Unit Essential Question

How do we know human activity is influencing climate, and what can we do about it?

Introduction

At the heart of the arguments around climate change is the question of whether Earth is just in another natural warm period or whether human beings are causing the global warming effects we are seeing today. If we want to know whether humans have caused the temperature increases of the last century, we need to compare the times when humans put little CO_2 into the atmosphere to the times when humans have put more into the atmosphere. Looking at data of CO_2 and temperature over a long period of time is helpful because there have been natural changes to the amount of CO_2 in the atmosphere before humans emitted much CO_2. Lucky for us, scientists have figured out how to analyze the climate from thousands of years ago by using ice cores. In this task, students will practice graph analysis skills to look at an abundance of evidence that supports one of two claims: human activities have led to the increase in global temperature; or Earth is just in another natural warm period. In responding to these claims, students will make a concrete connection between human activity, burning of fossil fuels, increased carbon dioxide, and increased temperature.

Objectives

Students will be able to

Content

- Compare levels of carbon dioxide and temperature in the past to those of today.

Science and Engineering Practices

- Analyze data to identify evidence to support a claim or counterclaim.
- Construct an argument about the cause of climate change.

Equity and Groupwork

- Build on other group members' ideas.

Language

- Construct an argument based on evidence.

Academic Vocabulary

- claim and counterclaim
- climate
- emissions
- evidence
- fossil fuels
- global
- ice cores
- methane
- reasoning

Language of Instruction

- chain
- defend
- neither (support nor refute)
- refute
- support
- units

Timing

This task can be completed in 5 class periods (based on 45-minute periods).

- Part I • The Claim (0.5 class period)
- Part II • What Do You Still Need to Know? (1.5 class periods)
- Part III • Collect Evidence (1 class period)
    - Part III • Addendum (Optional)
- Part IV • The Argument (0.5 class period)
- Part V • Chain of Cause and Effect (0.5 class period)
- Part VI • Connect to the Culminating Project and Assessment (1 class period)

Student Materials

- Handout: Evidence from Graphs
- Optional: Pencils (plain or colorful), pens, paper, scissors for ice core simulation

Teacher Materials

- "What Is Causing Climate Change, and How Do We Know?" digital slide presentation
- Video clips:
    - *CO_2 in the Ice Core Record*: http://earththeoperatorsmanual.com/segment/5
    - *Products of Burning Fuel*: https://www.youtube.com/watch?v=FfFs4q6PSaU (optional)

Background Knowledge

Drilling into ice sheets in Greenland and Antarctica allows scientists to measure the atmospheric conditions of the past. Each winter new snow falls on top of previously unmelted snow. This process creates distinct layers of ice each year—summer ice appears light while winter ice appears dark. By drilling thousands of feet deep, researchers extract cores of ice formed hundreds of thousands of years ago. Air bubbles are trapped in the ice as it is formed. Analysis of the trapped gases and the chemical composition of the ice itself helps scientist know what the climate was like thousands of years ago. The most famous source of such data is found in Vostok, a Russian station near the South Pole.

Scientists have compared ice core and other proxy data (e.g., tree rings can be used to get temperature data) with direct measurements of CO_2 from the past several decades. Comparing these pieces of data indicate that the current CO_2 levels are higher now than they have been for at least 800,000 years, with a sharp rise in CO_2 since the Industrial Revolution (mid-1700s). Detailed estimates of CO_2 sources and sinks provide clear evidence that CO_2 levels are increasing as a result of human activities.

Recommended reading: IPCC FAQ: Is the Current Climate Change Unusual Compared to Earlier Changes in Earth's History?

- http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-6-2.html

Additional teacher and/or student resources:

- Ice Cores: http://lasp.colorado.edu/home/wp-content/uploads/2011/08/Ice-Cores1.pdf
- Paleoclimatology Data: https://www.ncdc.noaa.gov/paleo/ctl/cliihisbeyond.html
- Earth Observatory: http://earthobservatory.nasa.gov/Features/WorldOfChange/decadaltemp.php

Introduction

In the previous task, students learned about energy-absorbing gases (greenhouse gases) and how they affect temperature. Today they will analyze and interpret data collected by scientists and construct an argument about what has caused climate change. The focus will be on changes in greenhouse gases over time, and why those changes are contributing to climate change.

