

Separating Fact from Fiction in the Debate about Climate Change

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Contents of Curriculum Unit:

Overview

Rationale

Objectives

Strategies

Classroom Activities

Annotated Bibliography/Resources

Appendices-Standards

Overview

This unit has been designed with the secondary educator in mind, although with modifications, it could be used at middle school level. It would be suitable for use in either a general or advanced physics curriculum or an earth space science class. The approach is not so much didactic as it is exploratory. The subject of global warming is one that is loaded with both possibilities and pitfalls. This unit seeks not to present the last word on the subject but rather an approach that can be taken that will give students a balanced view. Both pro and con will be given equal time and weight because it is the opinion of the author that when presented with factual information, in a dispassionate manner, students will be able to come to intelligent conclusions quite on their own. Indeed the focus here, is not so much on the facts themselves, but is rather directed toward how information can be interpreted and analyzed. If one looks only at the data and documents presented by one point of view or the other on this issue, and doesn't think too deeply or long, it would be easy to conclude that whatever viewpoint you are currently looking at is the correct one. From my own research and study on this subject of climate change that goes back to my college days in the late 1960's, I have come to appreciate just how difficult and complicated it is to come up with absolute answers to many of the questions being asked in this debate. Therefore, rather than presenting our students with the "answer," we need to equip them with the skills and abilities that will allow them to sift through the large volumes of data that are being presented and make an intelligent and honest decision on their own. Neither side of this debate needs any more

disciples. What we do need, however, is people who have been trained to think through what they're being asked to believe and decide whether it squares with reality or not. The difficulty here is in knowing what the reality is. Obviously we cannot all do our own original research. We have to be able to trust what other people are telling us. Unfortunately, people do not always give you "just the facts." In fact, people rarely give you just the facts and it becomes incumbent on the reader/listener to see what the underlying objective that is being presented really is. What is going on in various places in the world for example, the Polar Ice Caps, or the mountain glaciers around the world, or in the ocean deeps, or in the upper reaches of the atmosphere, cannot be studied personally by each one of us. We must, therefore, have reliable sources that will tell us exactly what is happening not what someone would like us to think is happening. My own experience has taught that this can be problematic but if one is willing to look long and hard enough I believe the truth on these issues can be determined. If your intent is to persuade students to one side of the debate or the other, this unit will probably not be satisfactory for you. If however, you are not so much trying to persuade as to enlighten, and give students the tools necessary for them to do their own thinking; I encourage you to look further into this unit.

Rationale

The subject of global warming is one that is being hotly debated in almost every imaginable venue. It's virtually impossible to pick up a newspaper, turn on the television, look at your computer, or listen to the radio, without encountering something that is connected either directly or indirectly to the subject of climate change. It seems everybody these days has something to say on the subject. A home remodeling magazine will encourage its readers to use the latest type of low VOC paints in their remodeling projects because this is considered (green) and therefore good for the environment. The subtext is that by using this particular type of paint you will help in the battle against climate change. On the internet, at an automotive magazine's website, you will see featured a story about automobiles designed to run on compressed air and called zero emission vehicles. While neither these nor any other type of vehicle is ever zero emission, they may often be cleaner and have a lesser environmental impact than other types of cars. This misuse of the term "zero emission" is a classic case of misinformation, whether it is intentional or unintentional. It seems that in such places as California people are clamoring for a zero emissions vehicle. The fact that people believe that such a thing is possible shows the difficulty we have in carrying on a truly intelligent discussion about any scientific based subject but especially this one. I have heard commentators of all sorts and writers in magazines describing electric cars as zero emissions. It seems that the general public and these writers as well, have a very poor understanding of how electricity is produced. If the electricity is produced by wind, photo voltaics, or geothermal, then that electricity may very well in fact be zero emission or close enough that we can call it that. But the fact of the matter is, that the vast majority of electricity produced in this country does not come from the aforementioned sources. In fact, on a national level, burning coal generates more than half of the

