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The Greenhouse Effect and Me: How Do We Affect Each Other?

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Introduction and rationale

I teach introductory integrated science in four distinct classrooms of 9th grade students. The classrooms are heterogeneously grouped so that there is a broad mixture of students as they enter high school and include a number of students who are identified as 'inclusion' students. 'Inclusion' students are students who were previously enrolled in full time special education programs that are now participating in regular education classes as part of their IEP (individualized education plans). The class sizes are small (usually 15 to 20 students) with the room organized around bench tables. This allows laboratory work to be done while also making cooperative work possible-which is what we do most of the time. A mobile laptop computer unit with the unit connected to internet via wireless is available for the class. The unit will take advantage of that and include some integration of technology.

Every year we begin our study of the scientific method by having students explore 'inquiry labs'. 'Inquiry labs' are designed differently than the traditional cook book lab where the students follow directions to get to a predetermined endpoint. An inquiry lab is one that is set up so that the students acquire their own knowledge and are not only finding the answers, but are, in fact, asking the questions as well. This is important as inquiry based learning is becoming the standard, and the students are expected to perform such tasks when they are tested by the CAPT (Connecticut Academic Performance Task) in their 10th grade year. An traditional lab is converted into an inquiry based lab activity at the end of this unit.

We move through a lot of content as the year goes on. We first cover basic chemistry and chemical reactions, then move into physical sciences and energy. Finally, the year closes with an exploration of the universe, and most specifically our solar system. This exploratory science course moves quickly -- the rationale is to expose the students to concepts and theories, calculations and vocabularies, skills and techniques that will provide a background for the rest of their high school science curriculum. Students in New Haven study at least three years of science during high school, and this introductory course is aimed at reinforcing, or perhaps implementing, the foundation students need. Emphasis on using the scientific method to design and conduct research, organize and report results, and show understanding of real world connections is paramount to this course. This unit is designed with those goals in mind.

The overarching goal of the science curriculum at New Haven Academy is to develop thoughtful, responsible,

and active citizens who are able to acquire information to consider multiple perspectives and to make reasoned conclusions. This curriculum provides students with opportunities to critically reflect upon information and issues in order to examine the present, make connections with the past, and consider the future.

We are an interdistrict magnet school co-founded by Gregory Baldwin and Meredith Gavrin in September 2003. By definition, an interdistrict magnet school is a public school of choice designed to reduce racial, ethnic and economic isolation. It is our mission to provide a rigorous education that prepares all students to succeed in college and become active citizens able to make informed decisions about their lives and their communities. It is our goal to keep class sizes small in order to give students more personal attention. Asking the students to demonstrate their knowledge in writing, orally and through displays and projects is one of our central philosophies, and all students are required to complete and present projects in each of the classes at all grade levels. This unit will include a final project that asks students to demonstrate their ability to use scientific evidence to argue a particular debate topic with their classmates , and then present that information visually for a larger audience.

We are a member of the Coalition of Essential Schools, an organization whose mission it is to create and sustain equitable, intellectually vibrant, personalized schools and to make such schools the norm of American public education. Greg Baldwin, while at Brown University, studied under Ted Sizer, who is one of the leading reformers in education and founded the Coalition of Essential Schools in 1984. While following district guidelines, it is our goal to personalize our instruction for our students. Our school is our personal construction based upon teacher, student, parent and administrator expertise and input. We operate under five habits of mind, asking student to ask the following questions for any piece of information they encounter:

1. What is the evidence?
2. From who's perspective is it?
3. What are the connections and patterns?
4. How might things be different?
5. Why does this matter? Who cares?

New Haven Academy is in its second year of operation. Our classrooms consist of a variety of students, including fully included special education students. This necessitates differentiation of instruction such that you keep the top level interested while not losing those students at the lower end. Another challenge in managing the classroom at New Haven Academy is that we meet in 85 minute blocks. Many times it is necessary to have that amount of time if we are to really delve into and complete an activity. However, this also requires careful lesson planning and thought given to exactly how the time will be divided between direct instruction, hands-on activities and assessment. It is my goal to have the student-as-worker and the teacher-as-guide for as much of the class as possible.

To help students learn to think critically and understand the complexity of natural phenomenon, I have

developed this unit combining a theoretical understanding of a phenomenon with concrete evidence. The unit *The Greenhouse Effect and Me: How Do We Affect Each Other* focuses on how the greenhouse effect -- specifically as enhanced through the introduction of greenhouse gases by humans-- has affected Earth in the past, and what that effect will be in the future. In the unit, approximately sixty students will explore the impact that humans have had on our planet and what, if anything might happen in the future, depending on the decisions we all make. Students will connect the concept of energy to its favorable and detrimental effects on the environment and on patterns of political influence that could change those effects. In so doing, students will understand and apply concepts from their study of chemistry and physics to answer a specific 'essential question' (see below) about their impact on their environment, using evidence from their study of the greenhouse effect and using empirical evidence and pertinent information from their research to support their point of view. In the unit, the students will focus on the reasons that the earth has warmed due to the phenomenon referred to as the greenhouse effect. They will speculate how the Earth might be different without it this atmospheric phenomenon in place. Students will review their 9th grade science curriculum when we discuss the meaning of energy, heat, and chemical reactions; they will have the opportunity to make their own greenhouse; students will think about anthropomorphic causes that may change the environment; and finally students will research, digest and react to their gathered information to defend their position on an environmental topic in a political debate forum. In this way that can demonstrate what they are thinking and what they have learned.