Part I • The Claim

1. Introduce the lesson using the title slides of the digital slide presentation (Slides 1 and 2).

2. Show Slide 3. Have students complete Part 1 of their Student Edition by deciding who they agree with and why.

3. Have students discuss their answers as a group and/or as a class.

    - You might consider having them stand on one side of the room if they agree more with Emilio's idea and another side of the room if they agree more with Destiny's idea (human bar graph) and respond to each other's ideas.
    - Ask students to justify their ideas about who they agree and disagree with. Use these sentence frames as needed:
        - Why do you agree more with _____?
        - Why do you agree less with _____?

Part II • What Do You Still Need to Know?

1. Show Slide 4. Emphasize to students that they already learned a lot in Task 1, but that they still need to know more in order to decide whether they agree with Emilio, Destiny, or neither. Elicit background knowledge from Task 1 and have students record it in their Student Editions as you record it on the slide.

    - To emphasize the crosscutting concept of cause and effect, illustrate students' prior knowledge as a flowchart: More carbon dioxide —> more greenhouse effect —> more temperature increase.

2. Walk through the specific need-to-know questions for Destiny and the specific need-to-know questions for Emilio. (See below. These may be similar to some of the need-to-know questions students generated themselves in the Lift-Off Task.)

    - Destiny: Has this happened in the past? Are we just in a warm period?
    - Emilio: Is more carbon dioxide being made now than in the past? Are humans responsible?

Part III • Collect Evidence

1. Slide 5: Emphasize the importance of gathering evidence to support a claim.

2. Slides 6–8: Explain that looking at data of CO_2 and temperature over a long period of time is helpful because there have been natural changes to the amount of CO_2 in the atmosphere before humans emitted much CO_2. **If you want to know whether humans have caused the temperature increases of the last century, you need to compare the time when humans caused little CO_2 to be released into the atmosphere to times when they released more into the atmosphere.** Tell students that they will start by learning how scientists know about the climate from thousands of years ago.

3. Slide 9: Play the video clip, which focuses on ice cores: http://earththeoperatorsmanual.com/segment/5

    - Stop the video at 1:40. (The remainder of the video describes patterns in the data, but you want students to look at the data and make sense of it themselves.)

4. If you want to further emphasize ice cores, talk through Slides 10–14 (ice core images).

5. Slide 15: Segue to looking at **actual** data by telling students that they will now look at some of the data from the ice cores so they can support or refute Destiny's and Emilio's claims.

6. Distribute the handout Evidence from Graphs. Have students work in groups to examine the **first three graphs** on the handout and fill in the Climate Change Evidence Analysis Chart for Destiny's claim.
    - They should answer the analysis questions in the second column.
    - They should check either "Supports," "Refutes," or "Neither" to say how the evidence in each graph relates to the claim.
    - In the last column, they should provide their reasoning (based on the evidence from the graph) about their decision in the previous step.

7. We recommend that you model graph analysis by looking at the first graph together (Slide 16: Climate Readings to the Present).

    - First look at the axes and what is being graphed. Describe what the graph is about in your own words (this isn't the analysis, but it helps students get acquainted with the graph and how to describe the graph in their own words). Note that 0 is present. (You may want to write this on the board.)

    - Provide some criteria for analysis.
        - Describe patterns (repetitions) using the axis labels. If there are no patterns, state that. Use the following sentence frame: "As _____ increases/decreases, then _____ increases/decreases."
        - Describe exceptions to patterns—are there parts of the graph that are different than the pattern? (Look for peaks.) Use the following sentence frame: "However, in [some part of the graph] there are differences in the pattern."

