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Evaluation Study of Global Systems Science Part 1: Changing Climate

by
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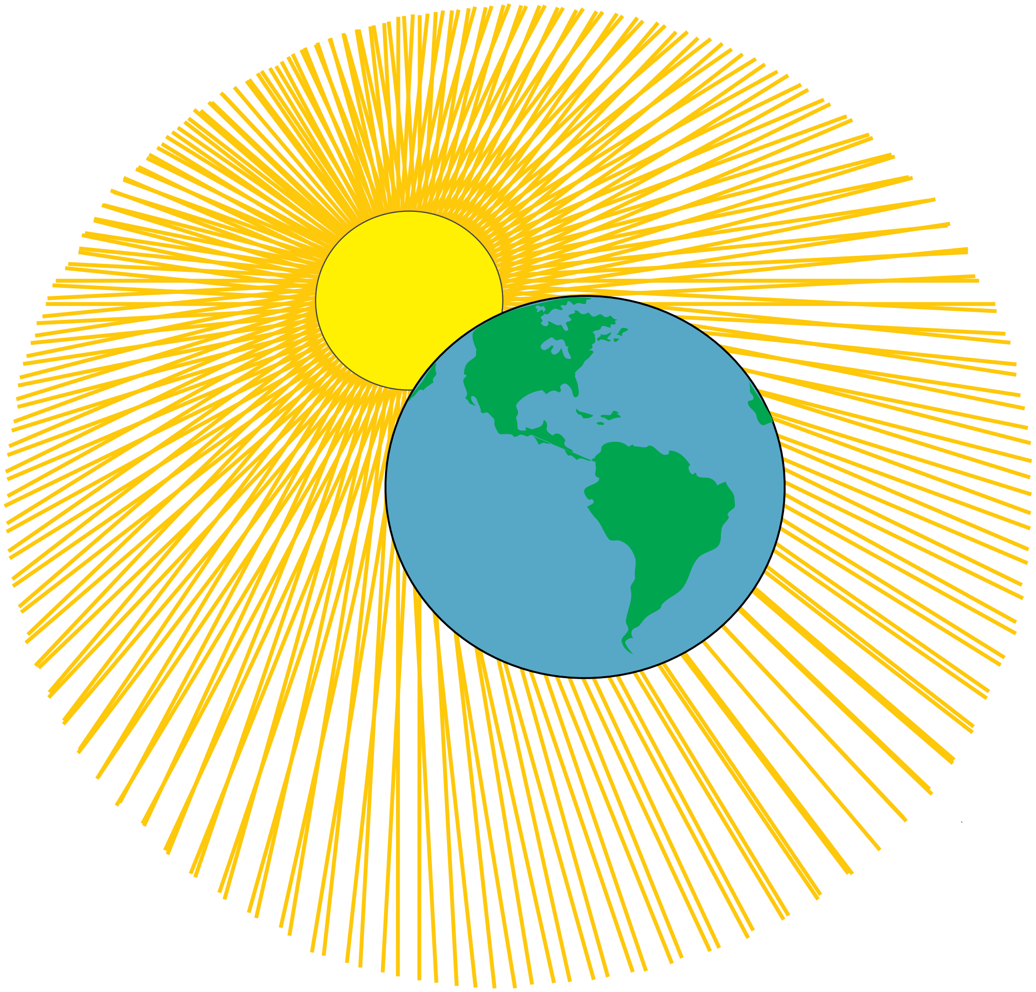

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The Global Systems Science project is an activity of the Lawrence Hall of Science, University of California. The Director of the Lawrence Hall of Science is Ian Carmichael. The Chairman is Glenn T. Seaborg.

Update—Fall 1996—The Global Systems Science course modules are currently undergoing further development and review. It is estimated that they will be available for purchase by Fall semester, 1998. To be placed on our mailing list concerning future developments in the GSS program, and for summer institutes and workshops, please contact:

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What Do Students Learn from the GSS Unit *Changing Climate*?

Paper presented at the NSTA Global Summit in Science and Science Education, San Francisco, CA, December 27, 1996

by

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Introduction

The worldwide climatic disturbances of 1988 (which included droughts, famines, severe storms, and forest fires) focused world attention on the possibility of enhanced global warming—the theory that increased carbon dioxide in the atmosphere, due to the burning of fossil fuels and other human activities, is increasing the natural greenhouse effect, causing the entire planet to warm up. The potential for the industrial revolution to cause global warming had been predicted over a hundred years ago, but now the prospect was being taken seriously, although scientists were by no means in complete agreement about whether or not global warming was underway; and if so, what it would mean for the future.