electricity we use. Most scientists would agree that this type of fossil fuel has the most adverse effect on the environment. These effects would include acid rain, which forms when the sulfur in the coal is burned producing sulfur dioxide, which then mixes with water in the atmosphere to produce sulfuric acid. The carbon dioxide produced in addition to its role as a greenhouse gas can also mix with moisture in the atmosphere to produce a form of carbonic acid. Next on the list is mercury that is present in almost all coal and is released as a gas into the atmosphere but eventually winds up in lakes, rivers, streams and ultimately the ocean. From there it finds its way into the food chain and into foods of all types. Depending on the type of coal the amounts of these substances will vary, but none of them could be considered desirable. So even if you own an electric car, the chances are that although as you drive down the street, your car emits no emissions at that particular point, however, at some other location, whether it is near or far away, plenty of emissions are being produced to make the electricity that charged your vehicle. Because of the inherent inefficiencies in any generating system, less than 50% of the energy consumed actually gets delivered to the customer. This means that someone driving an electric car may in fact, be putting more carbon dioxide in the atmosphere per mile driven than someone driving an automobile like the Honda Civic hybrid, which does use an internal combustion engine and does produce emissions at whatever location it may be found.

Fashion magazines regularly present cosmetics and or clothing that are supposedly produced in an environmental friendly way. The idea here is that even some of your more personal activities can have an effect on the environment especially when it is a summation of the activity of millions of people. The evening news regularly presents to us stories of the effects of climate change on everything from melting glaciers in the high mountains or the ice shelves of the Antarctic to the effect that higher temperatures will have on the flora and fauna of the world. It seems almost impossible these days, to escape the apparent plight of the polar bears. Because polar ice is melting sooner and more extensively than in the relatively recent past, we are told that polar bears are having a difficult time being able to do their normal hunting and as a result the population of polar bears is shrinking. The automatic assumption in this line of reasoning is that a reduction in the polar bear population is going to be necessarily bad for the Arctic environment in general. While this may in fact be true, I have yet to see any kind of study that demonstrates conclusively that this is a fact. What we are given is pictures of polar bears swimming in open water looking for seals or ice flows on which to rest. This stirs our sympathies and I'm sure this is exactly what the desired effect is supposed to be. The person or persons presenting this to us has a very definite take on what they think is good for the Arctic environment and is trying to make us see things their way. I have to wonder what the view of the seals would be if we could ask them. I have to imagine that they would think that fewer polar bears is a very good idea. Then there is the medieval warming period, a time when Greenland was actually green. The polar bears survived that all right and will survive this too.

If one turns to the weather channel there is an almost continuous reference to the subject of climate change whether it be snow in the high Sierra's, hurricanes and typhoons in the Atlantic and Pacific Oceans respectively, or the effects on the weather

caused by the destruction of the rain forest in various parts of the world. The common assumption has been that higher temperatures will create more intense as well as more frequent hurricanes. But as recently as May 19, 2008, a story was published in the New York Times whose headline read as follows, "study says global warming not worsening hurricanes." According to this article not only are the number of hurricanes not increasing, neither are the intensity of the hurricanes increasing. In fact, this study suggests that warmer temperatures would actually reduce the number of hurricanes in the Atlantic Ocean. This goes directly against the conventional wisdom that a warmer atmosphere means more evaporation, more condensation, and hence more thermal energy dumped in the atmosphere to drive the hurricanes. What the article does tell us is that there is a likelihood that the quantity of precipitation could very well increase by as much as 37%. What this study shows us is that there is not a simple cause and effect relationship when it comes to atmospheric phenomenon and that many of the things that we expect to see, we may not see. On the other hand, things that we do not expect may very well present themselves, perhaps things we may not even imagine. The recent disaster that struck Burma has been held up as an example of the effects of global warming. Unfortunately, this is in fact not the case. This storm was not more intense than others that have occurred in that part of the world, but happened to strike the coastline in precisely the best place to create the maximum disastrous effect. Added to this was the fact that it came in on a high tide and that along the coast, natural barriers that had been there for many years past had been removed for the purpose of agriculture. This allowed the storm surge to go much further inland and have a much greater effect than it would have otherwise had. In our own country, hurricane Katrina is also pointed to as an example of what we can expect as the atmosphere warms up. But once again, the primary effect of this hurricane was due to exactly where and when it made landfall. A few miles in one direction or the other, the results would have been quite different. By far, the most disastrous hurricane ever to hit the United States occurred early in the 20th century, when a category 5 slammed into Galveston, Texas, killing at least 6,000 people but most likely many more.

