Developing Activities for Conceptualizing Climate and Climate Change

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PURDUE UNIVERSITY

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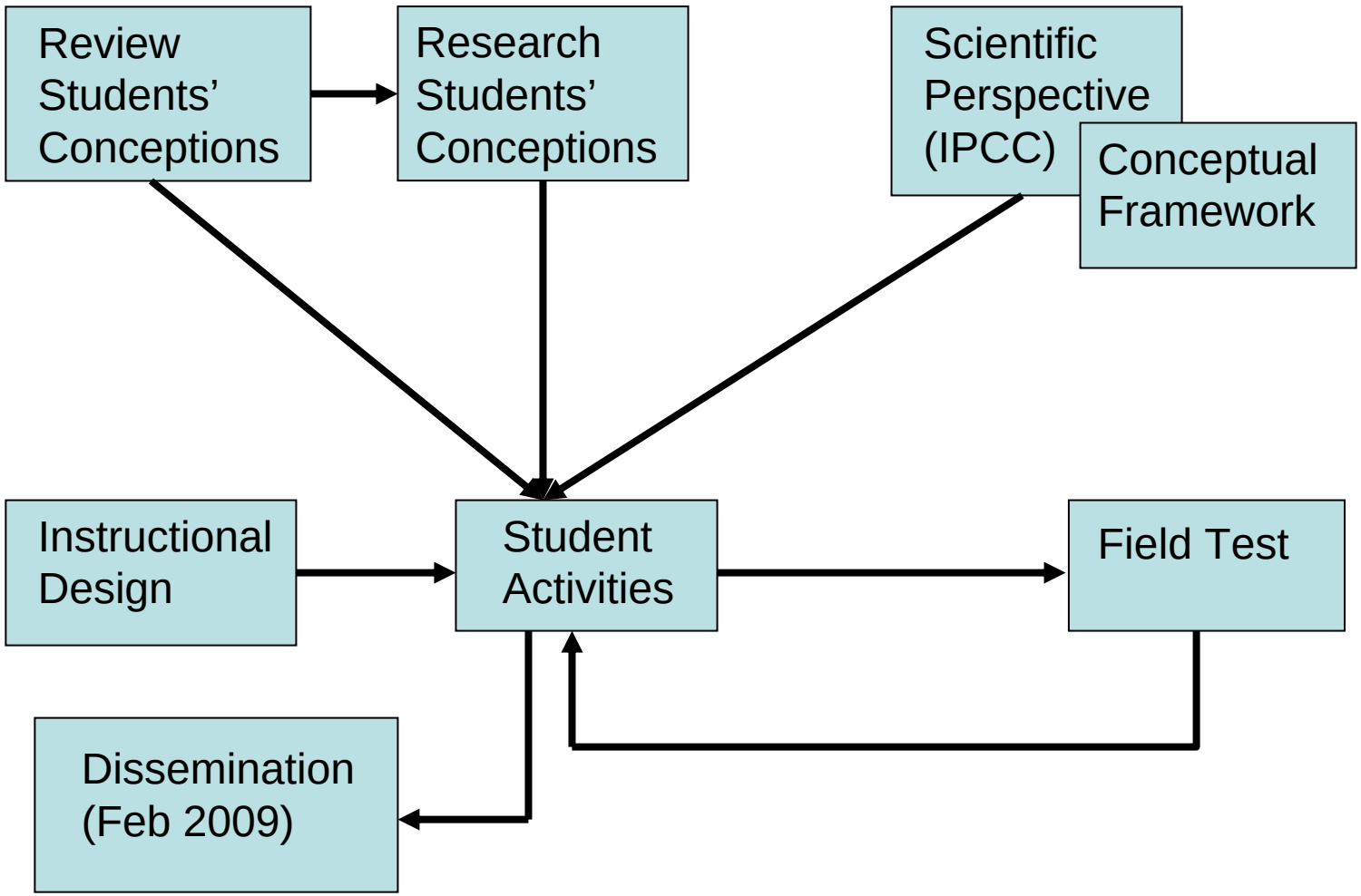
Project Goals