Overview of the Unit

"The Essential Question"

An essential question is a specific question that is asked which leads the students to use higher-order thinking skills to seek out knowledge, and is usually a question for which an answer cannot be looked up in a book or journal or website. In "Understanding by Design: Curriculum and Assessment"(1), a guidebook for designing essential questions, the authors recommend that the question:

> *have no one obvious 'right' answer: essential answers are not self-evidently true. Even if there are 'truths' and essential theories in a discipline, the student comes to know that there are other plausible theses and hypotheses to be considered and sorted through along with the 'sanctioned' views.*

Students will be required to use the information they gather to analyze, synthesize, and draw conclusions. The student is always asked to go beyond the information given to develop a response that is personal, thoughtful, and supported by evidence.

In this unit I am using the question -- " ***The Greenhouse Effect and me: How Do We Affect Each Other?*****"** as the essential question. In 9th grade we typically explore the ideas of heat and energy and of chemical reactions. We also look at the model of light energy through the electromagnetic spectrum. Our standards also state that students should be made aware of their impact on the world. In this new unit, I think that focusing specifically on the human activities that changed the global environment will capture the attention of

my students in a concrete way. Students will construct a greenhouse where they choose a scenario to investigate, model that scenario and collect scientific evidence from that model. They can then apply that information toward an understanding of how the greenhouse effect takes place and what are the pros and cons of the phenomenon. Additionally, students will be able to investigate a range of current issues about the environment in order to answer the essential question. The students will look not only at why the greenhouse effect is essential to life on Earth, but also how a runaway greenhouse effect could change the way that life on Earth looks and how biodiversity will be affected.

In Connecticut high schools, students need to demonstrate their ability to apply knowledge and learning on a standardized test (CAPT); I think that the ability to research and use facts and data to evaluate a scientific phenomenon is a useful step in developing skills to achieve this goal. I hope that the students will be able to make the connection that human influences by way of technology have an impact on the world that they live in, and that thinking about a complex question can generate even more curiosity and more questions about a topic.

Rationale

The unit *The Greenhouse Effect* will probably span two to three weeks and is sandwiched between the unit on heat and temperature and the unit on weather. After five class periods devoted to vocabulary, background, and hands-on exploration of basic concepts related to the greenhouse effect, the unit will culminate with students working in teams to research and develop arguments to support an opinion which is then defended in debate format. This will show whether they understand the ways that people are having an impact on the environment and how policy decisions influence it. Each team of students will research both sides of an environmental issue, and then will choose a point of view and defend it using the evidence they have collected. The essential question should be at the back of their minds as they work on any facet of the project.

As a class, we will discuss the science of the greenhouse effect as it is currently understood before students embark on their own research. Students will be aware of the need to define and refine their own notions of the environment before drawing any conclusions based on their gathered evidence. Of course, the evidence itself might contribute to a change in their view. We will discuss classroom generated definitions and questions. We will talk about the areas where students would clearly expect to see pollution and then also discuss some other lesser known contributors to the environmental dilemma. After these classroom discussions, students should begin to think of evaluating the essential question on the greenhouse effect as a complex issue.

Performance Tasks

The students will be writing a daily journal to record whatever new ideas they are mulling over as they conclude each session of research. These remarks will be used the next day to remind students where they left off and to trigger research for the new day. Students will be required to answer the 'Essential Question' more formally in a final concluding essay, but the daily notes will help to remind them of their changes in viewpoint. While conducting research, students will be encouraged to use at least one primary source as well as text-based resources to supplement any information taken from reliable websites. Students will include a bibliography of works cited in their final presentation.

Students will take notes from books and online resources and save their materials in a portfolio. "Cutting and pasting" huge paragraphs of information will not be allowed -- the value of using an 'Essential Question' to guide research is that the use of the material will be unique to the student and not easily imported from a website. Research that must answer an 'Essential Question' avoids the "download online information and call

it a report" behavior that many students have developed when using the Internet as a tool.

Students will present their findings to the class in two ways. First, they must prepare a PowerPoint presentation of the data that they collect from the greenhouse lab. This will be presented in seminar style forum, with each team presenting their evidence and drawing conclusions from it. Secondly, students will present information in a debate format, where they use evidence that they have gathered to defend a political position on a global issue. Students will also be asked to write an essay and design a poster to illustrate the causes and effects of a greenhouse effect on Earth. Students will follow rubrics (available in resource packet) to guide them through the requirements of their assignments so that each student will address the same general topics in answering the essential question. Text-based resources for the topic will be collected and made available in the classroom. Students will access some pre-selected websites that explain the greenhouse effect. Students will be given Internet research guides so that the time spent on the Internet is directed and focused -- in other words, students will be looking for specific information rather than surfing the Internet for inspiration. Students will maintain a list of works cited and include citations for images and animations.

Integrating technology

Integrating technology is an essential part of this unit. The unit's theme about the greenhouse effect and the impact of human population on Earth is also about technology, since technology, according to the American Heritage Desk Dictionary is "the application of knowledge to develop tools, materials, techniques, and systems to help people meet and fulfill their needs". The purpose for integrating technology in this unit is to encourage students to use information from the world-wide web judiciously; to use technology tools to help answer important questions and to evaluate and analyze the material they are reading online with a critical eye. Additionally, integrating office technology, such as PowerPoint and Excel, will help students develop confidence is using multi-media resources that will be expected of them later in high school and in college.