It has been nearly a decade since the summer of 1988, when NASA scientist James Hansen testified to Congress that he was 99% certain that the globe would warm dramatically during the next century. Hansen's testimony brought to the media's attention a storm of controversy among scientists that had been brewing for a number of years. Scientific controversies are by no means unusual, but they are usually only of great concern to a small community of people. In this case, however, the social implications of global climate change are potentially so volatile, that the controversy has remained in the public eye.

Yet despite extensive media coverage, few people are even familiar with the broad outlines of the theory of global warming, let alone the methods used by scientists to test the theory, and what actions have been proposed to slow the buildup of greenhouse gases in the atmosphere.

Global Systems Science: An Interdisciplinary High School Course

The subject of global warming was selected as the topic of a unit in the Global Systems Science (GSS) high school course being developed by the Lawrence Hall of Science, a public science center on the campus of the University of California at Berkeley. Global Systems Science (GSS) consists of nine Student Guides and a Teacher's Guide. The GSS course draws on a variety of disciplines to illustrate how scientists from a wide variety of fields work together to understand problems of global impact. The course materials involve students actively in learning. They perform experiments in the classroom and at home. They read and discuss background materials. Through reading and photographs, they "meet" a wide diversity of men and women who are working to understand global environmental change. They work together in small groups to dramatize their ideas for working toward solutions to worldwide environmental problems. They are challenged to make intelligent, informed decisions that are consistent with their growing knowledge and opinions, to help them prepare for their roles as voting citizens in a modern industrialized society.

This is the first of nine studies that are being conducted—one on each of the nine GSS units—involving a national sample of several hundred students, conducted with the assistance of more than twenty-five teachers from more than a dozen states. Three of the teachers tested the GSS unit concerned with the theory of global warming, entitled *Changing Climate*. This study is based on their efforts.

Purpose

The purpose of this evaluation study is to find out what students learn from the *Changing Climate* unit in the following areas:

1) The theory of the greenhouse effect;
2) Procedures for monitoring the concentration of carbon dioxide in the atmosphere;
3) The scientific controversies related to global warming;
4) Understanding the social and personal dilemmas related to global change; and
5) The students' opinions about whether or not anything should be done to slow global warming, and their understanding of what actions are consistent with their personal opinions.

In analyzing the data we attempted to characterize the students' understanding of the scientific concepts and social issues, remaining open to what the students had to say, rather than to whether or not they were saying what we expected to hear. We hoped that the results would provide a realistic vision of what most students could reasonably be expected to know before the course begins, and how their understanding and opinions are likely to change during the course. Finally, we hoped that the results would suggest ways to improve the instructional materials, and methods for assessing student learning.

Method

We used a pre-post-test instructional group only design. By comparing pre-test and post-test performance, we could infer what students learned from the instructional program. Because of the absence of a control group, we could not rule out the effect of maturation—the claim that the students would have learned from reading or hearing about global warming outside of school. In this case, however, maturation seemed an insignificant threat to validity since the instruction required only about 15 hours of class time over a period of less than a month. Still, we hope to conduct control group studies in the future.

The test instrument was a questionnaire, consisting of sixteen open-ended questions that were written with the assistance of 50 teachers during two GSS Summer Institutes in 1995. The questions were divided into five groups, responding to the five areas listed in the previous section.

Two other test instruments were developed as well: a concept map of the topic and a projective test. These other instruments turned out to be effective teaching devices, but were difficult to interpret as test instruments, so the results were not used in this analysis.

In each participating classroom the teacher presented the questionnaire before and after teaching the unit. The teacher sent all of the students' papers to GSS Headquarters, where they were scored by the authors of this paper—a team of researchers and teachers. Each teacher also filled out a form describing how the course was taught.