Children's television, everything from animated cartoons to live programming, whether scientific in nature or not, have something to say about climate change. If you watch Bob the Builder, Sesame Street, or Mr. Rogers Neighborhood, to name just a few, the subject of climate change will be presented in one form or another. On the other end of the spectrum, publications like AARP are encouraging their readers to think about environmental implications of all sorts of choices. As baby boomers retire, often selling their homes, they are being encouraged to consider the environmental benefits of downsizing, how to live comfortably, but in greater harmony with the environment. AARP even goes so far as to ask its membership to think about the environmental implications when choosing their final resting place or even if they are going to have a final resting place. Cremation is becoming a more popular option by the day. Is this truly better, how much energy is used to cremate a body and what effect will that have? I think it is safe to say that everybody in almost every area of life feels that they have some contribution to make on the subject of climate change.

My own interests in this area dates back to the late 1960's when I was a geology major at Edinboro State College in Edinboro, Pa.. I had a part-time job at the school to cover part of my tuition costs and that job was to assist the school's meteorologist in the preparation of the daily weather report that was broadcast over the school radio station. Back in those days, the information came in every six hours, from approximately 300 reporting stations in North America in a coded form over teletype. It was my responsibility to decode the information and plot station models on a large map of North America. I did this twice each day. The staff meteorologist and myself would then sit down and draw in the isobars showing the areas of high and low pressure and the attendant warm, cold, stationary, or occluded fronts that accompanied these systems. We would with considerable care and thoughtfulness produce a weather forecast based on this data. What never ceased to surprise me was how drastically the conditions could change in six hours. There were times when what appeared to be very well developed pressure systems and fronts, would simply disappear by the time the next set of data came in. Systems that were not present six hours earlier suddenly appeared. I began to develop a real sympathy for those whose responsibility was trying to predict the weather. I came to the conclusion that a good part of the time it was a crap shoot at best. I asked the meteorologist that I was working with why things could change so drastically and seemingly without reason. His response was that we simply did not have enough information. He told me a rather interesting little story about a friend of his who was a staff meteorologist of a television station in the San Francisco Bay area. Their office was perched on one of the hills overlooking the bay and they had a large plate glass window that allowed them to see up and down the entire length of the bay. His friend told him that on many occasion he had looked out the window on a clear and sunny day, where no storms or precipitation had been predicted to see a small storm charging one way or another across the bay. His point was that these storms were on nobody's map. They were too small and localized to be "noticed," and yet it was quite clear these "micro storms" were going to have an effect on the larger weather system and produce outcomes that would be difficult if not impossible to predict. Multiply this incident by a factor of a hundred or a thousand on a worldwide basis and one can begin to see where the difficulties lie. If this is true for day-to-day weather, what chance do we have for predictions that span decades or centuries?

The concept just mentioned, that a small input into a large and complex system, can have a large output later on is the basic principle of something known as Chaos Theory. Chaos theory was developed by a meteorologist named Edward N. Lorenz who was trying to predict the weather by using computers. He was not trying to develop a new scientific theory, but was simply trying to make accurate long-term weather predictions. By discovering "deterministic chaos" Doctor Lorenz had a profound influence on basic sciences and caused the most dramatic change in humanity's view of nature since as far back as Isaac Newton. This is a classic example of a happy accident that has occurred so many times in science. Briefly what happened was this, Doctor Lorenz was running weather models in a computer and had to stop the process part way through. When he restarted the program, instead of entering data to six decimals, he rounded it off to three. The results were completely different from his previous simulations. Doctor Lorenz believed that there was something wrong with his computers

and he had the tech people come and check it out. They told him his computer was functioning just fine. He ran his simulation again and it turned out exactly as he had expected. Upon thinking about this, he decided to run it again and he stopped it part way through, re-entering the data to three instead of six decimal places. Once again, he got a result completely different than any previous result. Even though Doctor Lorenz was using very simple (by today's standards) models, he realized that perfect weather prediction was never going to happen. He published his findings in 1963 and explained for the world to see why weather, at least in the long-term, is impossible to predict accurately.

