Earth2Class: An Innovative Strategy to Teach Climate Change Education

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Abstract
Climate Change is an important, yet controversial topic that students need to address as part of their Geography (or Social Studies) and Science studies. We review sets of Science and Social Studies Standards as they pertain to Climate and Climate Change. Then we describe one strategy, the Earth2Class program at the Lamont-Doherty Earth Observatory, which can provide classroom teachers and students opportunities to attain mastery of climate change-related Social Studies and Science Standards.

Keywords
Climate Change Education, Informal Outreach Strategies

1. Introduction
Student understanding of climate change involves extremely complex interactions of personal experiences and learned concepts. Young children gradually develop understanding of local daily weather conditions and, over a period of years, a sense of seasonal changes. Absent travel comparisons, it is hard for children to grasp that other places have different conditions, although what they see on TV or in movies provides some visual comparisons that may form the basis for climate understanding.

Constructing a mental model of climate change involves melding physical science and geography. Examples of necessary physical science concepts include global atmospheric circulation models, local environmental conditions, and energy fluxes. Geographic constructs include biome and topographic features, such as deserts and rainforests, and, of course, relative positions on our planet.

An additional complicating factor is the influence of politics to which a child is exposed by parents, teachers, and/or community members. Climate under-
standing of most parents and community members probably stems from what they see and read in media, rather than organized study of facts and theories, and thus strongly is influenced by political slants in what they view. Teachers, by training, are more readily influenced by what they see as scientific evidence and mandated Standards.

2. Standards

Pertaining to climate change, there are only a few sets of educational standards to consider. The U.S. Next Generation Science Standards (2013) (https://www.nextgenscience.org/) form the basis for formal science teaching in many States and is a major influence on curriculum development in most others. Climate and/or environmental change is included in Standards beginning at the Pre-kindergarten level, through high school.

Geography, which is taught in many countries around the world as a separate discipline, is rare in the United States. Instead, much of what is internationally considered to be “Geography” is taught in the United States, as Social Studies. Standards for courses have been established by the Center for Civic Education (1994) (https://www.civiced.org/standards?page=58toc); National Council for Social Studies Standards (2012) (https://www.socialstudies.org/standards/national-curriculum-standards-social-studies-introduction); and the National Council for Geographic Education (https://ncge.org/teacher-resources/national-geography-standards/). A compendium specific to Climate Change Education was developed by the North American Association for Environmental Education (2010) (https://cdn.naaee.org/sites/default/files/9_social_studies_standards_and_suggestions_for_climate_change_education.pdf).

The latter not only includes summaries of Social Studies Standards, but also examples of how teachers might use the standards in climate change education. For instance, a Standard dealing with how the government established by the Constitution embodies the purposes, values and principles of American Democracy that asks “Who represents you in the legislative and executive branches of your local, state, and national governments?” (Standard III E) could lead to “a discussion about who in government citizens could talk to about the effects of climate change on the environment.” Students can decide “which level of government they should contact to express their opinions or to get help on specific problems, e.g., the environment.”

One of the biggest questions for Geography/Social Studies teachers is where/how to incorporate Climate Change into the curriculum. Totz has explored some approaches to answering this question (Totz, 2016).

As noted, politics often comes into play in determining how to handle controversial topics. Members of the Michigan legislature attempted to block teaching about climate change, but opposition to this move eventually failed (Winowiecki, 2019).
Unlike the Social Studies Standards, in which climate change is not explicitly identified, the Next Generation Science Standards very clearly address important climate issues. The “Next Gen Standards” were developed through an extensive State-led process based on “A Framework for Science Education” developed by the National Research Council (2012) of the National Academies (https://www.nap.edu/read/13165/chapter/1#--text=%20The%20Framework%20highlights%20the%20power%20of%20integrating%20given%20to%20the%20ideas%20and%20practices%20of%20engineering). To date, forty-four States and the District of Columbia have Science Standards influenced by the Next Gen Standards. (This will impact more than 70% of all Students when fully in force.)

One thing that distinguished the Next Gen Standards from previous efforts to establish Standards is that they are based on how Science actually operates. There are three “Dimensions” to learning Science: Science and Engineering Practices, Cross-Cutting Concepts, and Disciplinary Core Ideas. Most previous Standard guides focused on sets of facts that students should know; the Next Gen Standards focus more on how students should be able to perform, what they can demonstrate they can do.

Climate change in the Next Gen Standards, are addressed much more directly than in the Geography Standards. For example, by the high school level, students are expected to be able to “Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems” (HS-ESS 3-5, https://www.nextgenscience.org/pe/hs-ess3-5-earth-and-human-activity).

Even at the elementary school level, students are expected to be able to “represent data in tables and graphical displays to describe typical weather conditions expected during a particular season”. (3 ESS2-1, https://www.nextgenscience.org/pe/3-ess2-1-earth-systems).

Numerous other references to climate and climate change can be found throughout the Next Gen Standards, many of which also pertain to Social Studies Standards.