The websites included in the unit are often interactive and can illustrate a combustion engine or the electromagnetic spectrum to give students far better than a one-dimensional illustration. Although this unit will be implemented in a classroom where each student has access to his own laptop everyday, it should also be possible to use computers in the library or computer lab and have the students work as teams.

What factors should students consider when analyzing their topics? What will help the students analyze the good and ill effects of the global warming as it ties into their lives? To help them focus, students will use mapping tools and planning guides during their lab investigations and research. Creating these visual outlines will help students formulate questions for research; creating visual rankings of data to organize their evidence about the positive and negative impacts of humans on global warming.

State Standards

The state of Connecticut lists the core scientific content and performance standards that are expected to be met during the high school science curricula. This unit is designed with many of these content and performance standards in mind. The specific standards that this unit addresses are available as part of the resource packet (available from author upon request).

Additionally the critical thinking skills the students will acquire in completing this project -- researching and finding evidence, taking a personal stand, recognizing divergent viewpoints, supporting a point of view-- are directly applicable to the Interdisciplinary Section of the CAPT that they will first encounter as sophomores in

high school. The *Writing Across the Disciplines* section of the CAPT requires students to apply knowledge and skills they have gained through their school career to an important contemporary issue. This assessment consists of two Interdisciplinary Writing tests. The tests measure how well students take a clear position on the issue and use accurate information from the articles to support their position. Students are assessed on how well they organize their ideas in a logical and effective manner so that their audience understands and follows their thinking, and express their ideas clearly and fluently using their own words.(2)

Classroom Discussions and Content

Energy and Global Warming

How does one take a classroom of students who think that the greenhouse effect has something only to do with growing tomatoes to a group of students who know how the greenhouse effect works and what role they play in contributing to global warming? Combining the goal to guide students to think critically about the positive and negative impacts of human technology with the objective that students understand the concept of our sun's energy and how the Earth's global climate works will be a challenge. Therefore, the unit will begin with a very structured framework before students can move to individual research.

We will begin by developing some basic definitions and creating a useful glossary of important terms and concepts. The students' understanding of this 'vocabulary' should be reflected in their final performance task by their using the words in the reports -- students also will encounter many of the terms in the course of their research and so a glossary will be helpful. More terms can be added as questions arise or as students discover other essential words or phrases. The teacher resource list contains books and websites (some interactive) that explain many of the basic terms in great detail and in varying degrees of complexity. The class will create a word wall of the terms and their definitions that will be accessible throughout the unit. Some of the key terms to be used in the unit are energy, heat, light, global warming and the greenhouse effect.

Energy is defined as the ability to do work. The kinds of energy include heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear energy. There is stored or potential energy (chemical or gravitational, e.g.) or working energy (mechanical and kinetic) energy. The sources of energy are renewable (solar, wind, hydropower) and non renewable (fossil fuels and nuclear). The class will discuss these ideas and come up with practical examples to demonstrate their understanding. We will relate the idea of fuel and energy to their eating of a good breakfast and the energy they have (or do not have) to do work throughout the day. We will talk about the furnaces in their homes and apartments and the kinds of cars their families drive -- what fuels are they using and where do they come from? Heat is energy that is transferred by a difference in temperature, specifically from a hotter object to a cooler object; thermodynamics is the study of heat and how it changes into different forms of energy. There are laws that describe how transfer takes place and for this unit we will look at the first and second laws of thermodynamics. Light and heat are considered electromagnetic radiation that is categorized by wavelength and frequency. Radiation with higher frequency has shorter wavelength and that with lower frequency has longer wavelength.

Global warming is a term usually used to describe the effects of decades of pollution on long-term weather patterns. Today, the idea of global warming is well known, if not well understood. It is not unusual to hear someone complaining about a hot day or a freak storm and blame it on global warming, even though it may

not be true. Additionally with blockbuster movies like "The Day After Tomorrow" people are growing more and more aware of what this term means. The greenhouse effect is a complicated phenomenon which involves the earth absorbing energy at all wavelengths and emitting them as heat, which is then trapped by gases in our atmosphere. When people talk about the global warming on Earth, they are usually referring to this somewhat more complicated process called the greenhouse effect. However, the greenhouse effect is not a bad thing by itself -- it is what allows Earth to stay warm enough for life to survive.

Weather and Climate

Weather is local and short-term. If it snows in the town where you live next Tuesday, that is weather. Climate is long-term and does not usually relate to one small location. Changes in climate sometimes take tens of thousands of years. That means if you happen to have a winter that is not as cold as usual, with not very much snow -- or even two or three such winters in a row -- that is not a change in climate. It is also important to understand that even small changes in climate can have major effects. When scientists talk about "the Ice Age," you probably envision the world frozen, covered with snow and suffering from frigid temperatures, but actually during the last ice age the earth's average temperature was only 5 Celsius degrees cooler than modern temperature averages (earthobservatory.nasa.gov). In specific terms, an increase of 1 or more Celsius degrees in a period of one hundred to two hundred years would be considered global warming. Over the course of a single century, an increase of even 0.4 degrees Celsius would be significant. It is also important to realize that in global warming the extremes are affected the most.

The Greenhouse Effect

Global warming is believed to be caused by an increase in the greenhouse effect. The greenhouse effect is not a bad thing by itself -- it is what allows Earth to stay warm enough for life to survive. You can think of the Earth like your car sitting out in a parking lot on a sunny day. Your car is always much hotter inside than the outside temperature if it's been sitting there for a while. The sun's rays enter through your car's windows. Some of the heat from the sun is absorbed by interior of the car. When those objects release this heat, it does not all get out through the windows. Some is reflected back in -- the heat radiated by the seats is a different wavelength than the light of the sun that made it through the windows in the first place. So a certain amount of energy is going in, and less energy is going out. The result is a gradual increase in the temperature inside your car.