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

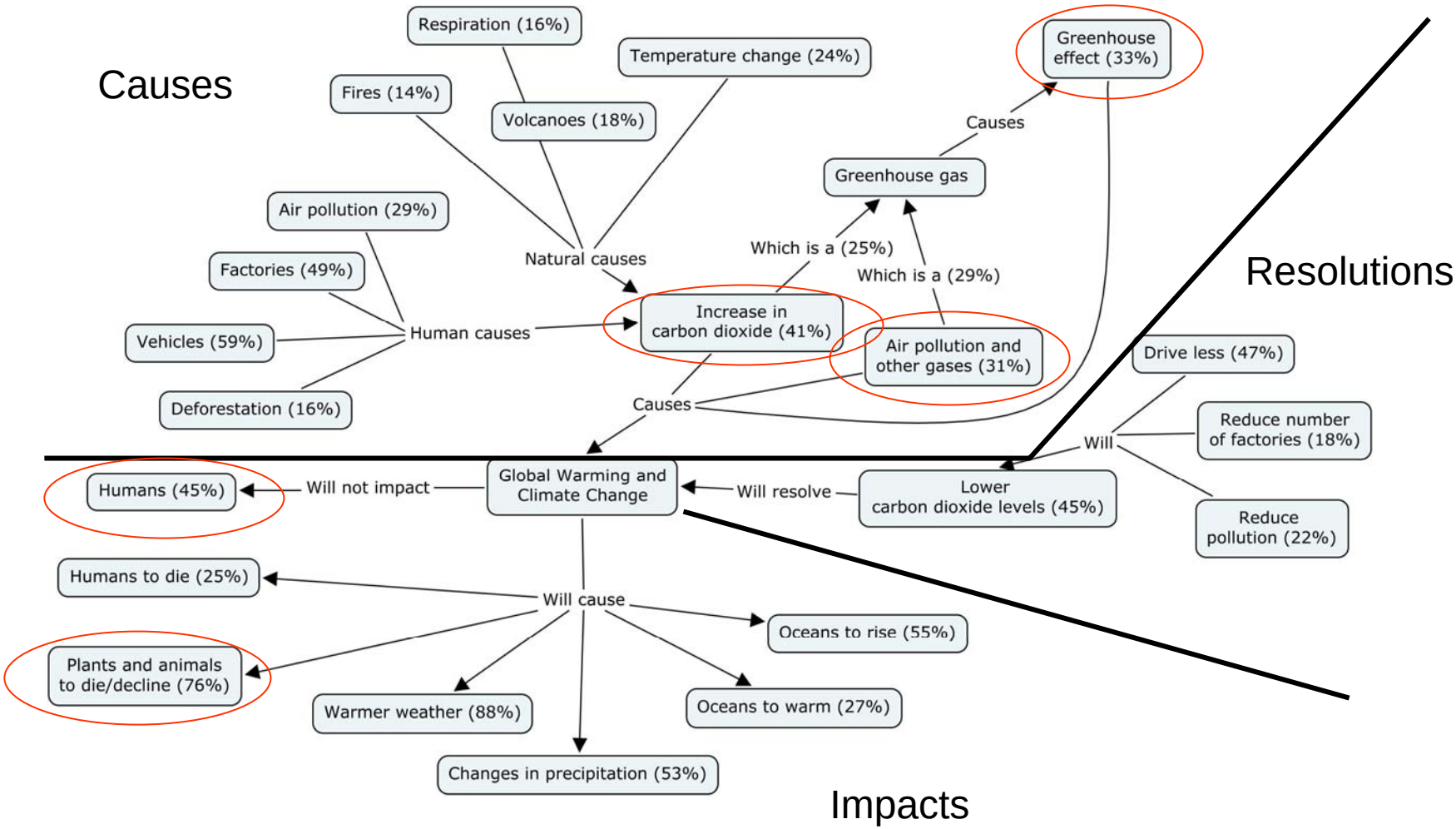
- Goal 2: Develop a conceptually-based series of activities that incorporates rich data sets, visualization activities, and case studies.

- Goal 3. Enhance students' conceptualization of climate and climate change.