Of the twenty-five teachers participating in this study, three taught the unit *Changing Climate* to one class of students. Inevitably, some students were absent on one of the two days that the questionnaire was presented. So that we could make a fair comparison, we included in the analysis only papers from students who were present for both the pre-test and post-test. All students for whom we had a pre-test and post-test were selected for the analysis. The 44 students whose papers were used in this study included: 17 ninth grade students enrolled in an environmental studies course in Omaha, Nebraska, 22 tenth grade students enrolled in a chemistry course in Cleveland Heights, Ohio, and 5 tenth grade students enrolled in a physical science course in Wilton, Connecticut.

Instruction

Each of the teachers estimated that they spent 15-16 class hours on the unit, spread over about one month. Additional time was spent by students in homework assignments. The *Changing Climate* unit consists of laboratory activities, readings, and writing assignments, as well as small and large group discussions. A summary of the content of each chapter and a description of the activities is discussed below, under "Results." Following are general comments drawn from the forms filled out by the teachers, concerning how they presented the course. Their comments also tell us about the context of the program, their students, and how their students responded to the course materials and activities.

> *Students enjoyed being able to have open-ended discussions and making their own minds up. I opened with a discussion to find out what they already knew or thought they knew. The labs were excellent. Directions clear. the students especially liked testing for CO_2. Dry ice worked a lot better than baking soda and vinegar for CO_2 production for ninth graders.*
> *Students learned specific information, but more than that. I think they were able to develop skills in processing and evaluating information.*
> *Students needed to take part in a discussion at the end—using specific information—to articulate their opinions and defend their position.*
> *Students found a related article from a current periodical then summarized the article, describing if the issue was evenly represented or if they thought there was a bias.*
> The systems approach is a unique aspect of these materials.

— Environmental Science Teacher from Omaha, Nebraska

> *After completion of the basic gas laws, we began the unit, using CO_2 as an example of a real gas with which students can relate. The lab, Sampling CO_2, served as an introductory activity to the chapter on acids, bases, and indicators.*
> *Presentation is very important. Integrating the unit into the study of gas laws was significant. Students were more enthusiastic about generating CO_2 and obtaining CO_2 from different sources, than the traditional hydrogen and oxygen gas labs.*
> *For many students this was their introduction to the greenhouse effect and CFC's. The field trip concerning the scientific measurement of CO_2 [in Chapters 4 and 5] was for many students an excellent description of what a scientist does. Students also learned that scientists disagree and that there can be more than one solution.*
> *Students read articles from newspapers, journals, and Internet on the greenhouse effect. They shared the articles with their class during discussions. They were required to answer the following questions about their articles: Who, What, When, Where, Why, and How will it affect you?*
> *Students wrote reports for the lab, Sampling CO_2. Modifications were made to the lab (as described on attached sheets).*
> The information and activities were presented in language and applications with which students can relate.

— Chemistry Teacher from Cleveland Heights, Ohio.

I can't tell you how well the GSS materials have fit into our constantly evolving curriculum in grade 10. The "intro book" [A New World View], Changing Climate, and Closing the Ozone Hole are now a permanent part of the Physical Science Course.
I'm really into the Changing Climate module, and was anxious to run it again with the 2-level kids this year. This went well, and was a focus of study for about three weeks, with suitable supplements and labs.

— Physical Science Teacher from Wilton, Connecticut

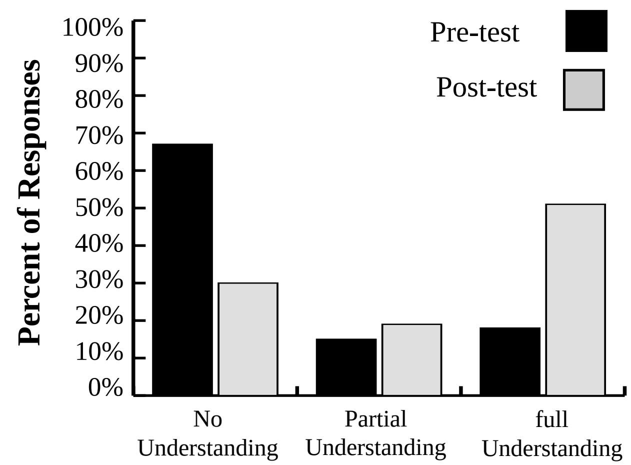
Results

As we categorized student responses it became clear that some ideas evidenced full understanding of the concepts presented in the unit, while others represented partial understanding, no understanding, or misconceptions. So, we were able to create a second tier of categories representing the level of understanding. This was not done for the last question, which requested students' opinions.