When the sun's rays hit the Earth's atmosphere and the surface of the Earth, approximately 70 percent of the energy stays on the planet, absorbed by land, oceans, plants and atmospheric gases. The other 30 percent is reflected into space by clouds, snow fields and other reflective surfaces (earthobservatory.nasa.gov). Even the 70 percent that gets through does not stay on earth forever, rather things around the planet, like bodies of water, land formations, or people and plants absorb the sun's heat then eventually radiate that heat back out. Some of it makes it into space, and the rest of it ends up getting reflected back down to earth where it hits certain gases in the atmosphere, such as carbon dioxide, methane gas and water vapor. This heat that is trapped by the Earth's atmosphere keeps the planet warmer than it would be without an atmosphere, because more energy is coming in through the atmosphere than is going out. This is all part of the greenhouse effect that keeps the Earth warm. If there were no greenhouse effect, Earth would look a lot like . Mars does not have a thick enough atmosphere to reflect enough heat back to the planet, so it gets very cold there.

The greenhouse effect happens because of certain naturally occurring substances in the atmosphere. Unfortunately, since the Industrial Revolution, humans have been pouring huge amounts of those substances into the air, including carbon dioxide (CO_2), nitrous oxide (NO_2), methane gas (CH_4) and water vapor.

Carbon dioxide (CO_2) is a colorless gas that is a by-product of the combustion of organic matter. It makes up less than 0.04 percent of Earth's atmosphere, most of which was put there by volcanic activity very early in the planet's life. Today, human activities are pumping huge amounts of CO_2 into the atmosphere, resulting in an overall increase in carbon dioxide concentrations.(3) These increased concentrations are considered the primary factor in global warming, because carbon dioxide absorbs infrared radiation. Increased CO_2 means more energy absorption and an overall increase in the planet's temperature.

The Institute reports that carbon emissions worldwide have increased from about 1 billion tons in 1900 to about 7 billion tons in 1995. The Institute also notes that the average surface temperature of Earth has gone from 14.5 degrees C in 1860 to 15.3 degrees C in 1980.(4)

Nitrous oxide (NO_2) is another important greenhouse gas. Although the amounts being released by human activities are not as great as the amounts of CO_2, nitrous oxide absorbs much more energy than CO_2 (about 270 times as much). The use of large amounts of nitrogen fertilizer on crops releases nitrous oxide in great quantities, and it is also a by-product of combustion.

Methane is a combustible gas, and it is the main component of natural gas. Methane occurs naturally through the decomposition of organic material and is often encountered in the form of "swamp gas." The following human-made processes produce methane:

1) By extracting it from coal
2) From large herds of livestock (i.e., digestive gases)
3) From the bacteria in rice paddies
4) Decomposition of garbage in

Methane acts much like carbon dioxide in the atmosphere, absorbing infrared energy and keeping heat energy on Earth. There is also evidence that a large-scale introduction of methane into the atmosphere (such as from the release of huge chunks of methane ice locked under the oceans) could have created brief periods of intense global warming that led to some of the mass extinctions in the planet's distant past(5).

Water vapor is the most abundant greenhouse gas, but it is, more often than not, a result of climate changes rather than of man-made emissions. Water or moisture on the Earth's surface absorbs heat from the sun and the surroundings. When enough heat has been absorbed, some of the liquid's molecules may have enough energy to escape from the liquid and begin to rise into the atmosphere as a vapor. As the vapor rises higher and higher, the temperature of the surrounding air becomes lower and lower because temperature decreases with height. Eventually, the vapor loses enough heat to the surrounding air and it condenses back into a liquid. Earth's gravitational pull then causes the liquid to "fall" back down to the earth, thereby completing the cycle. This cycle is also called a "positive feedback loop" which is when an action causes a reaction that then prompts the original action to reoccur, resulting in a cycle between the two. A "negative feedback loop' is when the action causes a reaction that then decreases the occurrence of the original reaction. Water vapor is more difficult to measure than the other greenhouse gases and scientists are uncertain as to the exact part that it plays in global warming. But, the NOAA does have this to say:

As water vapor increases in the atmosphere, more of it will eventually also condense into clouds, which are more able to reflect incoming solar radiation (thus allowing less energy to reach the Earth's surface and heat it up).(6)

Effects of Global Warming

We have seen that an average drop of just 5 degrees Celsius over thousands of years can cause an ice age; so what will happen if the Earth's average temperature increases a few degrees in just a few hundred years? There is no clear answer because even short-term weather predictions are never perfectly accurate because weather is a complex phenomenon. To make climate predictions we can only make educated guesses based on our knowledge of climate patterns through history.

Glaciers and ice shelves around the world could begin to melt. In fact, this is already happening (http://www.guardian.co.uk/climatechange/). The loss of large areas of ice on the surface could accelerate global warming because less of the sun's energy would be reflected away from Earth to begin. An immediate result of melting glaciers would be a rise in sea levels. Initially, this would only be an inch or two. Sea levels would also rise because ocean waters would grow warmer, causing the water to expand. Even a modest rise in sea levels could cause flooding problems for low-lying coastal areas. With a rise in the overall temperature of the ocean, ocean-borne storms such as tropical storms and , which get their fierce and destructive energy from the warm waters they pass over, would increase in number and force. Additionally, changes in sea level could alter the Atlantic current that keeps the northern hemisphere a temperate region.

