Lesson 8: Climate Change

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Learning Objectives	Assessment Criteria
Students will be able to identify the main greenhouse gas emitted by human activities and give examples of activities that emit this gas.	Students should respond with Carbon Dioxide (CO_2) as the main greenhouse gas.
	Examples of student responses of activities should include: driving cars, heating our homes in the winter, cooling our homes in the summer with A/C, using electricity.
Students will analyze the cause and effect relationship between human emissions of greenhouse gases and Climate Change.	Students should recall that greenhouse gases (like carbon dioxide) trap extra heat in the atmosphere which causes the global average temperature to increase over time.
Students will recognize the effect that the Human Enhanced Greenhouse Effect has on Climate Change.	Students should provide an example of what they can do to help slow climate change. Student responses should include: walk more, car pool, turn off lights, keep the heat low in the winter and the A/C low in the summer, etc.
Students will summarize the impact that atmospheric carbon dioxide has on the Earth's average global temperature.	Students responses should be that with the addition of a certain number of tons of CO_2 into the atmosphere, the average global temperature will increase by one degree Celsius.

Benchmark/Standard/Big Idea:

Human activities, such as the release of carbon dioxide from burning fossil fuels, are major factors in global warming. Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. A Framework for K-12 Science Education, ESS.3D: Global Climate Change, Grade 8 Endpoint.

Relationship to the driving question:

The lesson is related to the effects that the human enhanced greenhouse effect have on climate change and how students can help to slow the process of climate change.

Prior Knowledge:

Prior to the lesson, students should be familiar with the most common greenhouse gases. Students should be aware of the effects of climate change and the amount of time it takes for such a change to occur. Students should be aware of the difference between climate and weather and the hazardous weather caused by an increase in the average world temperature by small amounts such as 1˚C. Students will have learned about the different climatic zones and the sensitive balance which must be maintained to avoid adverse effects such as endangerment of plant and animal species and enhanced hazardous weather.

Instructional Strategies:

For this lesson, the students will develop and test a scenario using a climate model. Students will read and interpret graphs of data to understand the relationship between carbon dioxide emissions and global average temperature.

Instructional resources used:

www.windows2universe.org, a website founded by the National Earth Science Teachers Association. This website is dedicated to providing learning opportunities and teacher resources in the field of Earth Science. This website is in accordance with the National Science Education Standards.

http://www.nytimes.com/2010/02/11/science/earth/11climate.html, is an article by The New York Times to be used as an introduction as well as a tool to challenge students to apply their knowledge of climate change and check for understanding.

Materials and set-up needed:

-Computer Projection Screen
-Computer lab with internet access
-Flash Player installed on Computers
-"The Very, Very Simple Climate Model" online interactive activity
-Paper
-Pencils
-Markers
-Poster Board

Time required:

50 minutes for Introduction and Part 1 of the activity
50 minutes for Part 2 and Summary discussion

Cautions:

There were no specific dangerous or hazardous components of this lesson.

Instructional Sequence

1. Introducing the lesson

To properly introduce the lesson, first we will revisit the idea of climate change by sharing an article about climate change from The New York Times entitled "Climate-Change Debate Is Heating Up in Deep Freeze." I chose this article to show to the students because it clearly exposes unscientific arguments opposing climate change. I will not have the students read the whole article as I believe that it will bore them and they will get lost in the political discussion. The article is attached with the important sentences highlighted. By projecting the article up on a computer projection screen and highlighting important topic sentences and summarizing the article to students I will introduce the topic. After summarizing the climate debate I will show the first highlighted portion of the article that will hook the students into the lesson. I will ask the following questions about the article based on what they have already learned to check for understanding. "What is wrong with the argument that climate skeptics are making?" "What have you learned that provides evidence against the climate skeptics' argument?" As students are answering the questions via large group discussion, the students will hopefully pull from

their prior knowledge of climate change that the weakness in the climate skeptics' argument is found in the evidence of greenhouse gas emissions and their effect on recent climate change. As the students answer the questions, I will scroll down to the bottom of the article where I have highlighted portions of the article that explain the issues with the climate skeptics argument to either help the students come to the answers or show the students that they are on the right track.