    - Discuss overall graph conclusions:
        - Both temperature change and carbon dioxide decreased and increased from 450,000 years ago to the present. From about 440,000 years ago to 330,000 years ago, temperature change and carbon dioxide decreased. There were some small increases and decreases in the overall pattern during this time. Then there was a jump in both carbon dioxide and temperature. There were three more cycles like this. The carbon dioxide and temperature changes paralleled each other, **but just before the present, the carbon dioxide increased to more than it was at any other point on the graph, and the temperature didn't increase as dramatically.**
        - Explain that there is a lag in how long it takes the temperature to change after a rise in CO_2. Thus, the current high levels of CO_2 basically guarantee that there will be some warming, regardless of the steps we take (which students will learn about in order to make their school district presentations). However, people's actions will make a great deal of difference in how much warming will happen in the future and how it will affect the planet. *Note: We recommend that you make this point again at the end of the lesson, because students will make predictions about future temperature during the lesson.*

8. Use a meta-think-aloud to ensure that students grasp the three labels: "supports," "refutes," and "neither."
    - If students aren't sure or undecided, then model the reasoning "neither."
      Reasoning: Increases in CO_2 cause temperature to increase through the greenhouse effect. Graph 1 shows that CO_2 and temperature have paralleled each other until recently, but we don't know if the recent activity is due to humans or nature.
    - If they think that humans are the primary cause of climate change, model the reasoning for refuting Destiny.
      Reasoning: Graph 1 shows that CO_2 and temperature have paralleled each other for the past 400,000 years until recently. The amount of CO_2 affects temperature through the greenhouse effect. Recently, humans have put a lot of CO_2 into the atmosphere (more than the levels at all other times on the graph), so humans have caused the warming.
    - If they think that the climate change is due to natural causes, model the reasoning for supporting Destiny.
      Reasoning: The climate has always gone through natural cycles that occurred even before people inhabited the Earth.

LANGUAGE SUPPORT STRATEGIES

Offer students a poorly constructed reasoning in writing (e.g., "I disagree with Destiny that climate change is caused by humans because humans are polluting the air."). Critique the response with the class (e.g. it is too ambiguous or point out an error). Have students discuss and share out in pairs:

- The errors or ambiguity of the reasoning.
- An improved response

9. Have students work in groups to examine **graphs 4–6** on the handout and fill in the Climate Change Evidence Analysis Chart for Emilio's claim.

10. Show slides 17–21 to connect the increase in greenhouse gases to human activities that release carbon dioxide.
    - Recommended: Project Evidence 7 on the board as the final piece of evidence. Show students the *Products of Burning Fuel* video and analyze it as a class: https://www.youtube.com/watch?v=FfFs4q6PSaU. This video is a good starting point for Slides 17–21 because it connects how the burning of fossil fuels leads to an increase in carbon dioxide.

Part III • Addendum (Optional)

If time allows, consider using this optional hands-on activity to give students the opportunity to construct their own graph and ice core diagram.

1. Tell students that they will create a hypothetical temperature graph and a related ice core diagram that convey a possible real-life scenario. Their ice core diagram will be analyzed by another group of students.

2. Have each group think about and discuss possible climate scenarios for a 10-year period.

3. Have the groups create a graph that represents the temperature change from this 10-year period. (See example in Student Edition.)

4. Optional: You might have students add some detail by marking on the graph some events such as severe drought, volcanic eruption, etc. Students should include evidence of these events in their ice core diagram.

5. Optional: Have students add CO_2 levels to both their graph and ice core diagram.
6. Have students work as a group to decide how the changes in their graph would be reflected in an ice core.
7. Each group should make a diagram on a piece of paper to represent each layer of the ice core for each year (a template is provided in the Student Edition). Tell them to provide a key to their ice core diagram to help others make sense of it. An example diagram is provided in Slide 22.
8. After creating their graph and ice core, have each group pass their ice core diagram (but **not** the graph) to another group.
9. Have each group discuss and analyze the ice core diagram from the other group and create a graph based on the diagram of what the temperatures were like during this 10-year period. You may need to provide some scaffolding to help students through this process.