Less abrupt changes would occur around the world as average temperatures increased. In temperate areas with four seasons, the growing season would be longer with more precipitation. This could be beneficial in many ways for these areas. However, less temperate parts of the world would likely see an increase in temperature and a sharp decrease in precipitation, causing long droughts and potentially creating deserts.

The most devastating effects, and also the hardest to predict, would be the effects on the world's living ecosystems. Many ecosystems are very delicate, and the slightest change can kill off several species as well as any other species that depend on them. Most ecosystems are interconnected, so the chain reaction of effects could be immeasurable. The results could be something like a forest gradually dying off and turning to grassland or entire coral reefs dying. Many species of plants and animals would adapt or move to deal with the shift in climate, but many would become extinct. The effect on the biodiversity of the Earth could be devastating.

The human cost of global warming is hard to quantify. Thousands of lives per year could be lost as the elderly or ill suffer from and other heat-related trauma. Poor people and underdeveloped nations would suffer the worst effects, since they would not have the financial resources to deal with the problems that come with an increase in temperature. Huge numbers of people could die from starvation if a decrease in precipitation limits crop growth and from disease if coastal flooding leads to widespread water-borne illness.

Is Global Warming a Problem?

There is agreement that global warming is happening, but scientists disagree as to the severity of the problem and to what extent people should worry about its effect. Their arguments have to do with interpretation of data. For instance, the data show a measurable upward trend in global temperatures. Some scientists argue that this is either because we do not have enough long-term historical climate data or because the data we do

have is not clear enough. Some also argue that the data is being interpreted incorrectly by people who are already worried about global warming. That is, these people are looking at the statistics with biases in mind, instead of looking at the evidence objectively and trying to figure out what it means. Finally some argue that any increase in global temperatures we are seeing could be a natural climate shift, or it could be due to other factors than greenhouse gases, such as changes in solar activity. These scientists say that the Earth is more resistant to climate changes on this scale than we think. Plants and animals will adapt to subtle shifts in weather patterns, and it is unlikely anything catastrophic will happen as a result of global warming. Slightly longer growing seasons, changes in precipitation levels and stronger hurricanes, in their opinion, are hardly disastrous. They also argue that the economic damage caused by cutting down on the emission of greenhouse gases will be far more damaging to humans than any of the effects of global warming.

Most scientists, however, recognize that global warming is something to be worried about. They will tell you that global warming is real and that it is likely to do some kind of harm. The effects are sill being studied and debated, and political agendas have certainly had an influence.

What can we do to slow global warming?

There are a few things we can do to slow global warming. It all boils down to reducing the activities that create greenhouse gases. As individuals we can help by using less energy. The electricity that operates many of the devices in our homes comes from a , and most power plants burn fossil fuels to generate that power. Turn off lights when they're not in use. Take shorter showers to use less hot water. Use a fan instead of an air conditioner on a warm day, or keep the air conditioner set to a higher temperature and then use a fan to circulate the air. Take public transportation or drive more fuel-efficient cars. Walk or ride your bike if possible or car pool on your way to work. Driving your car generates more greenhouse gases than almost anything else you do. Other specific ways you can help decrease greenhouse-gas emissions are: to make sure your car is properly tuned up and the tires are inflated properly. This allows it to run more efficiently and generated fewer harmful gases. Turn lights and other appliances off when you are not using them. Even though a light bulb does not generate greenhouse gas, the power plant that generates the electricity used by the light bulb probably does. You should recycle. Garbage that does not get recycled ends up in a , generating methane; plus, recycled goods require less energy to produce than products made from scratch. It is good to plant trees and other plant life where you can. Plants take carbon dioxide out of the air and release oxygen. One should never burn garbage. This releases carbon dioxide and hydrocarbons into the atmosphere.

To really reduce the emission of greenhouse gases, we need to develop non-fossil fuel energy sources. Hydroelectric power, solar power, hydrogen engines and fuel cells could all create big cuts in greenhouse gases if they were to become more common.

At the international level, the was written to reduce CO2 and other greenhouse gas emissions worldwide. Thirty-five industrialized nations have committed to reducing their output of those gases to varying degrees. Unfortunately, the United States, the world's primary producer of greenhouse gases, did not sign the treaty.

Classroom lessons

I hope to spend some time discussing pollution that directly touches the lives of the students. Almost every student can relate to a trip to the gas station and the rising costs of filling a tank. They know from experience that an SUV will use more gasoline than a small compact car. Students need to realize that individuals and their governments can act to decrease the negative effects of the technologies so important to our thriving societies.

Many of these current issues can become the focus of homework after we have discussed concepts and terms in class. Students will read excerpts and look at charts and graphs from current news articles and magazines about relevant topics including gas prices, oil reserves, alternative heat sources, and global warming. We will talk about the homework assignments, both before and after the assignment is completed. These charts and graphs can be found in many of the resources in the bibliography and can be reproduced for classroom use. As the topics of fuel cells, hybrid cars, high oil prices and nonrenewable fuel supplies become increasingly mentioned on the news and in major newspapers, teachers and students can keep an eye out for current material to use in class. A possible homework assignment could also be to have students keep a running record with summaries of news articles and radio and television reports on the topic of pollution, the environment and fossil fuel issues that they encounter over the course of the unit.