After this discussion, I will ask the students what they think a scientific model is. After testing this method out, I believe that my students will have a difficult time coming up with a working definition of scientific models; I will then give an example. The example I will give will be "In biology cells work in a very specific way, let's say I built a town and assigned a role to each of the towns people which relates to how the cell actually works. How is this an example of a scientific model?" Then I will introduce the idea of scientific models more formally and how they are used to predict how Earth's climate will change in the future. Generally speaking I will describe that computer models use math to describe how the Earth works. A few brief notes will be posted on the chalk board/white board about climate models:

What is a Scientific Model?
-Scientific models are representations of objects or systems.
What Is a Climate Model?
Global Climate Models- mathematic representations of how the atmosphere, oceans, land, living things, ice and energy from the Sun affect the Earth.
Uses of Climate Models
-Scientists use models to better understand how global changes such as increased emissions of greenhouse gases will affect the Earth.
-Mathematics and models allow scientists to make predictions about what the Earth will be like hundreds of years into the future.

After this discussion and brief note taking, Interactive Activity: Part 1 will begin.

2. Body of the Lesson

Part 1:

Part 1 of the Interactive Activity helps the students to become familiar with how the model works. First, I will tell the students that they will be using a model to test what will happen to the atmosphere and climate over 100 years depending on the amount of carbon dioxide released into the atmosphere. Next I will pull up the climate model from this link: http://www.windows2universe.org/earth/climate/cli_model.html onto the overhead computer projector so that I can point to the different parts of the graph, as they inspect the graph I will ask them questions about them to engage the students in what the different parts of the graph are. I will focus on explaining the axes of the graph:

1. I will point to the x-axis, and ask the students "What does the x-axis measure?" If they struggle to answer this question I will urge them to look at the units at the bottom of the graph. Once the students grasp that the x-axis measures time in years, I might choose to ask the students if the x-axis is the dependent or independent variable. The students may not know right away, so I would ask students if time moves along on its own or does it depend on some other parameter to continue moving forward?
   -The x-axis measures years into the future

2. I will point next to the y-axis and ask the students "What do you think the y-axes measure?" Or I might ask the students, "What is different about this graph from graphs that you usually see?" I would hope that the students would notice that this graph has 3 separate y-axes transposing three different lines. I will then ask, "What do you think these axes measure?" I don't know that the students will be able to pick out these measurements, but I will again urge the students to look at the units along the y-axes to help them determine what the y-axes measure.
   The y-axis measures 3 different things
   a. Carbon dioxide emissions rate (measured in gigatons CO_2 per year) in BLUE
      -the students may need extra help understanding the concept of rate of which I will explain means the amount of a substance compared to some other quantity. In this example the amount of a substance is CO_2 emitted compared to time in years.
   b. Carbon dioxide concentration in the atmosphere (measured in) in BLACK
   c. Average global temperature in RED

Next I will point out the variables to the left of the graph that students can manipulate as they run the model. As a group we will use the model once together. I will first ask the students to predict "What would happen to Earth's temperature in the future if each year we released the same amount of carbon dioxide into the atmosphere as we did in the year 2000?" I will inform the students that the rate of carbon dioxide emitted in 2000 was 6 gigatons of carbon per year. I will instruct the students to set the "Timestep size" to 10 years using the popup menu on the right. I will explain that timestep size just means this is how far into the future we will tell the model to advance. I will then instruct the students to click the "Step Forward" button 10 times to collect data through the 21st Century. I will narrate as the students proceed by stating that each time they click the button 3 points will appear on the graph and that the color of the points matches up with the colors of the scales on the left side of the graph (the y-axis). To help the students visualize and make connections with what they are seeing on the graph I will write the following on the chalk board/white board:

- Blue dots= how much carbon we add to the atmosphere each year
- Red dots = average global temperature in degrees Celsius
- Black dots= how much carbon has accumulated in the atmosphere over time in parts per million
  Parts per Million-means there are x amount of molecules of carbon dioxide in the atmosphere for every one million molecules we look at

