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Fifth grade students' perceptions of STS issues: An action research project to explore a process for identifying students' knowledge and understandings of science, technology, and society (STS) issues

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FIFTH GRADE STUDENTS' PERCEPTIONS OF STS ISSUES: AN ACTION RESEARCH PROJECT TO EXPLORE A PROCESS FOR IDENTIFYING STUDENTS' KNOWLEDGE AND UNDERSTANDINGS OF SCIENCE, TECHNOLOGY, AND SOCIETY (STS) ISSUES

A Project

Presented to the

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ABSTRACT

This is an action research project whereby I was attempting to identify a procedure for determining students' understandings of Science, Technology, and Society (STS) issues. Students were asked to rank twenty STS issues from one to twenty in order of perceived importance and give the rationale for their choices. They were also asked to group the STS issues according to perceived relationships among the issues. An analysis of student responses about the STS issues showed topics of personal relevance to students and gave insight into their prior knowledge and misconceptions regarding STS issues. The research found that students do have knowledge and understandings of STS issues with relevance to their lives. A follow-up study was done to see if students' perceptions changed over time. The results of the second study showed that students gain most of their information from real-world sources outside of school. These findings have implications for science instruction, since the information learned would help in the development of appropriate integrated, interdisciplinary units of instruction to meet students' interests and needs.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

The demands of our rapidly changing world require changes in the way we teach science. We need to teach students to ask questions, analyze problems, gather information, and make reasonable decisions and judgments so that they may logically deal with increasingly complex issues in our society. Students need to have a strong knowledge of science concepts, as well as scientific process skills. Studies have shown that our citizens are not scientifically literate, and there are many calls for reforms in the way science is taught. According to the report *Before It's Too Late* by the National Commission on Mathematics and Science Teaching for the 21st Century (2000), "Our children are losing the ability to respond not just to the challenges already presented by the 21st century but to its potential as well. We are failing to capture the interest of our youth for scientific and mathematical ideas. We are not instructing them to the level of competence they will need to live their lives and work at their jobs productively. Perhaps worst of all, we are not challenging their imaginations deeply enough."

This report and many others state several reasons why it is imperative that all of our citizens achieve scientific literacy (AAAS, 1993; NSTA, 1990-1991; NRC, 1996). 1) The rapid rate of change in society and the American workplace demands science-related knowledge and abilities. It is estimated that 85% of all jobs are classified as "skilled," whereas in 1950, 80% of all jobs used unskilled workers (NCEE, 1984). 2). With the current issues in society concerning technology and science that all people must understand and act upon, all people must be able to analyze information and make reasonable decisions. They must be able to deal rationally with the issues, responsibilities, risks, and opportunities of our scientific and technological world. 3) We need to prepare scientists, engineers, teachers, and other professionals to compete in our changing global economy.

Citizens who do not possess the prerequisite skills suffer, as does our society. According to the report in *Our Nation at Risk* (1984), "Individuals in our society who do not possess the levels of skill, literacy, and training essential to this new era will be effectively disenfranchised, not simply from the material rewards that accompany competent performances, but also from the chance to participate fully in our national life. A high level of shared education is essential to a free, democratic society…citizens must be able to reach some common understandings on complex issues, often on short notice and on the basis of conflicting or incomplete evidence" (NCEE, 1984).

Our past methods of teaching science have not been producing scientifically literate students, or students who are interested in continuing with scientific study. Most students cannot perform more than at the recall level. They cannot apply the concepts and processes they have learned except to recall them for examinations, and they are seldom required to do more than that. They cannot apply the science they learn in new contexts out of the classroom. Even science majors in universities cling to their misconceptions (Yager, 1991). As students progress through school their attitudes toward science decline, and creativity skills decline as students become less curious. Few students are stimulated to pursue further study on their own, beyond the required courses (Yager, 1991).

Science education needs to deal with these problems.

The National Science Teachers' Association has stated that the two goals of science education are preparing students to understand and deal rationally with issues and opportunities of a scientific and technological world, and preparing enough qualified scientists, engineers, teachers, and related professionals to compete successfully in science and technology (NSTA, 1990). The National Science Education Standards add the goal that students need to experience the richness and excitement of knowing about and understanding the natural world (NRC, 1996a). To effectively do this, they recommend developing curricula that provide opportunities for all students to study real-life, personal, and societal science and technology problems. A study by the National Research Council (1996) has made similar recommendations. Students should acquire scientific literacy by direct experience with the methods and processes of inquiry. While doing open-ended investigations, they come to understand basic principles and connect science and technology to real-world problems and issues, including their own personal and societal needs. In doing this, students learn and understand the processes scientists use to investigate and solve problems. The students learn the science content in depth and use it in everyday situations. There is an emphasis on the posing and solving of problems as students learn the skills of observation, measurement, analysis, decision-making, and critical thinking (NRC, 1996).