Lesson Plan One: What is the greenhouse effect?

Rationale:

In order to access prior knowledge from the students, a brainstorming activity will be done first, followed by a lab where students begin to acquire their own knowledge about how the greenhouse effect works on earth.

Objectives:

1) Students will list any prior knowledge they have about the greenhouse effect, and then will list additional questions they would like to know the answers to.
2) Students will work in groups of two or three to construct models of the greenhouse effect and analyze the effect of different variables on the internal temperatures of those environments.

Background:

I like to do a K-W-L chart before each new unit. I solicit prior knowledge from the students by giving them a "journal prompt" on the board. They copy this into their journals, then try to answer it. Once they have had 5 minutes or so to contemplate their answer, I then go around the room and list each student's response on butcher paper. I then hang the paper up somewhere in the room so that we can refer to it as we proceed through the unit. I place a big "K" at the top of that page. Next, I hand out strips of plain white paper and ask them to write 2 questions on this "sentence strip". I collect these and read over them as I hang them on butcher paper. I place a big "W" at the top of this page and hang it next to the "K" page.

The lab is set up as a coupled inquiry lab. What this means is that I give the students the first question to answer, and then ask them to come up with a second question on their own, which they then must answer experimentally. I have a complete lab packet for this that is used as a handout for students. It is too long to include in this printing, but is available as part of a resource packet upon request (crystallavoielycos.com). During the lab, the students investigate how having an atmosphere allows the temperature of the planet to increase relative to a planet with no atmosphere. Once they compare the temperatures with "atmosphere" to "no atmosphere" by constructing a line graph of their data, they then ask a different question (e.g. "How does the composition of the earth itself affect the global temperature?) that they answer in a similar way. The second part of the lab will carry over into the second lesson.

Procedure:

1) Journal prompt: What do you know about the phenomenon called "the greenhouse effect"? (allow students 5 minutes to think and write in their journals).
2) List students' responses on butcher paper.
3) Ask students to complete sentence strips.
4) Hang sentence strips on butcher paper, reading them aloud as you do.
5) Introduce and run first part of lab.
6) Ask students to graph their data from their first experiment.

Assessment:

Teacher will read journal entries and assess them informally for their thoughtfulness and reflection on the ideas discussed. Graphs will be assessed for accuracy and completeness.

Lesson Plan Two: What variables can affect the greenhouse effect?

Rationale:

Students continue to work through an investigation of the greenhouse effect. As they conduct their experiments, it is important to go around to each group and solicit explanations for the phenomenon that they are observing. It is important to remind them of their lessons on thermodynamics and ask them to use the correct vocabulary from those lessons in their explanations.

Objectives:

1) Students will use the models that they have constructed to analyze the affect of some variable of their choosing on the internal temperature of their terrarium.
2) Students will graph their data and form valid conclusions based upon that information.

Background:

In the last lab activity, the students looked at a "closed" system versus an "open" system. This modeled a planet that has an atmosphere compared with one that does not. After constructing a graph of their data, the students should have been able to conclude that a planet with an atmosphere should maintain a higher average temperature than a planet without an atmosphere. In today's lab activity, students will ask a different question and then conduct a similar experiment to analyze how another variable might affect the average temperature of a planet.

Procedure:

1) Journal prompt: What was the difference in temperature between the closed and open systems in yesterday's experiment? Why do you think this was so? (allow students 5 minutes to respond).
2) Discuss journal prompt. Show a model graph from one of the student groups.
3) Introduce and run second part of lab.
4) Have students graph new data.
5) Ask one student from each group to present the group's data to the class. Ask the groups lots of questions to try and lead them to conclusions about the greenhouse effect.
6) Assign lab report.

Assessment:

Teacher will read journal entries and assess them informally for their thoughtfulness and reflection on the ideas discussed. Graphs will be assessed for accuracy and completeness. Assess oral presentations for understanding and for validity of conclusions based upon data. Lab reports will be assessed as an exam grade.

Lesson Plan Three: What is the phenomenon we refer to ask the greenhouse effect and how does it contribute to global warming?

Rationale:

Students will examine an overview of the phenomenon of the greenhouse effect. This will be done through a traditional lecture and note-taking session, directed by me using a power point presentation (available from resource packet). Topics that will be included in the lecture include: the greenhouse effect, the electromagnetic spectrum, evidence to support global warming on earth, comparison of the run-away greenhouse effect on Venus. Students are expected to take their own notes during the lecture. In the last 15 minutes of class, students will be given a worksheet with pertinent questions taken from the lecture. They will use their notes to answer the questions and then hand this in as a class assignment. If they do not finish during class, they can finish it for homework.

Objectives:

1) Students will take notes from teacher-directed lecture.
2) Students will use their notes to answer questions.

Background:

After completing the lab activity, students are starting to get an idea for how the greenhouse effect works on earth. Additionally, they have been able to draw from prior knowledge that the gained during the heat transfer unit, and can apply some of those concepts toward explaining this phenomenon. During this lesson, students are given factual information that will either support or deny the conclusions that they made during the lab activity. They will be asked to incorporate this content into their lab reports.

Procedure:

1) Journal prompt: How does the greenhouse effect contribute to global warming on earth? (allow students 5 minutes to respond).
2) Discuss journal prompt.
3) Deliver lecture while students take notes.
4) Have students answer questions using only their own notes.
5) If time permits, go over answers. If not, assign for homework and go over answers during the next class.