A detailed analysis of results for each question on both the pre-test and post-test provided excellent information on student knowledge prior to instruction and learning during instruction. However, the detailed analysis would be too long and tedious for the current summary paper. Consequently, we combined the results of each set of questions, within the five areas listed above under "Purpose." Each section begins with a list of the relevant pre-post-test questions. That is followed by a summary of the instruction concerned with that area of learning, and finally the results of the study. For this exploratory phase of the research we did not perform a statistical analysis; but represented the frequency of responses by bar graphs.

Understanding the theory of the greenhouse effect

1 Describe what occurs in a glass greenhouse so that it becomes warmer inside than outside.
2 How is the greenhouse effect in an actual greenhouse different from what occurs in the Earth's atmosphere?
3 What is the difference between the "natural" and "increased" greenhouse effect?
4 How would Earth's climate be different if there were no carbon dioxide in the atmosphere at all?
5 Why does carbon dioxide absorb infrared energy while oxygen and nitrogen do not?



Instruction. The theory of the greenhouse effect is presented in chapters 1 and 3. Chapter 1 "What is Global Warming?" begins with reports of the worldwide climatic extremes of 1988—including droughts, floods, forest fires, and a super hurricane—and the electrifying Congressional testimony in the summer of that year by James Hansen, a NASA scientist, who was "99% confident" that global warming had arrived. On the next page, they read a 1989 clipping from the *San Francisco Chronicle* which summarizes some of the key points in the scientific controversy that were reported in the media a year after Hansen's pronouncement. These are followed by a recent article from *The New York Times*, dated 1996, which discusses the results of the Intergovernmental Panel on Climate Change (IPCC) which cautiously concludes that "...the observed warming is 'unlikely to be entirely natural in origin,' and that the weight of evidence 'suggests a discernible human influence on climate.'"

The students are asked to carefully examine the graphs that accompany the articles, to compare and contrast statements made by the various scientists, looking for evidence of consensus as well as points of disagreement, and to supplement their investigations with further library research. Finally, they are asked to decide whether or not they think Hansen's conclusions were justified at the time, and whether or not the evidence they have seen so far supports his views today. The remainder of the chapter discusses the history of the greenhouse effect theory, how the industrial revolution has resulted in increasing the amount of carbon dioxide in the atmosphere, and ends with a short discussion on the predictions of the IPCC, that carbon dioxide concentration is likely to double by the year 2100, resulting in an increase of the average global temperature of 1°C to 3.5°C.

Chapter 3 "What's So Special About CO2?" provides a more detailed discussion of the theory of the greenhouse effect, beginning with the properties of matter and energy, and how they interact. The physical explanation for the greenhouse effect involves the concept of *resonance*. Greenhouse gases absorb infrared radiation because their molecules absorb energy in the infrared region of the spectrum, while the more common atmospheric gases—oxygen and nitrogen—do not resonate at infrared frequencies. This concept is explained in the text, and illustrated in a laboratory activity. In the activity, students make models of several molecules and observe that carbon dioxide resonates at certain shaking frequencies (corresponding to infrared energy) while oxygen and nitrogen do not. Although the size of the "molecules" is much larger, and the frequency of vibration is much slower, the effect that students experience as they transfer mechanical energy to the model molecule is a real resonance effect.

The chapter goes on to discuss how real molecules of carbon dioxide and methane—another greenhouse gas—interact with infrared energy. The simple explanation of the greenhouse effect from Chapter 1 is then revisited at the molecular level, and this explanation is then contrasted with what occurs in the Earth's atmosphere.

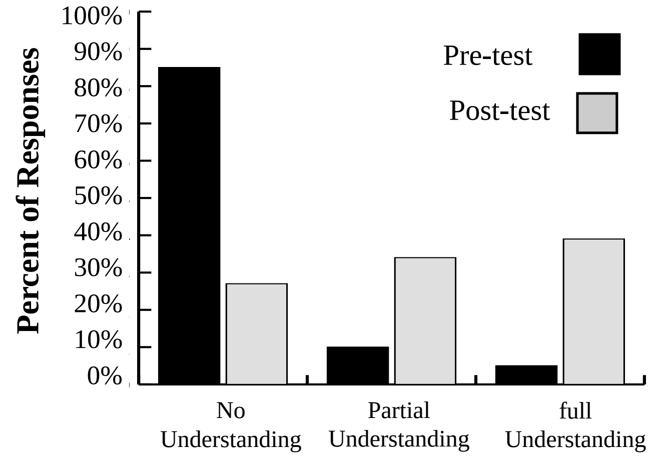
Findings. The graph shows an average of the results of the five questions related to the theory of the greenhouse effect. Comparing the pre-test and post-test shows that the number of students who express no understanding falls from 67% to 30%; while the number of responses that evidence full understanding increases from 18% to 51%. The pattern of answers for all five questions was similar: In all five questions, the number of responses that evidenced partial or complete understanding of the concepts was greater after instruction than before.