Next we will discuss the graph that we have made together. First I will ask the students what they think the graph tells them, if necessary, I will facilitate this discussion by asking the students "Why are the blue dots forming a straight line across the graph?" The answer to this question is because the rate stayed the same, we did not increase the rate at which carbon dioxide is emitted into the atmosphere. This means that we are always emitting the same amount of carbon dioxide every year according to this model. Next I will ask the question "By looking at the red dots, can you tell if the temperature of the Earth increased, decreased or stay the same after 100 years?" The students should notice by the line sloping upward that the initial temperature in 2000 was 14.3 degrees Celsius and that the predicted temperature of 2100 rose steadily to 17.5 degrees Celsius, thus they should recognize that the global

temperature increased. I will ask the students what they understand about the black dots and what this means in terms of the graph. The students should understand that the carbon emitted does not just "go away" once it is emitted, the carbon remains in the atmosphere unless we do something to get rid of it, which is very difficult. This means that carbon builds up in the atmosphere which leads to bclimate change.

Part 2:

First, I will ask the students "Do you think the test run will reflect what people will do over the 21st Century?" I will ask them to explain their answers. The actions of humans are the largest unknown when it comes to future climate change, I will ask students probing questions such as "Will we release the same amount of carbon dioxide into the atmosphere that we do now?" "Will we release less?" "Will we release more?"

Next, I will have the students brainstorm as a class how and why carbon emissions might change in the future. We will record this information on the white board in a T-chart which will look like this:

Actions that change Carbon emissions	Carbon Emissions- Increasing/Decreasing
More power plants that burn fossil fuels	Increase
Innovative technologies that reduce use of fossil fuels	Decrease

I will provide an example: Carbon emissions will go up if more power plants are created that burn fossil fuels, yet carbon emissions will go down if more technologies are invented that reduce the use of fossil fuels.

Based on the class brainstorm, I will have students work in small groups of 3 or 4 students to come up with a scenario that they would like to test. For example: carbon dioxide emissions rise through the middle of the 21st Century and then decline after that. To be accurate to real world circumstances, students must start with emissions at 6 gigatons of carbon dioxide per year as it was in 2000. Students will be asked to write a brief description of their scenario before they begin testing their model. Students will also be required to maintain a timestep of 10 years. In their groups, students will form a hypothesis about the scenario they want to test and they will record this hypothesis on a worksheet (attached). The students will also need to record how they will test this hypothesis including what the x axis, and y axis measure and how the graph will respond to the test that they will run.

I will inform the students that if they want to run a few models or clear their model if they made a mistake that they need to refresh their browser

After running their models and filling out their worksheets, students will share what they did, by projecting their graphs to the rest of the groups. By doing this, students will participate in the sharing/communication of science. This worksheet will serve as an evaluation of learning.

3. Wrap up lesson

To wrap up the lesson, once the students have run their models, I will ask the students to clean up the materials, close their web browsers and return to their desks. As a large group, the class will hold a discussion of the various student scenarios. I will pose the following questions to begin discussion:

"What happened to temperature over time?"

"Is some global warming inevitable?"

"Which scenario had the least warming?"
"Which had the most?"

4. Evaluating Learning

Evaluation of learning will occur informally during the final large group discussion as well as with the worksheet that the students fill out during the lesson. The evaluation of learning will also take place informally via the questions asked throughout the lesson. The questions include: "What is wrong with the argument that climate skeptics are making?" "What have you learned that provides evidence against the climate skeptics' argument?" "Do you think the test run will reflect what people will do over the 21st Century?" "Will we release the same amount of carbon dioxide into the atmosphere that we do now?" "Will we release less?" "Will we release more?" "What happened to temperature over time?" "Is some Climate Change inevitable?" "Which scenario had the least warming?" "Which had the most?"

Design Rationale

I chose to structure this inquiry based lesson as an investigative online interactive activity. The students were engaged with a scientific event- climate change. This connected to what they had already learned in the previous lesson as an introduction to climate change as well as current events which was implemented through the use of the New York Times article. The students were given the opportunity to explore ideas through the manipulation of a scientific model and were challenged to create explanations for their observations. The students were also engaged in data analysis and interpretation helping to clarify concepts. Student understanding was extended in application of what they have learned to a new situation. Students practiced scientific inquiry by forming hypotheses and testing scenarios.