At the same time that I was assisting the meteorologist, in my geology courses we were studying the subject of glaciers. Not the localized mountain variety but continental glaciers and the drastic climatic changes that accompanied them. It was abundantly clear, from what my professors told me, that ice ages had occurred on planet earth over the last several million years on a cycle of approximately 100 thousands years of ice age followed by ten to twelve thousand years of inter-glacial period. The evidence that was available was incontrovertible that these events had occurred and could be seen in many places around the world. What was unclear however, was what caused these ice ages to begin and why they ended. This is a subject that is still a matter of much debate, even today amongst the most respected glaciologists. Researchers have tried without success to come up with a formula or set of data that will explain why an ice age starts or why it comes to an end. The assumption is that since glacial periods and inter-glacial periods seem to follow a cyclical pattern that this should be relatively easy, however, it has turned out not to be. Some scientists have sought links between sunspot cycles and glacial periods. Others have looked at the precession of the earth's axis in relation to changes in the eccentricity of its orbit as triggering factors. Other scientists have sought the answers in periodic volcanism or changes in deep ocean currents. But to date, none of these or any other explanations that have been proposed have been able to satisfactorily answer the question, why are there ice ages? During my student years I came across a paper written by a couple of geologists whose names I cannot remember, who came up with what seemed to me to be a very reasonable suggestion concerning what conditions would have to be present for continental glaciations to occur in the Northern Hemisphere. What they said in brief, was that in order to have the quantity of snow to make the quantity of ice necessary was a continuous and reliable source of moisture in the atmosphere in the far northern latitudes. They noted that currently the northern and southern polar areas of the earth are deserts. That is, they receive less than ten centimeters of precipitation per year. This simply would not be enough to allow continental glaciers to form. They suggested that the Arctic Ocean would have to be open. That is, the polar ice cap would have to have melted. They made no attempt to explain why this might happen. They simply conjectured that in order to have an ice age this condition would have to exist. I thought at the time and still do today, that this was a very reasonable and logical conclusion. I have kept this in the back of my mind all of these years. I remember very clearly in the mid 1970's, here in Pittsburgh, a couple of winters we had back to back that were particularly severe. In one of these years the temperature dropped below zero and stayed there for over two weeks. The Monongahela River froze over for the first time in over a hundred years. And this was when the steel

mills were still going full blast and dumping millions of gallons of hot water into that river every day. Schools and businesses were closed because the gas companies could not get enough natural gas to keep everything going. Indeed, I had a friend who was living in an old wood frame, two story house in Sewickley, whose furnace was running continuously 24 hours a day and the temperature in his house was going down every day. Time Magazine had a feature story titled “The Ice Age Cometh?” The article had a number of prominent scientists weighing in on the probability of a new ice age. It is ironic that nearly thirty years later we seem to be concerned not about ice ages, but an overheated planet. Even as those “authorities” were wrong about a new ice age one wonders if today the same sort of “authorities” are wrong about an overheated planet. What is clear is that there is no lack of persons with opinions on the subject and mountains of data to support their particular point of view. What is unclear is how correct any of these assertions may be.

A scientist by the name of Naomi Oreskes, has attempted to deal with this particular problem in a website where she lays out a number of standards that can be used to determine the trustworthiness of the data that you are dealing with. For example, things like tests of reliability, that would include replication, witnesses, and peer review. Or tests of consistency that includes consistency of evidence among many lines of evidence. That is, are they all coming to the same conclusions from divergent starting points? Then there are three performance standards:

1. Does it stand up to prediction?
2. Has it held up over time?
3. Can we use it to do real things?

When describing the first of the performance standards, “Does it stand up to prediction?” we are faced with perhaps the most serious test. Prediction is at the very heart of the scientific method. If your theory or idea cannot predict what will happen then it does not have much value. Sometimes however, being wrong can lead you to a new truth. In one of the great ironies in all of science, two noted physicists from Case Western Reserve in Cleveland, Ohio, came up with a brilliant experiment to prove what was a widely held view in science and it turned out that the predicted results did not occur. A scientist named Michaelson and his assistant Morley devised a brilliant experiment to prove the existence of “luminiferous ether”. Scientists were convinced that this substance must exist in order for light to be transmitted through space. No one had ever been able to detect or measure this substance but every one was convinced it was there. It was an old concept dating back to the time of Aristotle. To everyone’s surprise, the experiment showed that the ether did not exist. Michaelson was convinced he had done something wrong and so checked and rechecked his experiment and ran it hundreds of times. Each time it gave the same result. There was no ether. It took the scientific community a number of years to accept this fact. Sadly, Michaelson never did.