Assessment:

Teacher will read journal entries and assess them informally for their thoughtfulness and reflection on the ideas discussed. Answers to questions will be assessed for accuracy and understanding.

Lesson Plan Four-Six: Is global warming really affecting our planet? What, if anything, should we do to prevent global warming?

Rationale:

Students will work in teams to conduct research on a topic that remains controversial in our political arena. To do this, students will be given access to the internet as well as print resources and each student will be assigned a specific role within the team. Planning sheets will be used to help students organize their research and also to validate their information. It is important that the facts they choose to present are confirmed by more than one source, so there is an area for this on their planning sheets (available from resource packet).

Finally, each student will be asked to prepare a small (5 slide) power point presentation on the area of research they were responsible for.

Objectives:

1) Students will choose a debate topic.
2) Students will research their debate topic using planning sheets.
3) Students will prepare oral arguments to defend their debate topic.
4) Students will prepare a poster that summarizes their arguments and visually represents their stance on the issue.

Background:

I often use debates in my class to make students think more critically about a scientific issue. Debate forces them to take the knowledge that they've gained during class and apply it to a current issue. Students will be asked to prepare both the con and the pro side of the issue during the planning stage, and then on the day of the debate they will flip coins to decide which side they will actually defend. This will allow students to become "experts" on both sides of the issue, so that they will not only be able to present their side well, but can also answer the questions from the other side well.

There are many topics that could be used for a debate of this type. Some examples are:

1) Should the United States have supported the Kyoto Protocol?

2) Should the United States support and fund drilling for oil in the Alaskan Wildlife Refuge?

3) Should the United States support and fund hydrogen as an alternative fuel source?

4) Should the United States consider using nuclear fusion as an alternative to carbon fuels?

I have found that students struggle with research. For this reason it is extremely important that the teacher continue to circulate throughout the research time and redirect students that are having difficulty. It will be helpful to have a list of trustworthy websites ready for students that do not know where to begin. Also, allowing some flexibility with time will be important as sometimes this can take longer than you think it will.

Procedure:

1) Journal prompt: Diagram the greenhouse effect as it occurs on earth. Label the diagram using the terminology we discussed during yesterday's class. (allow students 5 minutes to respond).
2) Discuss journal prompt. Have at least two students come to the board to draw and discuss their diagrams.
3) Introduce debate topics. Assign debate teams.

4) Allow students to sign out computers. Distribute planning sheets. Tell students that the planning sheets will be graded in addition to the debate itself.
5) Collect all material at the end of class and hold on to it until the next class.
6) As student groups begin to finish their research, ask them to mock debate among themselves.
7) Conduct debate in a traditional debate format. Have students that are observing complete assessment sheets for the teams. Ask them to indicate a "winner"
8) Give students one class period (60 minutes) to design and complete their posters.
9) Assign power point presentation.

Assessment:

Teacher will read journal entries and assess them informally for their thoughtfulness and reflection on the ideas discussed. Debate planning sheets will be assessed for accuracy and use of resources. Debate presentations and posters will be assessed for clarity, understanding and use of evidence. Power point presentations will be assessed for accuracy, neatness, and creativity.

Reading List

Teacher resources -- electronic

http://www.oneworld.org/energy/whatis.html Great site answering the question: What is energy?

http://jersey.uoregon.edu/vlab/ University of Oregon Physics department site -- lots of good information on laws of thermodynamics with applets that illustrate the explanations.

http://www.secondlaw.com/two.html#time A wonderfully readable chat about the laws of thermodynamics, definitely way beyond what is needed for the unit but helpful for general understanding.

http://my.unidata.ucar.edu/content/staff/blynds/tmp.html This is a great place to learn about the meaning of heat!

http://auto.howstuffworks.com/inside-engines-roundup.htm Use this site either as a teacher resource or to use in a whole class discussion -- especially if the interactive engines can be shown to the class.

http://www.epa.gov. Good information on global warming, and a plethora of general environmental information.

http://www.epa.gov/teachers. Great curriculum information, grant suggestions, workshop and conference info.

http://science.howstuffworks.com Great source for information on greenhouse effect.

http://climatechange.unep.net/. Information on federal Fossil Energy Programs

http://www.energy.gov/engine/content.do?. Science Education Initiative of the Department of Energy

http://www.worldwatch.org/ A leading source of information on the interactions among key environmental, social, and economic trends.

http://www.ct.gov. Statewide information on environmental quality and pollution prevention

http://www.dep.state.ct.us. Good source for auto emission information

www.noaa.gov. Good source for global warming stuff

www.ncdc.noaa.gov National Climatic Data Center. Great information on weather and climate

www.epa.gov A complete global warming website

www.csde.state.ct.us The Connecticut State Department of Education website. This is the place to go for CAPT related materials.

Student resources -- electronic

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http://www.classroom-energy.org/teachers/energy_tour/pg1.html All about petroleum website -- good activities for teachers and students that introduce or review basic concepts.

http://www.glenbrook.k12.il.us/gbssci/phys/Class/energy/u5l1a.html This website explains the meaning of work and has an online quiz about work that students can try.

http://www.nsta.org/Energy/find/primer/primer1_1.html Good examples for kids to explore to understand about energy and work, all terms are defined by examples.

http://www.oneworld.org/energy/whatis.html Nice definitions of energy and work.

http://www.eia.doe.gov/kids/whatsenergy.html More kid friendly descriptions of basic terms and concepts on energy.

http://www.energyquest.ca.gov/story/index.html An online book of info --very readable for 8th grade.

http://inventors.about.com/od/famousinventors/ A good general resource site linked to many other sites about inventors and the growth of technology.

http://solar-center.stanford.edu Activity on ultraviolet light

http://www.epa.gov/kids. EPA's website for kids. Good links called "Science Room" and "Ask EPA"

http://www.worldbookonline.com. On-line version of World Book Encyclopedia, complete with atlas, dictionary, and a history section entitled "Back in Time"

http://www.brainpop.com. Information on energy sources, fossil fuels and global warming

Text Resources -- Teachers

Ahrens, C. Donald. Meteorology Today. Brooks Cole. 2002.

