Developing Activities for Conceptualizing Climate and Climate Change

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Copy Editor
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Project Goals

• Goal 1: Develop a research base on students’ conceptualizations of climate and climate change that informs instructional development.

• Goal 2: Develop a conceptually-based series of activities that incorporates rich data sets, visualization activities, and case studies.

• Goal 3. Enhance students’ conceptualization of climate and climate change.
The Design Process

- Review Students’ Conceptions
- Research Students’ Conceptions
- Scientific Perspective (IPCC)
- Conceptual Framework
- Instructional Design
- Student Activities
- Field Test
- Dissemination (Feb 2009)
Student Conceptions

**Causes**
- Respiration (16%)
- Temperature change (24%)
- Volcanoes (18%)
- Fires (14%)
- Air pollution (29%)
- Factories (49%)
- Vehicles (59%)
- Deforestation (16%)

**Natural causes**
- Increase in carbon dioxide (41%)
- Air pollution and other gases (31%)

**Human causes**
- Greenhouse effect (33%)
  - Causes
  - Which is a (25%)
  - Which is a (29%)

**Impacts**
- Global Warming and Climate Change
  - Will not impact Humans (45%)
  - Will cause Humans to die (25%)
  - Plants and animals to die/decline (76%)
  - Warmer weather (88%)
  - Changes in precipitation (53%)

**Resolutions**
- Will resolve Lower carbon dioxide levels (45%)
  - Will
  - Reduce number of factories (18%)
  - Reduce pollution (22%)
  - Drive less (47%)

- Will cause Oceans to rise (55%)
  - Oceans to warm (27%)
Example Student Drawings
# Literature Review

## Student Conceptions about Climate and Climate Change

| Confusion between climate and weather | Pruneau, Gravel, Courque, & Langis (2003)  
Growda, Fox, & Magelky (1997) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change is caused by the sun’s rays getting trapped in atmospheric ozone</td>
<td>Pruneau, Gravel, Courque, &amp; Langis (2003)</td>
</tr>
</tbody>
</table>
| Climate change is caused by general air pollution | Boyes & Stanisstreet (1997)  
Growda, Fox, & Magelky (1997)  
Boyes, Chambers, & Stanisstreet (1995)  
Boyes & Stanisstreet (1993) |
| Climate change is caused by the ozone hole | Rebich & Gautier (2005)  
Pruneau, Gravel, Courque, & Langis (2003)  
Österlind (2005)  
Pruneau, Moncton, Liboiron, & Vrain (2001)  
Boyes, Stanisstreet, & Papantoniou (1999)  
Koulaidis & Christidou (1999)  
Mason & Santi (1998)  
Growda, Fox, & Magelky (1997)  
Dove (1996)  
Boyes, Chambers, & Stanisstreet (1995) |
| Confusion between the greenhouse effect and global warming | Rebich & Gautier (2005) |
Conceptual Framework
Challenges

- Student conceptions
  - Weather vs. climate
  - Greenhouse effect
  - Carbon dioxide layer

- Ability to observe climate change
  - Collect local weather data, but cannot monitor climate change due to time and scale issues

- Data handling difficulties
  - Distinguishing between description and interpretation
  - Calculating and comparing means
  - Making and Interpreting graphs
The activities require students to:
  • interpret, visualize, and transform scientific data
  • apply scientific concepts
  • analyze, evaluate, and explain scientific evidence and information
  • discuss and represent ideas
  • work collaboratively to make decisions and draw conclusions
Project Overview

This project will develop a digitally-based instructional program that contains data-rich case studies and visualization activities, as well as a visual library as a resource for K-12 teachers and students. This program will be organized as a series of activities that move scientifically from climate to climate variability to climate change. A central goal of this program is to explore the complex interface between science and society that forms the basis of management decisions related to climate change issues. Also, affective learning experiences require that instructional programs and activities be designed based on the students' ideas and understandings. The scientific perspective that guides the development of this instructional program seeks to guide students so that they can align with the scientific perspective as well as the student's own affective learning experience. This approach allows instruction to be sequenced in a way that moves students toward scientific conceptualization—curricular continuity (Driver, Squires, Rushworth, and Wood-Robinson, 1994).
## Modules and Activities