Research supports STS (Science/Technology/Society) education as an effective way to teach science content, get students interested in science and technology, and teach technological and scientific process skills. In addition, STS has been shown to improve scientific and technological literacy that is necessary to be an informed citizen. Research also shows that students learn best and can apply the knowledge learned, when actively working to solve real-world problems that have personal relevance.

A substantial amount of research has been published on why and how STS is an effective way to teach science and technology (Yager,1996; Roth, 1996), but research on how to pick appropriate STS issues for the classroom is not as abundant. This action-research project was designed to explore a method of selecting topics by looking at students' perceptions and beliefs about STS issues and analyzing their perceptions of the relationships between these issues. Knowledge of students' conceptions of STS issues and relationships would be beneficial for effective teaching and curriculum development in science. Analyzing students' ideas about several STS issues, and their perceptions of the relationships among the issues, would show topics of personal relevance to students, give insight into their prior knowledge, and may shed light on any misconceptions in science. The information learned would help in development of appropriate integrated, interdisciplinary units of instruction to meet students' interests and needs.

This study looked at fifth grade students' perceptions of the importance of twenty science, technology, and society issues and the relationships between these issues. Fifty-one students ranked the issues according to perceived importance and gave written rationale to explain their thinking. They grouped issues that they believed were related and gave written explanations to explain their thinking. The results show that students have developed knowledge and understanding of issues that have relevance to their lives, such as health and nutrition. They showed less conceptual knowledge of issues with less relevance, such as space exploration and some environmental issues. This action research study demonstrates how examining students' prior knowledge and current understanding can be used to develop science curriculum that has personal relevance to students. The study also shows that there may be science concepts that students have little understanding of which may need to be addressed when developing science curriculum.

CHAPTER TWO

LITERATURE REVIEW

To meet the demands of our changing world, we need to change the way we teach science. Our traditional methods of teaching are not producing scientifically literate students (AAAS, 1993). Most students will not choose a career in science, but all students need to be scientifically and technologically literate to meet their own, as well as society's needs.

Traditional Science Education

Science education can no longer be defined as basic concepts and process skills to be taught directly. This view of science has proven to be ineffective (Yager & Blunck, 1995). Although our rapidly changing world requires students to acquire new skills and knowledge, in most science classrooms the method of teaching hasn't changed to keep up with the changing needs of society (Mastropieri & Scruggs, 1994). Most science teachers use textbook driven approaches, where the textbooks, lectures, and written assignments constitute the mode of instruction. Science is viewed as a collection of facts and vocabulary to be memorized and recalled later. Most student activities are paper-pencil tasks or low-level process skills to prove what was read, and most activities do not promote exploration, problem solving, decision-making, or creative thinking (Mastropieri & Scruggs, 1994; Lord, 1998). Even after successfully completing a science course, students retain large misconceptions. Student comprehension and understanding is low, as a result of students not being encouraged to look critically at the content or extend their thinking to other activities and contexts (Yager, 1991). Other problems seen with traditional teaching methods are the 1) lack of personal relevance to students and no application to their daily lives 2) teachers are viewed as authoritative sources 3) science is restricted to classroom resources 4) textbooks are without relevant context (abstract generalizations not put in everyday, relevant context) (Yager & Lutz, 1995).

A study by NAEP (National Assessment of Education Progress, 1998) in *Every Child a Scientist*, which was designed to measure the progress of students in grades 4, 8, 12, found that by 12th grade students know some basic facts and principles, but they can't apply scientific knowledge to new situations, design an original experiment, or explain the reasoning behind their answers. Another finding, supported by other studies, was that students, especially girls, lose interest in science as they progress to higher-grade levels (Dimitrov, 1999; Friedman, 1999). Research (NCES, 2000; Yager & Lutz, 1995; Monhardt, 2000) also shows that:

1) Science achievement decreases as students move through the grades.
2) More than one-half of students like science in elementary school, but only one-fourth like science in high school. The high school students reported that science was not useful or valuable to everyday life.
3) Boys have higher achievement in science than girls.
4) White students' science achievement in higher than minority students. 42% of classes with a composition of more than 40% minority students are labeled "low ability."
5) Our best students under-perform the best students in other countries.