Alters, Sandra, Energy: Shortage, Glut or Enough? Information Plus Reference Series, 2003. Good basic overview of the energy situation.

Arms, Karen, *Environmental Science,* Holt, Reinhart and Winston, 1999. Standard textbook used in New Haven.

Blatt, Harvey, Our Geologic Environment, Prentice Hall, Inc., 1997. Textbook used at SCSU for an introductory Earth Science class. Great resource.

Boyle, Godfrey, Renewable Energy: Power for a Sustainable Future, Second Edition, 2004, Oxford University Press, New York. A textbook written as a major component of the Open University's second level undergraduate course *T206 Energy for a Sustainable Future.* Written from the British point of view. Very informative and readable.

Cacopardo, Matthew. *Energy in a Clean Environment* . YNHTI Curriculum Unit 04.04.04.

Chandler, Gary, *Alternative Energy Sources,* Millbrook Press, 1996. Part of a book series ("Making a Better World"), a good starting point for alternative forms of energy. Short and easy to read.

Fay, James A., and Dan S. Golomb, Energy and the Environment, 2002, Oxford University Press, New York..

Freedman, R.A. and W.J. Kaufman. Universe. W.H. Freeman publisher.

Goodrich, Judith. *Industrial Revolution in America: Exploring the Effects of the Heat Engine on the Growth of Cities* . YNHTI Curriculum Unit 04.04.05

Keeling, C.D. and T.P. Whorf. 2005. "Atmospheric CO2 records from sites in the SIO air sampling network". In *Trends: A Compendium of Data on Global Change* . Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A

Miller, G. Tyler, Jr. 1998. *Living in the environment: principles, connections, and solutions.* Belmont, California: Wadsworth Publishing Company. Described as the best college text on environmental science, also used by high school environmental science students. Takes an interdisciplinary approach by combining natural and social sciences.

New Haven Science Teachers' Curriculum Development Team, *Content Standards and Expected Performances for High School Science Grades 9-12* , November, 2003.

Pack, Janet, *Fueling the Future,* B&B Publishing, 1992. Good source for fossil fuel and alternative energy information. Nice photos and

suggestions for follow-up activities with organizations.

Pipkin, Bernard, Geology and the Environment, Fourth Edition, 2005. Thompson Learning, Inc. Textbook used at SCSU for an introductory Earth Science class. Great resource.

Sandfort, John. *Heat Engines : Thermodynamics in Theory and Practice* (Science Study Series)Greenwood Press, 1979. I came across mention of this book as something that is easy to read and not full of math -- perhaps even good reading for a 14 year old..

Stern, Beverly. *Creating Our Energy Future* . YNHTI Curriculum Unit 81.05.10

Wiggins, Grant and Jay McTighe. *Understanding by Design: Curriculum and Assessment* . Pennington, New Jersey: The Center on Learning, Assessment, and School Structure, 1997.

Wysession, Michael, David Frank and Sophia Yancopoulos, Physical Science: Concepts in Action, Prentice Hall, 2004. High school text selected for NHA students. Good graphics and activities.

Text Resources -- Students

Alters, Sandra, Energy: Shortage, Glut or Enough? Information Plus Reference Series, 2003. Good basic overview of the energy situation.

Gardner, Robert, *Science Projects About the Environment and Ecology,* Enslow Publishers, 1999. Discusses the environment in relationship to ecology, global cycles, humans, population trends, and energy. Each section offers hands-on activities, many specifically suited to science fair entries. Written in handbook form, it is very concise and readable.

Grolier Library of Environmental Concepts and Issues, *Using Earth's Resources,* Grolier Publishing Company, 1992. Informative, concise text. Offers "Envirobits" (thumbnail facts on the environment) throughout.

Kerrod, Robin and Sharon Ann Holgate. *The Way Science Works.* New York: DK Publishing, 2002. Good illustrations.

Langholz, Jeffrey, and Kelly Turner, You Can Prevent Global Warming, Andrews McMeel Publishing, Kansas City, 2003. Written in handbook form, a light-hearted guide to 51 ways to help reduce global warming (and save money) on a daily basis.

MacAulay, David and Neil Ardly. *The New Way Things Work* . New York: Hought-Mifflin, rev. 1998.

Roa, Michael, *Environmental Science Activities Kit,* The Center for Applied Research in Education, 1993. A good source for science fair ideas.

Endnotes

1. Wiggins, Grant and Jay McTighe. Understanding by Design: Curriculum and Assessment. Pennington, New Jersey: The Center on Learning, Assessment, and School Structure, 1997.

2. www.csde.state.ct.us CAPT Program Overview

3. Keeling, C.D. and T.P. Whorf. 2005. "Atmospheric CO2 records from sites in the SIO air sampling network". In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A

4. http://www.worldwatch.org/

5. Discover Magazine, Dec. 2003

6. www.ncdc.noaa.gov