<table>
<thead>
<tr>
<th>Climate and Climate Change Module</th>
<th>Activity Title/Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fossil Fuels and Greenhouse Gases</strong></td>
<td>Energy, Fossil Fuels, and the Carbon Cycle</td>
</tr>
<tr>
<td><strong>Climate and Severe/Extreme Weather</strong></td>
<td>Weather and Climate</td>
</tr>
<tr>
<td><strong>Climate Change and Ecological Impact</strong></td>
<td>Climate Change and the Arctic Ecosystem</td>
</tr>
<tr>
<td><strong>Natural Processes and Climate Change</strong></td>
<td>El Niño and Global Warming</td>
</tr>
</tbody>
</table>
Example: Student Activity

### Your Family’s Carbon Footprint

**Key Concepts:**
- Carbon footprint
- Carbon dioxide
- Greenhouse gas
- Greenhouse effect
- Methane
- Nitrous oxide

**WHAT YOU WILL LEARN**

1. You will calculate the amount of carbon dioxide you and your family release into the atmosphere each year—your carbon footprint.
2. You will identify ways for you and your family to reduce your carbon footprint.
3. You will calculate the mean, median, mode, and range for your class’s carbon dioxide emissions data—your class carbon footprint.

### Engage Your Thinking

How much greenhouse gas (carbon dioxide and methane) does your family release into the atmosphere each year? How do you and your family contribute to the greenhouse effect and to global warming? To answer these questions, you will use the Environmental Protection Agency’s (EPA) Personal Emissions Calculator to estimate your family’s greenhouse gas emissions and to think about how you and your family could reduce your greenhouse gas emissions. Before starting this activity, however, answer the following questions based on what you currently know and think.

1. In what ways do you and your family release greenhouse gases into the atmosphere?

2. How might these activities contribute to the greenhouse effect and to global warming?

3. What can you and your family do to reduce your greenhouse gas emissions?

### Explore and Explain

Scientists believe that global warming is caused by an increase in the atmospheric concentration of the naturally occurring greenhouse gases. The major greenhouse gases are water vapor, carbon dioxide, methane, and nitrous oxides. The main greenhouse gases that enter the atmosphere because of human activities are:

- **Carbon Dioxide (CO₂):** Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees, and wood products.
Your Family’s Carbon Footprint

- Methane (CH₄): Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and from the decay of organic waste in municipal solid waste landfills.

- Nitrous Oxides (NOₓ): Nitrous oxides are emitted during agricultural and industrial activities, as well as during the combustion of fossil fuels and solid waste.

Many of your daily activities result in carbon dioxide and methane emissions; these activities add greenhouse gases to the atmosphere and this contributes to global warming and climate change. The greenhouse gas emissions you produce reflect your carbon footprint: the amount of greenhouse gases you contribute to the atmosphere measured in units of carbon dioxide. By calculating your carbon footprint you better estimate your contribution to global warming. When you understand the impact of your actions on the environment, you can make more informed decisions about specific ways to reduce your carbon footprint and to minimize your personal impact on the Earth’s temperature and climate.

The Environmental Protection Agency (EPA) has developed the Personal Emissions Calculator that allows individuals and households (families) to calculate the amount of greenhouse gas they emit each year and to estimate their individual carbon footprints. The estimate is based on energy use and waste disposal. In the following activity, you will use the EPA online calculator to estimate how much greenhouse gas you and your family release into the atmosphere each year. To use the online calculator go to:

http://epa.gov/climatechange/emissions/ind_calculator.html

Follow the instructions for using the calculator; you will need about 10–15 minutes to enter the data. For more accurate results, ask your parents to assist you in answering the following questions before going to the online calculator:

How do you heat your home?
How much does your family spend per month on electricity?
How much does your family spend per month on natural gas?
How much does your family spend per month on heating oil?
On average how many miles does your family drive per week?
What is the average gas mileage for your family car(s)?
Does your family recycle newspaper?
Does your family recycle glass?
Does your family recycle plastic?
Does your family recycle aluminum/steel cans?