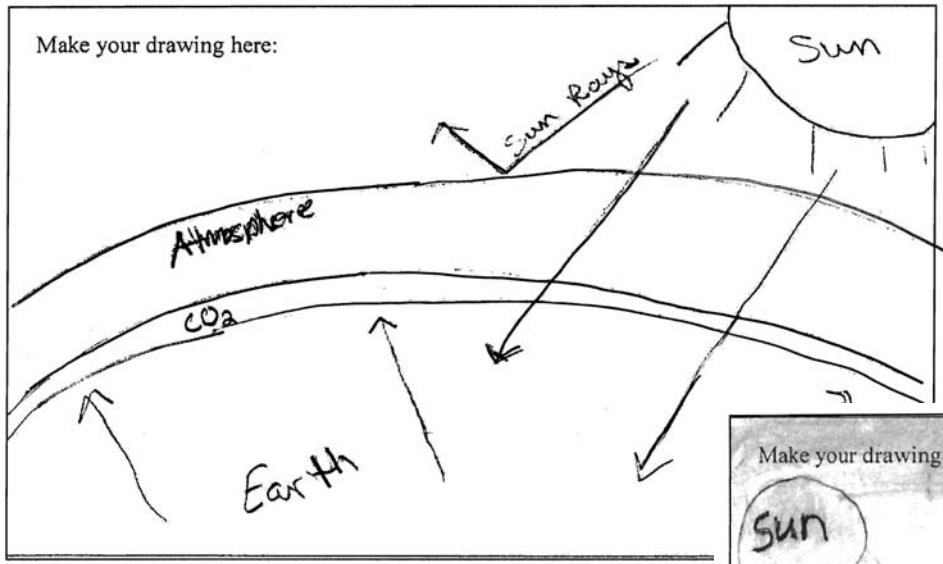
The Design Process

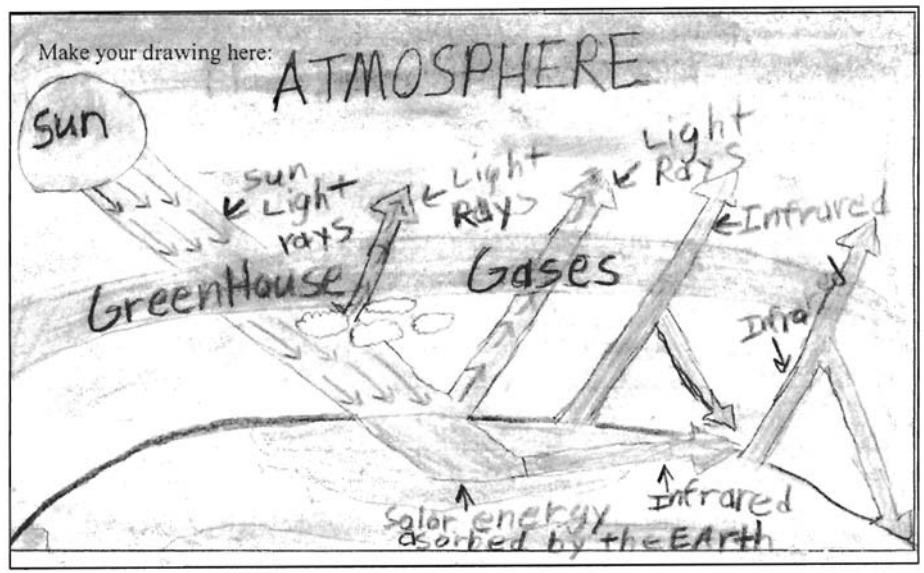


Student Conceptions



Example Student Drawings

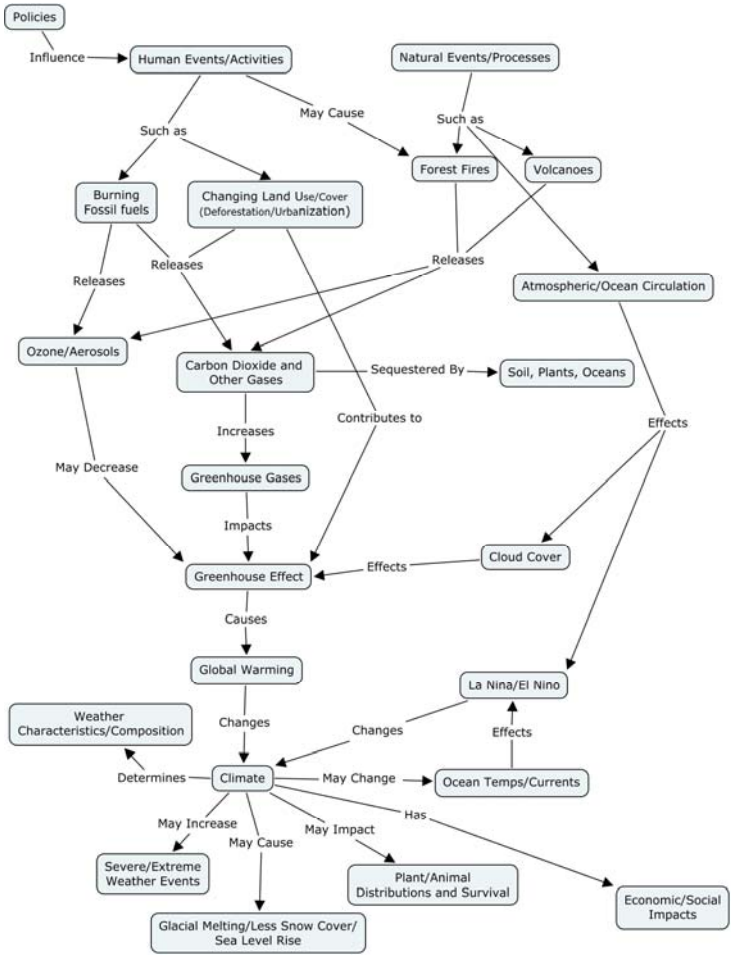




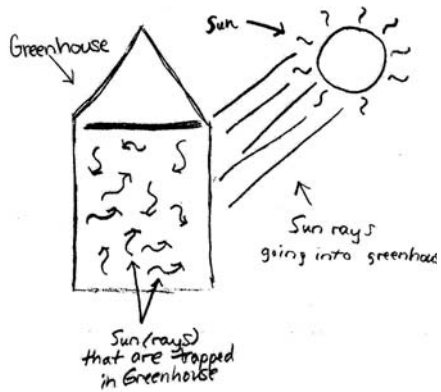
Literature Review

Student Conceptions about Climate and Climate Change	Author(s)
Confusion between climate and weather	Pruneau, Gravel, Courque, & Langis (2003) Growda, Fox, & Magelky (1997)
Climate change is caused by the sun's rays getting trapped in atmospheric ozone	Pruneau, Gravel, Courque, & Langis (2003)