Changing how we teach science could lead to the solution of these problems of low student achievement, and students' declining interest in science as they progress through the grades.

Research In How People Learn: Constructivism

Research in how people learn shows that real learning occurs when individuals engage their minds in a process of actively constructing meaning for themselves. Students do not learn by absorbing information from others. They must be engaged in experiences that challenge their preconceptions and initial explanations and that require a change in their initial beliefs. Students construct their own understandings, which are built on prior knowledge and past experiences (NRC, 1999). This research in how people learn has led to reform in education based on the learning theory of constructivism. Science education in a constructivist classroom can be identified with four major components (Klein & Merritt, 1994; Stern, 1996):

Introduction of a Real-life Problem

The problem must be authentic: a real-world challenge in a real-world setting. It must be relevant to the students and rich in design, as well as open-ended with alternate solutions. The problem must require students to participate actively, and it must include important concepts in science, as well as attitudes, vales, and skills. Students choose their own resources, which include authentic and realistic information that is flexible and rich in context.

Student-centered Instruction

Teachers solicit students' prior experiences, explanations, and ideas, which the teacher builds on and adapts to help students construct new knowledge. Cognitive progress is characterized by adapting, rather than erasing, prior knowledge. Students become clear of their own understanding and then see the inadequacies of their beliefs. The students construct alternate beliefs that work better for them personally and that are more consistent with those of the scientific community, as compared to traditional science teaching, which doesn't do well at changing misconceptions (Colburn, 2000).

Productive Group Interaction

Students experiment, investigate, observe and discuss as they work collaboratively on relevant problems. They choose their own methods and explain and defend their views.

Authentic Assessment

Assessment occurs all through the learning process. Students are assessed in the beginning for prior knowledge and throughout the duration of the learning activities. Assessment is not just an examination at the end of the unit for a grade, before moving on to the next unit. Assessment provides feedback to the students and teachers to improve teaching and learning, and students are given opportunities for revision.

In a constructivist classroom there is a focus on broad conceptual schemes in science. Fewer topics are covered in much greater depth. Children are perceived as constructors of meaning and understanding. Unlike a traditional science class, where the teacher expends the cognitive energy, in a constructivist-based room, the student is the one expending the cognitive energy most of the time (Lord, 1998). This method of teaching leads to meaningful learning, rather than rote memorization. Students who learned science in a constructivist environment had more positive attitudes about learning science, felt they understood what they were being taught, and were more likely to continue with science by taking more science courses (Lord, 1998).

Science, Technology, Society To Meet Goals Of Science Education

A major reform effort in science education is STS, Science/Technology/Society. STS is a teaching strategy that seeks to increase student understanding and interest in science and technology in a constructivist environment through relevant, real-world investigations. Through their investigations, students develop an understanding of the interrelationships between science knowledge and concepts, technology, and society. There is an emphasis on major concepts in science that are important to citizens, and students develop understanding of the uses, limits, and consequences of science and technology in society. Students learn science in a real-world context. STS supports students in making sense out of the natural world (science), the artificially created world (technology), and the social world (society)(Aikenhead, 1998).

The basic characteristics of STS are supported by research in the cognitive sciences (Yager, 2000; Roth &

McGinn, 1996). STS incorporates the characteristics of constructivism: 1) Student questions and ideas guide instruction. Students identify problems with local interest or personal relevance. 2) Students are actively involved in seeking information through a variety of relevant, authentic resources. They identify their assumptions and engage in open-ended activities to test misconceptions and previous knowledge. 3) Science is viewed as more than content for future tests. Students work collaboratively to observe, infer, experiment, describe, ask questions, and construct and test explanations. They look at diverse viewpoints and competing interpretations of data. They determine possible causes of action, solutions, and consequences. They make logical choices and defend their choices (NSTA, 90-91;Yager & Lutz, 1995; Singleton, 1988). There is a focus upon the impact of science and technology on the student, which makes learning relevant and extends it beyond the classroom. Students experience citizenship roles and career awareness.