Your Family’s Carbon Footprint

As you enter your information, the calculator automatically estimates the pounds of greenhouse gas your family emits in carbon dioxide equivalents: your family’s carbon footprint. Record the pounds of carbon dioxide equivalent in the table below.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Total from Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td></td>
</tr>
<tr>
<td>Home Energy</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
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</tbody>
</table>

Note: Waste produces methane, the calculator converts this to the equivalent of pounds of carbon dioxide.

4. How do your family’s greenhouse gas emissions compare to the U.S. average? (Note: The U.S. average is for a family of 2; for a family of 4, double the U.S. average.)

To explore actions your family could take to lower your greenhouse gas emissions while reducing energy and waste disposal costs, use the What You Can Do to Reduce Emissions section of the calculator. For each of the actions listed below, the calculator displays the amount of emissions your family could avoid. Calculate the items below, and record your results in the table.

a) If your family bought a new car that gets 5 miles per gallon of gas, how many pounds of carbon dioxide would your family avoid releasing into the atmosphere per year?

b) If your family drove 10 fewer miles per week how many pounds of carbon dioxide would your family avoid releasing into the atmosphere?

c) If your family turned down the heating thermostat in the summer by 2 degrees and turned up the air conditioning thermostat in the summer by 2 degrees, how many pounds of carbon dioxide would your family avoid releasing into the atmosphere per year?
d) If your family replaced two incandescent light bulbs with two ENERGY STAR compact fluorescent light bulbs (CFLs), how many pounds of carbon dioxide would your family avoid releasing into the atmosphere per year?

e) If your family does not recycle, how many pounds of carbon dioxide would they avoid releasing into the atmosphere per year if they did recycle?

Table 2. Potential reduction in greenhouse gas emissions per year

<table>
<thead>
<tr>
<th>Activity</th>
<th>Amount of Greenhouse Gas Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) More energy efficient car</td>
<td></td>
</tr>
<tr>
<td>b) Drive less</td>
<td></td>
</tr>
<tr>
<td>c) Turn down thermostat in the winter and up in the summer</td>
<td></td>
</tr>
<tr>
<td>d) Use compact fluorescent light bulbs</td>
<td></td>
</tr>
<tr>
<td>e) Recycle</td>
<td></td>
</tr>
<tr>
<td>Total Reduction of Greenhouse Gas</td>
<td></td>
</tr>
</tbody>
</table>

5. In which ways would these changes reduce your family’s carbon footprint?

Extend Your Thinking

How many pounds of greenhouse gas do the families in your class emit in a year? Using the class data:

6. Determine the total pounds of greenhouse gas emitted by the families in your class.

7. Calculate the mean, mode, median, and range of greenhouse gas emitted by the families in your class from transportation, home energy, and waste disposal (Table 3).

Table 3. Yearly class total pounds / carbon dioxide equivalent emissions

<table>
<thead>
<tr>
<th>Activity</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td></td>
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</tr>
<tr>
<td>Home Energy</td>
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<td></td>
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<tr>
<td>Waste Disposal</td>
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8. How do your family’s greenhouse gas emissions compare to those of your classmates’ families?

There are about 100 million families (or households) in the U.S. If each family did the following, how much greenhouse gas would be eliminated from the atmosphere?

9. If each household replaced two incandescent light bulbs with two ENERGY STAR compact fluorescent light bulbs (CFLs), how many pounds of carbon dioxide would be eliminated from the atmosphere per year?

10. If each family drove 10 fewer miles per week, how many pounds of carbon dioxide would be eliminated from the atmosphere per year?
11. If each family turned down the heating thermostat in the winter by 2 degrees and turned up the air conditioning thermostat in the summer by 2 degrees, how many pounds of carbon dioxide would be eliminated from the atmosphere per year?

**Apply What You Have Learned**

Create a brochure that could be used to inform families about actions they could take to reduce greenhouse gas emissions, and why such actions are important. The brochure needs to explain the ways in which each action would reduce greenhouse gas emissions and make a positive impact on the atmosphere and the environment.

**Reflect on What You Have Learned**

12. In which ways do you and your family release greenhouse gases into the atmosphere?

13. How might these activities contribute to the greenhouse effect and to global warming?

14. What can you and your family do to reduce your greenhouse gas emissions?

15. Please explain changes in your ideas and thinking about greenhouse gases and your family’s carbon footprint.