Climate change is caused by general air pollution	Boyes & Stanisstrret (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



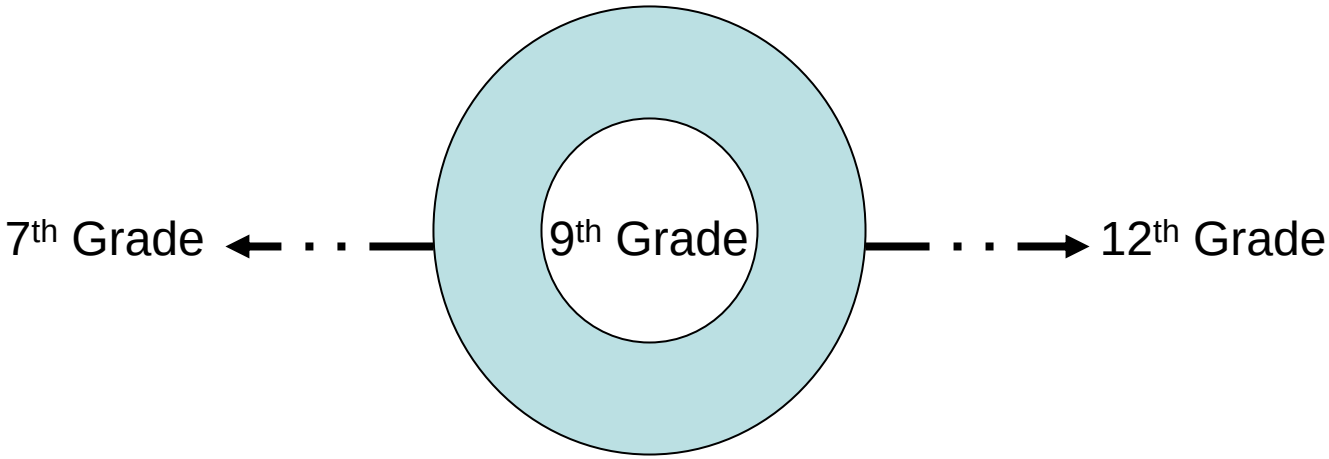
Challenges



- 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

About the Activities

Curricular Supplement



The activities require students to:

- interpret, visualize, and transform scientific data
- apply scientific concepts
- analyze, evaluate, and explain scientific evidence and information
- discus and represent ideas
- work collaboratively to make decisions and draw conclusions