An NSTA position statement on STS states that learning science in an STS context results in students with more sophisticated concept mastery and students with improved ability in the use of process skills, creativity skills, and the use of science concepts in their daily living. STS education is a valid way of achieving scientific literacy for all students. Students use concepts of science and technology to solve everyday problems and engage in responsible, personal and civic action (NSTA, 1990-1991). This belief that STS leads to superior learning for students of all abilities in all learning domains is supported by many research studies. Students' attitudes are more positive when students perceived more personal relevance and shared control of their learning with the teacher (Kim & Fisher, 1999). Students learning with STS show gains over traditional students in process skills and science inquiry skills. Their knowledge skills were at least as good (Aikenhead, 1998). Students take ownership of their learning in an STS environment where they are exploring topics and problems of personal relevance. Students show improvements in mastery of science concepts and skills, application of science concepts and processes in their own lives, and attitudes regarding the study of science and science careers. They have an increased curiosity to find out more and more creativity in designing investigations and exploring possible solutions (Yager & Blunck, 1995; Roth & McGinn, 1996; Gabel, 1994, p. 62).

Science, Technology, Society to Meet Needs of All Students

All students make gains in content and process skills when they are involved in activity-based classrooms, such as those taught in the context of STS. Barak found that low achieving students, taught around problems which aroused their interest and which had personal relevance, made large gains in achievement as they worked on technology projects (Barak & Yehiav, 1994). Students who were academically or economically disadvantaged made the greatest gains in science content and process skills after being involved in an activity-based classroom, where students worked on relevant and meaningful problem solving (Gabel, 1994, p. 238).

In another study McShane and Hull found that when minority students were taught with STS instruction, they had increased attention span and a gradual shift from concrete to abstract functioning (Yager, 1996). STS was effective in reducing differences in attitudes, creativity, application, process, and concepts between the minority and majority students. In fact, the minority students performed better in the application, attitude, and creativity domains. Scruggs and Mastropieri (1994) found that special education students with mild learning disabilities had improved achievement after learning in an environment with active exploration of a variety of scientific materials. Adding meaningfulness and relevant experiences, with many social influences and interactions with teachers who built on prior knowledge, led to significant gains in learning.

Our best students, according to the TIMMS report (NCES, 2000), do not perform as well as expected on science achievement tests. When gifted students received integrated math and science instruction, which included high-level thinking skills with real-world problem solving, they scored higher on the science section of the ACT than a comparable control group. They retained their higher scores two years later, when they were tested again in the 12th grade (Tyler-Wood, 2000). In Minnesota, 8th graders did very well in comparison with other 8th graders throughout the country on the TIMMS study. A comparison of curriculum shows that while the U.S. curriculum as a whole is "a mile wide and 1" deep," in Minnesota, teachers introduce fewer topics and devote more time for in-depth study. Students are actively involved in a given area of focus, with a small number of topics, as in STS (NSTA, 2000-2001).

Science taught in an STS context has also proven to be an effective method of reducing gender inequity in the science classroom. Although many girls lose interest in science as they continue through school, Friedman found that girls who participate in problem solving in a constructivist environment, with hands-on activities and cooperative strategies, had an increased comfort level and interest in science (Friedman, 1999). Solomon and Harrison (1991) found no gender differences in students who participated in regular group discussions of controversial science and technology issues. The discussions appeared to be an essential part of the construction of understanding that increased the girls' interest in science. Tsai (1999) had similar results in her study of female cognitive outcomes with STS instruction. She found that STS may be the potential method of narrowing the gap between male and female students, as STS seems to fit the learning preferences of females, since it involves discussion of social-related issues, which females view as important in learning science.

When women who have careers in science fields were asked what factors in the classroom encouraged them to continue in science, they listed many of the characteristics of STS: hands-on experiments, labs, field trips, experience-based learning, field observations, problem-solving experiences, open-ended questions, challenges and independent analysis. They also emphasized cooperation, group work, respectful and supportive teacher-student interactions, and content that was relevant. Negatives listed were too much competition, masculine examples and application (especially common in physics) and content that has no connection to female experience (Taylor, 1999).

Research shows that students who learn science with STS out perform students in traditional science classes in their knowledge of science content, science application, and science process skills and applications. STS adds relevancy to science courses, and leads to integration of the curriculum and an emphasis on higher order thinking skills across content areas. The benefits of STS appear to be worth the effort of getting this method of instruction and learning into the science classroom.