The Earth2Class Model:

Presented here is one innovative strategy to address scientific and geographic Standards pertaining to Climate Change and other cutting-edge scientific issues. The “Earth2Class Program” offered at the Lamont-Doherty Earth Observatory of Columbia University (E2C) connects research scientists with classroom teachers and students (middle school, high school, and university). E2C evolved out of informal Saturday morning talks by LDEO researchers to a small number of teachers in the New York City region in 1998. Today, due to COVID-19 restrictions on access to the Lamont Campus, E2C is provided via zoom.

This has some drawbacks over the earlier live model. Participants can no longer visit Lamont campus facilities, such as geochemistry laboratories or the deep-sea core repository. On the other hand, Zoom access means E2C is not limited only to those who can get up early on a Saturday morning and drive to the
campus in Rockland County, NY. As a result, we now include people in distant States and even in Europe. We are now also easily able to record the sessions and post them for later viewing by those not available for the “live presentations” on the E2C website (Earth2Class Home Page, https://earth2class.org/site/).

Over time, the format of an E2C workshop has taken on a structure that has proved very efficient. Because participants arrive with a wide range of background knowledge, I provide a 5- to 15-minute introduction that gives everybody some common understanding and knowledge of key terms. Then the scientist provides a self-introduction, describing events in a life and career path that led to their position, some of the motivating questions that informed the research, and the methods by which the research was carried out. Much of this involves aspects of Science Practice which do not make it into the textbooks that often constrain classroom teaching. Of course, some topics of E2C presentations involve such cutting-edge discoveries that they are not, and will not, be in textbooks for many years to come.

Consider now, some of the E2C programs directly pertaining to Climate Change. In March 2021, Dr. Christopher Zappa, a Lamont Research Professor, discussed “Ikaaqvik Sikukun: Bridging the Scientific and Indigenous Communities to Study Sea Ice Change in Arctic Alaska” (https://earth2class.org/site/?p=16971). This project has successfully built bridges between a diverse team of scientists and Indigenous Knowledge-holders to study the changing sea-ice environment of Kotzebue Sound, Alaska. They have broken new ground by co-producing our hypotheses in partnership with an Indigenous Elder advisory council to develop research questions that cut across disciplinary boundaries and address the needs of both the local and scientific communities.

In this E2C program, we addressed numerous parts of the National Geography Standards. Among these are:

- Using maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information.
- Using mental maps to organize information about people, places, and environments in a spatial context.
- Analyzing the spatial organization of people, place, and environments on Earth’s surface.
- Physical and human characteristics of places.
- How culture and experience influence people’s perceptions of places and regions.
- Physical processes that shape the patterns of Earth’s surface.
- Characteristics and spatial distribution of ecosystems and biomes on Earth’s surface.
- Patterns and networks of economic interdependence on Earth’s surface.
- How human actions modify the physical environment.
- How physical systems affect the human systems.
- Change that occurs in the meaning, us, distribution, and importance of resources.
Applying geography to interpret the present and plan for the future.
(Source: National Geography Standards Index, https://www.nationalgeographic.org/standards/national-geography-standards/)

Other E2C programs address potential future climate change issues. Among recent examples were:

- Klaus Jacob (Sep 2019) “Can Coastal Cities Cope with Sea Level Rise?” (https://earth2class.org/site/?p=16480)
- Nathan Lennsen (Oct 2021) “How Do We Know the Temperature of the Earth?” (https://earth2class.org/site/?p=17349)
- Ajit Subraniam (Jan 2018) “Great Rivers and Changing Oceans” (https://earth2class.org/site/?p=17349)

Understanding future climate change demands understanding past climate changes and paleoclimates. Among E2C programs that look at research into these questions have been:

- Dallas Abbott (May 2018) “How Can We Determine the Location, Size and Climate Effects of Volcanic Eruptions During the Past 2000 Years?” (https://earth2class.org/site/?p=15085)
- Michael Kaplan (Feb 2019) “Glaciers Before and During the Little Ice Age and Why We Care” (https://earth2class.org/site/?p=15776)
- Jerry McManus, Gisela Winckler, and Allison Jacobel (Oct 2016) “What Can Dust Reveal about Past Climates?” (https://earth2class.org/site/?p=11750)

Another important value provided by the E2C program is to place a spotlight on the scientists who become role models for the students. When the campus was more accessible (pre-covid), several high school participants leveraged attendance in E2C into summer and school-year research internships with presenters, and/or were strongly influenced by their experiences in E2C leading to their college majors.

One drawback of the current, Zoom-based format is that participants no longer have the extended day to work through examples of learning activities or more extensive, informal discussions with the scientists that were possible when the program ran into lunch and the afternoon. Even so, we are seeking ways to expand the connections between participants and scientists.

3. Conclusion

The Earth2Class format can be one efficient model to address many published Geography and Earth Science Standards pertaining to Climate Change, through upcoming and previous sessions.

Note: Anyone wishing to participate in future Earth2Class sessions can register by sending me an email.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.
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Website

https://eric.ed.gov/?id=ED536508