As an example of how the individual responses were categorized, consider the first question, which asked what occurs inside a glass greenhouse. Evidence of full understanding was the statement that sunlight (or heat) passes through the glass of a greenhouse, and becomes trapped. Evidence of partial understanding would be if a student said that sunlight warmed the interior of the greenhouse, or that the earth and plants absorbed sunlight. Some students said that the greenhouse "trapped gasses," confusing the trapping of energy by greenhouse gases with the trapping of the gases themselves. In contrast to the other four questions, in which pre-tests indicated little or no understanding before instruction, 50% of the students showed full understanding of this first question. The number increased to 75% on the posttest.

Consistent with the teachers' observations that the students enjoyed the activities more than the reading assignments was the finding that the greatest difference between pre-test and post-test was on question 5, concerning the concept of resonance. The percentage of students who understood this concept fully changed from 2% on the pre-test to 39% on the posttest. However, we were disappointed that 23% of the students indicated no understanding of the concept after instruction.

How scientists monitor carbon dioxide in the atmosphere

6 How could you measure the concentration of carbon dioxide in a sample of gas?
7 How do scientists measure the concentration of carbon dioxide in the atmosphere?
8 How does the concentration of carbon dioxide in the atmosphere change during the year? What causes the change?
9 How has the concentration of carbon dioxide changed since 1958? What caused the change?
10 Name at least three other greenhouse gases and their sources.



Instruction. In Chapter 4 "How Do We Measure Carbon Dioxide?" the students "travel" to Mauna Loa Observatory through photos and diagrams, where they meet scientists, technicians, and student assistants who are measuring levels of carbon dioxide in the atmosphere. Data collected at Mauna Loa has led to the conclusion—supported by virtually all scientists involved in climate research—that the concentration of carbon dioxide is increasing in the atmosphere. Through pictures and interviews, the students see how the technology to measure carbon dioxide concentration has improved over the decades, and they conduct chemistry experiments in the classroom to measure the concentration of carbon dioxide in gas samples, answering questions such as: Is there more carbon dioxide in car exhaust or in human breath?

In Chapter 5 "Is the Atmosphere Really Changing?" the students analyze actual data from Mauna Loa and other sites, discovering the relationship between atmospheric carbon dioxide and seasonal changes in different parts of the world.

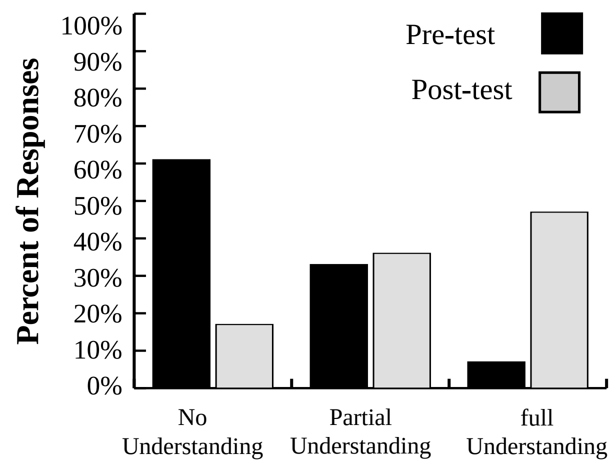
Chapter 6 "What Are the Greenhouse Gases?" completes the global picture by discussing each of the major greenhouse gases, listing the sources and contribution of each one to the enhanced greenhouse effect predicted to occur over the next century.

Findings. As shown on the graph, the number of students who express no understanding on the next five questions falls from 85% to 27%, from the pre-test to the post-test; while the number of responses that evidence full understanding increases from 5% on the pre-test to 39% on the post-test.