Part IV • The Argument

1. Slide 23: Emphasize the following conclusions:
    - In the past, the global temperature on Earth has been as high as it is today, but conditions were far different from the conditions we have today. For example, there were no ice caps at the poles.
    - In the past, it took thousands of years for the global temperature to change 2–3°. Recently, significant change has occurred in just 100 years.
    - The carbon dioxide level has not been this high in the last 420,000 years—although it was much higher millions of years ago.
    - There is a lag in how long it takes the temperature to change after a rise in CO_2. Thus, if CO_2 keeps increasing, temperatures are virtually certain to surpass highs of the past 420,000 years.
2. Slide 24: Review the structure of an argument. Provide examples of arguments that are well constructed and one or two that are not. Ask students to identify the strengths and weaknesses of each argument.
3. Have groups determine whether, based on the data they have reviewed, they now agree more with Emilio's or Destiny's claim.
4. Have them write an argument about the claim that they agree with by filling in the table in the Student Edition and then writing their final argument in their science notebook.

Part V • Chain of Cause and Effect

1. This section of the task highlights the crosscutting concept of **cause and effect**, and sums up what students have learned in the unit so far.

2. Display Slide 25. Have students think about what they learned in the unit in order to fill in the empty boxes of the cause and effect diagram in their Student Edition.

   Second box: increased carbon dioxide; last box: increased global temperature or global warming

Class Concept Map

1. Return to the whole-class climate change concept map from the Lift-Off Task.

2. Have students work in groups to brainstorm new words or new connections that they learned in this task that they would like to add to the class concept map.

3. Ask groups to share their ideas aloud in a class-wide discussion, and add their ideas to the class concept map.

4. Some facilitating questions to ask students are:

   - Are there any connections you want to change?
   - Do you want to revise and/or add anything to the description of the relationship between any concepts?
   - Are there more connections you can make between the ideas/concepts already on the map?
   - Do you want to add any new ideas/concepts to the map?

ELL SCAFFOLD

Reinforce the causal relationships being suggested by the class by drawing arrows and eliciting from students why two terms are connected.

5. Highlight any connector words that relate to the crosscutting concept of **cause and effect**. These could be phrases such as “which results in,” “which causes,” “that explains why,” “is due to,” etc.

6. At this point, students should be able to add the connection that burning fossil fuels releases the greenhouse gases that cause an increase in global temperature. They should also be able to add other specific human activities that lead to increased greenhouse gases in the atmosphere, such as methane from landfills, driving cars, factory production, etc.

7. Once again, the purpose of this concept map is to promote language development throughout the unit. Allowing students to give names to concepts and to share their ideas about how the concepts are related will help their oral and written language development.

Part VI • Connect to the Culminating Project and Assessment

1. Have students independently complete the Task 2 section of the Individual Project Organizer during class.
2. Collect the Individual Project Organizers and assess using:
    - The "Analyzing and Interpreting Data" and "Engaging in Arguments from Evidence" rows of the Science and Engineering Practices Rubric
    - A criterion of your choice
3. Return the Individual Project Organizers. Give students time to make revisions based on one of these two options.
    - Have students make changes to their Individual Project Organizer according to your comments. (This could be done for homework, depending upon students' needs and/or class scheduling.)
    - Ask students to exchange their Individual Project Organizer with a partner, and give partners 5 minutes to provide written feedback. Then allow students time to make changes to their work according to the feedback.

ELL SCAFFOLD

Pair ELLs with a student with a higher level of English proficiency, and one who can offer content insight that could strengthen what they wrote. Further, ELLs may need additional time to work on the Individual Project Organizer.

Reflect

At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following two questions in their Student Edition:

1. At the beginning of this task, you agreed with Destiny's or Emilio's claim and defended your choice. Look back at your decision and justification. After considering all the evidence today, how would you change your decision or add to your justification? Use your Climate Change Evidence Analysis Chart to help you.
2. In this task, you focused on the crosscutting concept of cause and effect, or how one event can lead to another. Give one example of how this crosscutting concept came up in today's task.

There are no right answers. If students are stuck, remind them to look back at their Student Edition. Emphasize that students should not change their initial responses, but rather modify and add to those responses based on what they learned in this task.