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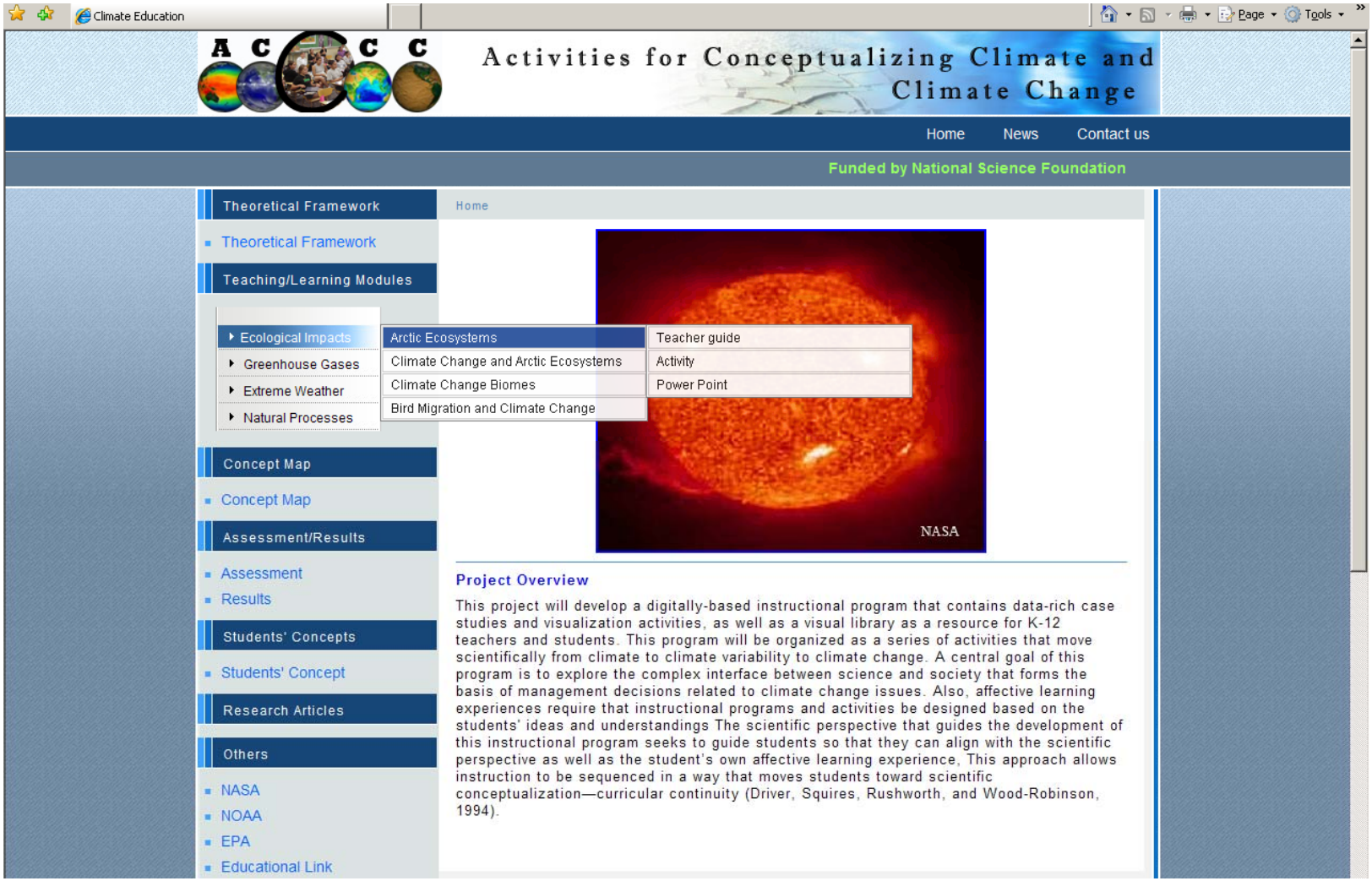

Modules and Activities

Climate and Climate Change Module	Activity Title/Topic				
Fossil Fuels and Greenhouse Gases	Energy, Fossil Fuels, and the Carbon Cycle	Fossil Fuel Use and Carbon Dioxide Emissions	Case Study: Carbon Dioxide and Global Warming	Your Family's Carbon Footprint	Climate Change: The Debate
Climate and Severe/Extreme Weather	Weather and Climate	Climate Change or Climate Variability	Mid-Latitude Cyclones and Climate Change	Case Study: Hurricanes and Global Climate Change	
Climate Change and Ecological Impact	Climate Change and the Arctic Ecosystem	Climate Change and Biomes	Case Study: Climate Change and the Arctic Ecosystem	Bird Migration and Climate Change	
Natural Processes and Climate Change	El Niño and Global Warming	Volcanoes and Global Warming	Milankovitch Cycles	Sun Spot Activity	

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 (CO_2): Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees, and wood products.

- Methane (CH_4): 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 (NO_x): 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? _____

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 1. Pounds of carbon dioxide equivalent emitted per year

Activity	Total from Activity
Transportation	
Home Energy	
Waste	
Total	

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 more 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 winter 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

Activity	Amount of Greenhouse Gas Reduction
a) More energy efficient car	
b) Drive less	
c) Turn down thermostat in the winter and up in the summer	
d) Use compact florescent light bulbs	
e) Recycle	
Total Reduction of Greenhouse Gas	

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

	Mean	Median	Mode	Range
Transportation				
Home Energy				
Waste Disposal				

- Create a graph that displays the relationship between the amount of greenhouse gas emitted in a year from transportation, home energy use, and waste disposal for the families in your class.

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 florescent 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.

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