The most dramatic difference is attributed to question 6, concerning how to measure the concentration of carbon dioxide, in which the percentage of responses that indicate full understanding increases from 2% on the pre-test to 77% on the post-test. It is interesting, though not surprising, that virtually all of the students refer to the use of the chemical technique that they used in the laboratory for measuring the concentration of carbon dioxide, rather than the method used by professional scientists at Mauna Loa. This affirms the observation that students remember what they do more readily than what they read about.

Understanding the scientific controversies related to global warming

11 On the subject of global warming, what do scientists agree about?
12 Describe at least four issues on which scientists disagree about global warming.
13 Name at least four environmental changes that may occur if the Earth's climate warms up, and when they might occur.



Instruction. When we selected the topic of global warming in the late 1980's, the primary reason was because it was a controversial issue at the cutting edge of modern science. The controversies among scientists provide a much better window on the process of science than the well-accepted classical theories that are featured in traditional textbooks. Yet there is a danger that emphasizing the controversy in Chapter 1 will leave students with the impression that the issue is not worth studying: "If even the scientists' can't agree, why should I bother about it?" It was for this reason that we placed a review of the points of agreement and disagreement near the front of the unit, in Chapter 2.

In Chapter 2, students learn that there is virtually universal **agreement** in the scientific community that the natural greenhouse effect has kept our planet at a livable temperature during the entire time that life evolved on our planet; and that if it were not for the carbon dioxide produced by volcanic activity, and water vapor evaporating from the planet's oceans, global temperatures would plunge by more than 60° C. Secondly, the concentration of carbon dioxide and other greenhouse gases are increasing in the atmosphere, primarily as a result of human activities. And thirdly, as long as these human activities continue, the Earth will eventually warm up.

Points of **disagreement** revolve around: whether or not the observed warming over the past century is due to human activities, or is just part of a natural cycle; how rapidly greenhouse gases will build up in the atmosphere; how much the Earth's temperature will increase; and how global climate change will affect us and other living things on Earth.

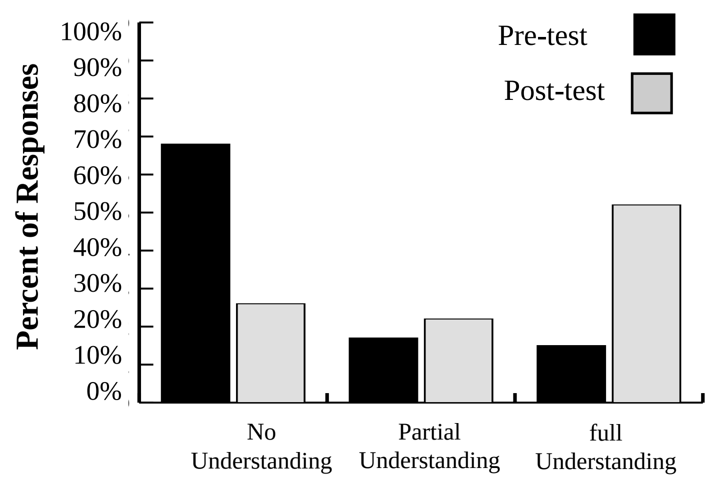
Findings. As with the previous sets of questions, the average responses of questions 11, 12, and 13 showed that students' understanding of these points of agreement and disagreement increased during instruction. The percentage of students who had no understanding of the issues declined from 61% to 17%, and those whose responses could be classified as evidence of full understanding increased from 7% to 47%.

Questions 11 and 12, which concerned the points on which scientists agreed and disagreed, revealed increases in full understanding from pre-test to post-test. (7% to 32% in the case of question 11, and 9% to 45% in the case of question 12.) However, the largest difference was in question 13, concerning the potential effects of climate change. The number of students who could name at least three possible effects increased from 5% to 64%. Changes listed by the students included: rising sea levels, more desert, more rain, more storms, more fires, more droughts, increase of vegetation in some places, loss of vegetation in other areas, and more disease.