The second performance standard is “Has it held up over time?” It demands that something found must be true by experiment over long periods of time. Some ideas that were widely held and believed for even considerable periods of time have been proven

ultimately to be wrong. A classic case in point would be spontaneous generation. It was not until the 19th century that this idea was finally laid to rest by good solid experimental work. The third performance standard, “Can we use it to do real things?” is an absolutely necessary test for much of what is going on in the study of climate change. Since we cannot experiment with the climate directly we have to use computer models. This has proven to be an area of considerable controversy and difficulty. It is very closely related to the old saying that statistics never lie but statisticians do.

In the final analysis, we must meet all standards of verification to determine the accuracy and truthfulness of the data that we are using. The consequences of being wrong on this issue are simply too high for us to allow that to happen. If the scientific community as a whole forcefully and boldly states that human induced climate change is in fact happening and it turns out that it is not, the credibility in the public mind, for any future statements on any subject would be seriously compromised. If on the other hand, human induced global warming is correct, and the predictions that have been made thus far are accurate or even close to it, the consequences of not doing something to mitigate the conditions would be catastrophic. This I think is the heart and soul of the discussion. This is the center point on which everything else turns and it is here that we cannot afford to be wrong. For that reason, we need people who can see clearly and chose wisely; hence this unit.

Objectives

It is the purpose of this unit as previously stated, not to persuade students to a particular point of view but to enable students to think clearly and logically in order to reach their own conclusions. This is not an easy thing to do. Our school systems have been set up by and large, for teachers to dispense information and for students to repeat it back. Most students have been so conditioned to this process, that when we ask them to do something different, there is a considerable amount of resistance. And lets be honest, especially in this day of one standardized test after another there is tremendous pressure on educators to provide students with a bank of facts that they may draw on in order to do well on the test, so in turn, the schools will look good. While I would never argue that a solid foundation of factual material and basic principles is necessary to doing higher order thinking, focusing solely on these things will not get us to where we want to be.

In order to achieve the desired goals students will need to be able to do basic research. That is, know where sources of information are and how to access them. It will be necessary to work closely with the school’s librarian to set up times and opportunities for him or her to instruct the students in the use of all the various resources that are available in the library. They will also need to be able to tell the difference between a stated fact and a fact that is being used to make a statement. Students will have to be able to be willing to set their own personal beliefs and agendas aside, and allow themselves to be led wherever the information takes them. This is perhaps the most difficult aspect to achieve. It is well known that scientists and researchers are not emotionless, dispassionate persons, simply churning out facts as they encounter them. To the contrary, people who have invested much time and effort into a particular point of view will often

promote and defend it beyond reason. The classic example of this would be the “Flat Earth Society” in London. Here is a group of people who in spite of photographs of the planet from space, satellite photographs, and live feeds from the space shuttle, still refuse to believe that the earth is round. I would have thought that Eratosthenes settled the matter about two thousand years ago, but apparently not. The point is, for some people and on certain issues, and it may be a significant minority or even a majority of a population will refuse to believe something regardless of the information provided. The preponderance of “Urban Legends” is a classic example. There is a very well known story about the man who discovered how to do blood transfusions. He was of African-American descent and the story goes that he was in an automobile accident in some southern state and was taken to a hospital where he was refused a blood transfusion because he was black. According to this story, as a result he died. The man’s own daughter has testified on National television and radio that her father did not die in this way, yet there are millions of people who refuse to believe this. Another old chestnut is the one about putting sugar in somebody’s gas tank as a way to wreck the engine. The fact of the matter is, sugar will not dissolve in gasoline. Hence, all it will do is lie in the tank. But a large segment of the population refuses to believe this. As humans, this is quite a natural thing to do. But if one is searching for the absolute and unmitigated truth, it is something that cannot be indulged in.

