct conception that ozone depletion is mainly caused by CFC gases. However, they could not explain the reason for their answers.

Almost all of the pre-service teachers carried the misconception that climate change is the change in weather or change in seasons of a geographic area.

Most of the pre-service teachers had the correct conceptions that emission of CFCs and carbon dioxide will increase the greenhouse effect and lead to climate change. However, several of them also had the incorrect perception that acid rain and radioactive wastes from nuclear power plants make the greenhouse effect stronger and affect climate change.

Most of the pre-service teachers correctly identified that climate change will have both human and environmental impacts. They listed flooding, famine as a result of poor crop yield, and a hotter climate as some of the consequences of climate change. However, several incorrectly associated climate change with an increase in sunlight intensity and the risk of cancer.

The majority of Ghanaian pre-service teachers carried the misconception that ozone depletion is the main cause of climate change. They incorrectly believe that an increase in sunlight intensity on the Earth as a result of ozone depletion is what causes the climate to change.

Some of the pre-service teachers believed that climate change causes ozone depletion. They carried the misconception that climate change will lead to warming of the Earth and eventually deplete the ozone layer.

The majority of pre-service teachers identified textbooks, teachers and the internet as sources of their ozone layer and climate knowledge.

IMPLICATIONS FOR TEACHING

Designing instruction that provides students the opportunity to engage in hands-on activities and discussions on the ozone layer and climate change will be essential in effecting conceptual change among learners. Finding the balance between encouraging students to accommodate new information and engaging in authentic scientific investigations will lead to conceptual change.

Providing students with credible resources on the ozone layer and climate change rather than having students read from textbooks and internet/media should be encouraged by teachers.

Professional development programs focused on climate concepts and issues should be regularly organized for science teachers. Most of the participants indicated they learned misconceptions from teachers, suggesting a need for regular professional development courses focusing on climate science.

Science educators and climate experts should make the effort to be more vocal in the national discussions on climate matters to provide credible information to the general public. This will reduce the amount of misleading climate information put in the media by journalists and non-experts.

REFERENCES

Boyes, E., & Stanisstreet, M. (1994). The ideas of secondary school children concerning ozone layer damage. *Global Environmental Change* 4, 317-330.

Boyes, E., Chuckran, D & Stanisstreet, M. (1993). How Do High School Students Perceive Global Climatic Change? What Are Its Manifestations? What Are Its Origins? What Corrective Action Can Be Taken? *Journal of Science Education and Technology*, Vol. 2, No. 4, 541-557.

Groves, F. G & Pugh, A. E. (1999). Elementary Pre-Service Teacher Perceptions of the Greenhouse Effect. *Journal of Science Education and Technology*, Vol. 8, No. 1, pp. 75-81.

Herman, B. C., Feldman, A. & Vernaza-Hernandez, V. (2015). Florida and Puerto Rico Secondary Science Teachers' Knowledge and Teaching of Climate Change Science. *Int. J. of Sci and Math Educ* (2017) 15:451-471.

Lambert, J. L., Lindgren, J. & Bleicher, R. (2012) Assessing Elementary Science Methods Students' Understanding About Global Climate Change. *International Journal of Science Education*, 34:8, 1167-1187.

Arslan, H. O., Cigdemoglu, C. & Moseley, C. (2012) A Three-Tier Diagnostic Test to Assess Pre-Service Teachers' Misconceptions about Global Warming, Greenhouse Effect, Ozone Layer Depletion, and Acid Rain. *International Journal of Science Education*, 34:11, 1667-1686.

Papadimitriou, V. (2004). Prospective Primary Teachers' Understanding of Climate Change, Greenhouse Effect, and Ozone Layer Depletion. *Journal of Science Education and Technology*, Vol 13, No. 2, pp. 299 – 307.

ACKNOWLEDGEMENT

We thank the Western Michigan University Graduate College and The Mallinson Institute for Science Education for funding this project. We are grateful to the Ghana Council for Tertiary Education for allowing us to conduct the survey and interviews in the three colleges of education. Special thanks also goes to Dr. Peggy McNeal, Laura Tinigin, Jay Cockrell and Kristen Foley.