Understanding the social and personal dilemmas related to global change

14 What actions have been proposed within the United States to reduce the possibility of global warming?

15 Why is it difficult for the US Congress to come to agreement on actions to reduce the possibility of global warming?



Instruction. These issues are discussed in Chapter 7 "What is the U.S. Government Doing About Global Warming? The body of the chapter is an excerpt from an actual Congressional Hearing that occurred in 1994, as Congress debated how best to respond to The President's Action Plan to reduce greenhouse gas emissions which was initiated as a result of the treaty on global warming signed by former President George Bush in 1992. Several scientists from various government departments were present to respond to simple but penetrating questions from the U.S. Representatives who were conducting the hearing. The chapter ends with an update on what has happened to The President's Action Plan, and whether or not the U.S. and other industrialized nations are living up to the promises they made in the 1992 treaty.

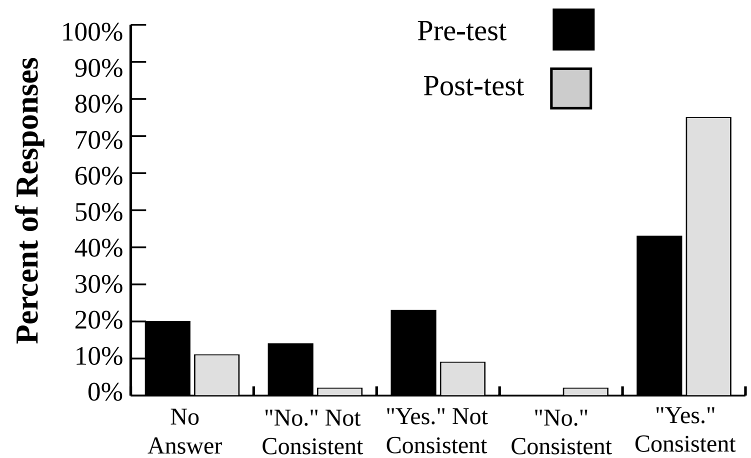
findings. As in the science areas, knowledge of the policy issues increased during instruction. Responses that evidenced no knowledge decreased from 66% to 26%, while responses that evidenced full understanding increased from 15% to 52% during instruction.

On question 14, only 7% of the students could name actions that have been proposed to slow global warming, while after instruction, 30% listed actions such as: reduce energy use, use less fossil fuel, create guidelines for business and industry, recycle, and car pool.

On question 15, the percentage of students who expressed an understanding of the difficulties faced by Congress increased from 23% to 75%. Some of the ideas expressed by students included: closing factories would mean loss of jobs, making a better world in the future means fewer jobs today, disagreements between members of Congress, and the difficulty of making decisions when the scientists are not certain how serious the problem will be.

Students' Personal Opinions

16 What is your personal opinion: Should we take actions to reduce the possibility of global warming? If so, what could you do personally? If not, why not?



Instruction. In Chapter 8, the final chapter of the unit, the students imagine that they are members of Congress, and it is their job to decide what, if anything, to do to slow global warming. Working in small groups, the students consider possible actions from the viewpoints of science and technology, economics, politics, and ethics. Finally, they participate in a debate on the floor of Congress to hammer out an Action Plan that is acceptable to the majority of the groups. In a final essay, the students express their personal opinions about climate change and what, if anything, should be done about it.

Findings. In the GSS course, students are encouraged to make up their own minds on the social issues; and a "Yes" response receives as much support from the teacher as a "No" response. The emphasis is on the students' reasoning, and the actions that they believe flow from their opinions.

Some students responded directly to the question asked, giving a "Yes," or "No" followed by one or two personal actions that they felt were consistent with their opinions. Others gave reasons to justify their opinions. We categorized answers depending on whether or not the students' response was consistent with their opinion, whether it was a rationale or an action. All responses were categorized in these five groups:

No Response

1—No response, "I don't know," or "I don't care."

Inconsistent Responses

2—"No," inconsistent responses included: "We should move to Alaska," and "If God didn't want CFC's and CO_2 he wouldn't have made them."

3—"Yes," inconsistent responses included stopping the use of aerosol spray cans, not littering, or reducing pollution. While these actions may help to protect the environment, they are not directly related to the problem of global warming.

Consistent Responses

4—"No," consistent responses, included: "We should not put people out of jobs, it's more important to worry about issues oppressing people today," or "We'll be able to solve the problems with new technology in the future."

5—"Yes," consistent responses, included driving less, using less energy, recycling, joining an environmental organization, creating new jobs for people (who work in the energy industry), and planting trees.