Strategies

In order to achieve the goals as described in the objective section of this unit, a number of different approaches will be taken. First, it will be necessary to assess the present level of understanding of the students concerning this subject. Prior knowledge will be established by a pre-test on the basic issues involved in climate change. This will enable the instructor to tailor his or her methodologies and strategies to meet the students where they are and take them to where it is they need to be. Obviously, not all students will be at the same level of understanding. Rather than try and fill in the gaps for the entire class, students will be assigned research based on their areas of weakness and they will present a summary of their findings on the subject to the class as a whole. By this method, all members of the class can be brought to approximately the same level of knowledge.

A survey will be given to the class in order to find out what their present view of climate change is and the class will be divided into groups based on their prevailing attitudes. Material will need to be presented which will stimulate discussion and thinking on part of the students. Fortunately, there is no lack of materials available in both video and written form, representing both sides of the debate. Things such as, Al Gore’s film, “An Inconvenient Truth”, Emanuel Carey’s “What We Know About Climate Change”, or the IPCC report are just three examples of the types of resources that are available and can be used. Following each of these presentations, a discussion or series of discussions by the class reflecting on what they have seen or read will be undertaken. This is perhaps the most difficult aspect of this unit in that the teacher must put his or her point of view aside and be a facilitator for discussion and understanding. As stated earlier, we are not trying to persuade the students one way or another, we are simply trying to equip them to

make their own decisions. It is altogether too easy to take a group of young people and whip them into a frenzy on one subject or another. This sort of thing, however, is counter-productive to the overall good of society and the students themselves in the long run. While it may be satisfying to have a group of people who agree with you and think that you are “oh, so right!”, it is not helpful if what we are aiming at is truth in its purest form.

Where and when available, experts in some aspect in the field of climate change should be brought into the classroom to speak to the students and give them the opportunity to interact with someone who is actually doing research on some aspect of the subject. I have found this to be extremely beneficial and rewarding. A few years ago, I had the opportunity to attend a two-week session at a NASA research facility in Greenbelt, Maryland. While there, I was given the opportunity to speak to researchers one-on-one, as well as hear them make group presentations in their field of expertise. From this experience I have come to appreciate the great value of being able to converse with experts in the field on a personal basis. I think students need to have the same opportunity.

After each presentation whether it is by a guest speaker or a group of students, it will be necessary for the students to evaluate and analyze what has been said and to offer their points of view and reasons for the same. It is important here, that the teacher stress that we are not looking for mere opinions, which is most often simply based on how we feel about something, but in fact, is a conclusion founded on evidence from one side or the other. Once again, this is not an easy process. Students have by and large not been trained and taught to do this. We should not expect to be able to make up for years of deficiency in one or two classroom sessions. This will in all likelihood, require many sessions and practice on the part of the students with teacher acting as facilitator helping the students not to rely on emotion and opinion but on factual data.

After going through this process enough times that it has become clear to the teacher that the students have developed a view-point and are able to support it factually, the class should be divided into two groups based on their stated positions. A series of debates should be undertaken on specific aspects of climate change. These would include but are not limited to, greenhouse gases and their effectiveness, the earth's albedo and how it changes, the effects of more moisture in the atmosphere, the effects of aerosols, both natural and man-made, the relationship of deep ocean currents and atmospheric cycles, and finally, the sun and its effects on global climate. These are but a few of the many areas that impact the subject of global climate change. Once the above activities have been carried out and students have had the opportunities to speak about and defend their particular points-of-view, the class will then be told that they must debate and defend the opposite position. This will doubtless be met with considerable resistance and it is incumbent upon the teacher to make it clear to the students that in order to truly appreciate the opposition, one must so to speak, get inside their heads. There is no better way to do this than to actually defend that point-of-view. Or as an old Native-American saying put it, “Let me not criticize any man until I have walked a mile in his moccasins.”

What we need to do, is to put them in the other person's shoes and hopefully, to help them better see what information could be described as factual as opposed to what might be called propagandistic.