Implementation of Science, Technology, Society in the Classroom

There are three basic ways to incorporate STS issues into the science curriculum. 1) The issues can be infused into existing lessons or units of study. 2) The STS issues can be separate lessons or units added on to a regular course. 3) STS could be a new course of study (Singleton, 1988).

In the traditional science classroom, science content is taught first, and then the application of the content and the societal aspects. Pedretti (1999) suggests we reverse the order and start with the societal aspects and then teach the science content and applications in a relevant and meaningful context. In her model students explore issues of immediate interest and relevance in conjunction with existing science curriculum.

In Aikenhead's model for implementation of STS into the curriculum, the starting point could be any place of student interest or personal relevance in science, technology, or society. For example, students could start with a discussion about the societal issue, and then proceed to the technological and science aspects of the problem, or they could start with the technology or science, since all areas are directly related (Aikenhead, 1998).

The literature suggests several key issues for study in the classroom around which science knowledge and process skills might be taught. Bybee and Mau (1986) asked 262 science teachers from 21 countries what they believed the most important global issues were. The teachers responded that the most pressing problems were world hunger, population growth, air quality, water resources, human health and diseases, and the destructive capacity of modern weapons.

Singleton, in his book for staff development on STS for science educators has a similar list of topics considered by teachers and scientists to be among the most important (1988). His list of important issues include:

- Population growth (world population, immigration, carrying capacity)
- Water resources (waste and supply)
- World hunger (food production, drought, cropland

conservation)

- Air quality (atmosphere, acid rain, global warming)
- War technology (nerve gas, terrorism)
- Energy (shortages, fossil fuels, solar, nuclear)
- Land use (soil erosion, wildlife habitat loss)
- Human health and disease (diet, nutrition, addiction)
- Hazardous substances
- Extinction (endangered plants and animals)
- Natural resources (mining, recycling)

The AAAS in Project 2061 (1993) gives the following list of technologies that affect society and that are affected by society. These include Bybee's and Singleton's important issues, but are stated in broader terms:

Materials cycle	Energy
Manufacturing	Agriculture and Food
Biotechnology	Environment (atmosphere)
Communications	Electronics
Computer Technology	Transportation
Space Exploration	

When students are actively investigating any of these real world problems, or other problems that have relevance to their personal lives, they learn science concepts, process skills, and science applications as they move towards scientific and technological literacy.

Conclusion

When students learn science with STS, they learn to become effective problem solvers. As students explore, investigate and reach conclusions in the science classrooms, they learn how scientists go about their work and reach scientific conclusions (AAAS, 1993). They also learn what the limitations of their conclusions are, and are more likely to react skeptically or thoughtfully to science claims. They are also less likely to accept or reject information uncritically or without logical reasoning (AAAS, 1993). The applications of science and technology in society involve risks as well as benefits. STS supports the development of students' abilities to examine issues critically and understand risks involved. When considering controversial issues, students (and citizens) make decisions and judgments that affect society. When learning science in the context of STS, they learn to make cost-benefit-risk analyses and participate in decision-making, after examining all available evidence (Cross, 1993). A student, or citizen, who can ask questions, analyze problems, gather information, and then make rational decisions and judgments has achieved scientific literacy, which is the goal of science education.

CHAPTER THREE

METHODOLOGY

This is an action research project which attempted to explore a process by which a teacher could identify Science, Technology, Society (STS) issues with personal, real-world relevance to students. Students were asked to rank STS issues in order of importance and to group the issues according to perceived relationships among the issues. They gave written rationale for their rankings, as well as their groupings. Student responses provided information about their interests, prior knowledge, previous experiences, and misconceptions. This has implications for the science classroom, since this information is essential for effective science teaching.

Design of the Investigation

Research Questions

How do students rank STS issues? What relationships do students see in the issues presented? Does the rationale for their responses give the teacher insight into the students' interests, knowledge, and understanding and provide a basis for curriculum development?

Participants of the Study

Data was collected from fifty-one fifth-grade students. Twenty-eight of the students were girls and twenty-three were boys. They were all ten or eleven years old. The students were from two self-contained classrooms, Class A and Class B, at the same school in San Bernardino County. Class A had 26 students participate in the survey, and Class B had 25 students participate.

Instrument Development

During the process of reviewing the literature on STS, a list of issues was compiled that scientists and educators believe to be the most important issues facing our society concerning science and technology. Using the Bybee and Mau study (1986) as a template for setting up the list, twenty issues were selected as being the most appropriate for fifth grade students. The list is based on the research, on the researcher's knowledge of the elementary science curriculum, and my eight years of experience as a fifth grade teacher.