It is interesting to note that before instruction, most students felt that something should be done to reduce the possibility of global warming. (66% responded "Yes," and 14% responded "No," while 20% gave no answer.). After instruction, the class position shifted further in the direction of doing something (84% "Yes," 4% "No," and 11% gave no answer.). What is more important, however, is that (combining "Yes" and "No" answers) the number of students who gave a logical rationale or actions consistent with their opinions increased from 43% on the pretest to 77% on the posttest.

Conclusions and Recommendations

This study has provided evidence that students who study the *Changing Climate* unit increased their understanding of the theory of the greenhouse effect, how scientists monitor the level of greenhouse gases in the atmosphere, the scientific controversy surrounding global warming, and the social and personal dilemmas related to global climate change. Many students also learned about specific actions that they can take personally that are consistent with their opinions about whether or not something should be done to reduce the possibility of global warming.

On the other hand, there is certainly room to improve the instructional materials to increase the number of students who fully understand key concepts, who are able to support their ideas with evidence, and have a solid grasp of the personal actions that flow from their opinions. Three major changes are suggested by this study to improve the instructional program.

A unifying challenge. The finding that students better understand and recall concepts when they are actively engaged (as in a laboratory experiment) suggests that engagement might be improved by starting with a challenge that could sustain interest throughout the unit. One way to do this would be to bring to the front of the student guide the challenge currently presented in Chapter 8: to create a Congressional Action Plan about Global Climate Change. Each chapter would be tied into the challenge with a short paragraph explaining why it is important to understand the material in the chapter in order to accomplish this task.

A new laboratory activity on the natural greenhouse effect. The finding that many students still do not grasp the magnitude and importance of the natural greenhouse effect suggests that we should add a new chapter at the beginning of the unit on this topic. The chapter could start with an activity currently in the *Energy Flow* unit, in which students design and test greenhouses using a shoe box as a base. This activity has proven to be very popular in classroom trials because it provides excellent opportunities for students to be creative. The activity also illustrates the greenhouse effect, providing a strong experiential base for the rest of the unit.

Revise the assessment instrument. The teachers who categorized student responses for this study pointed out that many students would have provided more complete responses if the assessment instrument were more attractive. They noted that on the post-test, some students answered the first five or six questions fully, and then skipped the rest, or answered with a minimum of words and effort. It's likely that this was due to the length of the questionnaire (16 questions), the fact that it was the second time the students were asked to answer these questions, and the small amount of space (about 1") provided for student answers.

We would like to put the pre-test into the context of the unifying challenge described above. For example, we might survey the members of Congress to determine their views before the hearings begin. This would make responding to the questions on the pretest somewhat more interesting, and motivate some students to provide fuller answers. Secondly, we'd like to break up the post-test into five essays, grouping the questions as we have done in this report. Student teams would have an opportunity to discuss the questions; but each individual would be expected to write their own answers. These would be presented as assignments at five points during the course, with the final essay, on the students' personal opinions, due at the conclusion of the unit. Consequently, assessment would become integrated into the instructional program. The essays could then be categorized by the teacher in the same way as described in this paper. The essays can also be collected into a portfolio for each student, to be used as evidence for student achievement to evaluate the effects of the program (by comparison with the pretest), and to give feedback to the students and their parents.

Finally, it is important to point out that instruction about global climate change does not end with the *Changing Climate* unit. Several other units of the GSS series deal with other aspects of this issue. In *Life and Climate*, the students learn how life and the Earth's atmosphere have co-evolved throughout the entire history of our planet. In *Energy Flow,* they learn more about how energy flows through the Earth's atmosphere, gaining further insights into the theory of the greenhouse effect. In *Ecosystem Change* they learn how human land use patterns have reduced the capacity of the biosphere to absorb carbon dioxide from the atmosphere. And in the two units *Human Population Impact* and *Energy Use*, students learn more about the specific human activities that may be impacting the global climate, and what can be done to slow the release of greenhouse gases into the atmosphere.

As the first in a series of nine planned studies of the impact of the Global Systems Science program on students' understanding of issues at the interface of science and society, this study has shown that *Changing Climate* is educationally effective. However, it has also recognized considerable room for improvement, and made several suggestions for changing the instructional materials and the method of assessment. These findings and recommendations will continue to shape the development of the program over the next two years, prior to publication of the materials for use in high schools throughout the country.