One of the challenges is to make this whole debate as personal as possible. In other words, challenge the students to consider what changes in lifestyle they will be willing to make if they believed that human-induced climate change is a reality. Things such as; what sort of car you own, or whether you would rely primarily on public transportation, the size of the house you have, and where you chose to live, decisions you make on the sources for the food you eat, the degree to which you would invest in and use alternative energy sources, all need to be considered. In both cases, for pro and con, students will be asked based on the information they have gathered, to project what they believe the outcome for the world will be if one course or the other is followed.

Classroom Activities

- **Doing basic research:** Arrangements will need to be made with the school librarian to enable the class to be instructed in all areas of research available not only in the school library but in the community libraries as well. It is anticipated that this will require a minimum of two to three class periods and a maximum of five to six. The areas that the students must research should be coordinated with the results of the pretest given at the beginning.
- **Proper techniques and procedures for debate:** Unfortunately, most students don't know the difference between a debate and an argument. Most "discussions" wind up in name-calling sessions or verbal fights. It must be made very clear at the outset that this is totally unacceptable and will not be tolerated. If the school has a debate team, the teacher who is in charge should be asked to come to the class and make a presentation on the basic rules and structure of debating. If necessary, some textual information should be used and it will be necessary to spend some time practicing these skills. Without this structured format the desired goals for this unit will not be achieved.
- **Role-plays:** Once the students have advanced to the point that they have a point-of-view based not on emotion or opinion, but on factual information backed by research, role plays can be come a good way for students to see how and why it is that people defend the points-of-view that they have. These role-plays could be set in the context of a party, a business lunch, a chance meeting of friends, or almost any other circumstances that the instructor could conceive. Students should be asked to take on the role of , for example, the CEO of a car manufacturing corporation, The Chief of Operations for an oil drilling platform, a coal miner, a US congressman or senator, are just a few examples of the many persons involved in this debate that could be represented. After each role-play the class will be asked to discuss the validity of the arguments presented.
- **Where Do You Stand?** A series of role play where students will take the part of a believer in global climate change will be having a discussion with

someone who is either someone either unconcerned or opposed. This could be set in a restaurant or a party at someone's house or some other typical venue. The following role-play would be reversed with the person opposed to global warming presenting their ideas and viewpoint. Each person in the class would have the opportunity to be the advocate, either pro or con, and the rest of the class would evaluate the validity of the arguments presented.

- **My Future Life:** Students would be asked to construct a future lifestyle based on type of job, home they live in, where the house is located, what sort of transportation they would use, and sort of diet they would have. This would require a fair amount of research by the students in order to see exactly what the environmental effects of each would be. Each choice would be scaled for energy use and attendant effect on the environment. A rating scale would be developed from a category of very green, somewhat green, not green, and somewhat harmful to the environment, to total environmental disaster. After seeing where their choices place them students would be asked to decide what choices they would be willing to make to improve their (greenness).
- **Exploring technologies:** It is the common assumption by most people that recycling is good for the environment, i.e., recycling uses less energy and is therefore less harmful to the environment than sourcing new materials. With the exception of metals, especially aluminum, this is generally not the case. At this particular time there is actually less of an environmental impact in using new raw materials than in recycling. Asking the question, whether such things as energy star appliances, i.e., refrigerators, washing machines, and conditioners are in the long run better for the environment than similar appliances that are less green but which will last one and a half to two times as long. In other words, the amount of energy necessary to replace appliances on a ten to twelve year cycle should be compared to older appliances which use more energy but last longer. A case in point, would be a friend who has a chest type freezer in the garage that was built in 1954, is now over 54 years old and still running. While it is true that it uses more electricity than the newer ones, at the current replacement cycle at least 4 other freezers would have to be produced, transported and sold to equal this one. Students should be divided into groups and given the responsibility of determining the total amount of effect that producing a particular product has on the environment. This could include such things as, cell phones, I-pods, computers, computer games, etc. Also included should be the environmental effects and costs of these various items when they have to be disposed of.

Annotated Bibliography/Resources

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Appendices-Standards

Standard 3.1.12.B- Apply concepts of models as a method to predict science and technology.

Standard 3.2.12.B – Evaluate experimental information for appropriateness and adherence to relevant science processes.

Standard 3.2.12.C – Apply the elements of scientific inquiry to solve multi-step problems.