Procedure

First Study

The students were each given the list of twenty issues. The issues were read aloud, as students followed along, and students were told that these were issues of concern to many people in society (the world). A very short description of each issue was given. For example: *Population Growth: This refers to the amount of people in the world or in a given area.* (There was no discussion of any of the issues during the study.) The students were asked to rank the issues from 1 to 20, in order of importance, with 1 being the one the student thought was most important and 20 being the least important. The students were also asked to write a reason for their ranking of each issue, or at least the ones about which they felt most strongly. It was emphasized that they should give reasons for their top choices, as well as those they ranked as least important. This activity was designed to show students' knowledge and understandings of each issue. When this activity was completed, the students were asked to group any issues that they thought were related and explain the relationships. The groupings they chose would provide further insight into their knowledge of the issues. The purpose of the grouping activity was to see if complex relationships, or the lack thereof, might become apparent.

The issues the students were asked to analyze were:

- Population Growth
- Air Quality
- Space Exploration
- Use of Natural Resources
- Loss of Wildlife Habitat
- Global Warming
- World Hunger
- Human Health and Diseases
- Solar Energy
- Hazardous Substances
- Acid Rain
- Transportation
- Ground Water Contamination
- Nutrition and Diet
- Endangered Species
- Pesticide Use
- Water Resources
- Energy Resources
- Deforestation
- Recycling

The Follow-up Study

A follow-up study was done two months later on Class A to see if students' perceptions of STS issues changed over time. Students were asked to rank the twenty STS issues again and write where they learned about the issues. The purpose of this activity was to investigate whether STS issues in the news affected students' perceptions of the importance of the issue. Student responses would also show where students gain their knowledge of the STS issues.

CHAPTER FOUR

FINDINGS

Data

The following table (see Table 1) shows the students' ranking of the issues.

Table 1. Results Of Student Surveys Ranking the Twenty Science, Technology, Society Issues

STS ISSUE	CLASS A	CLASS B	TOTAL
World Hunger	5.6	4.8	5.2
Health and Disease	7.5	5.5	6.6
Air Quality	7.1	7.7	7.4
Loss of Wildlife Habitat	7.1	7.9	7.5
Water Resources	6.7	9.1	7.8
Endangered Species	7.9	9.0	8.4
Energy Resources	9.0	10.1	9.5
Ground Water Contamination	10.5	9.5	10.0
Use of Natural Resources	9.6	11.5	10.5
Deforestation	10.9	10.6	10.7
Recycling	8.7	13.0	10.8
Global Warming	11.3	10.8	11.0
Hazardous Substances	11.4	10.8	11.1
Acid Rain	12.9	10.1	11.5
Nutrition and Diet	12.2	11.3	11.8
Solar Energy	11.3	13.3	12.3
Population Growth	13.0	11.5	12.3
Pesticide Use	13.6	12.3	13.0
Transportation	14.4	14.3	14.4
Space Exploration	15.4	14.0	14.7

The rankings were determined from the student surveys by adding the relative placement of each issue in each student's survey and then finding the mean score. For example, if a student ranked "world hunger" as the most important, it got 1 point. An issue ranked 4 on the list was given 4 points, etc. Thus, the issue with the lowest mean score after adding up all the rankings on the 51 surveys, was the one the students considered to be most important, and the issue with the highest mean score was the least important to the students. The mean scores for each issue are given. The issues that were ranked as the most important by these fifth grade students were world hunger, health and disease, air quality, loss of wildlife habitat, water resources, and endangered animals.

Students' Perceived Relationships Among Science, Technology, Society Issues

Students grouped the issues into the following major clusters. The rationale given by the students explains why they grouped them as they did. The frequency with which students grouped each issue with other issues is shown in the table in Appendix C.

Human health and nutrition relationships (55% of students):

- Nutrition and diet, human health and diseases:

people's health.

- Nutrition and diet, world hunger: People need to stop eating so much, so other people could eat more.
- Nutrition and diet, hazardous wastes, pesticide use: these affect people's health
- Nutrition and diet, world hunger, human health and diseases: about people's health. If you don't eat good food, you could get sick.
- Nutrition and diet, air quality, water resources, pesticide use, world hunger, global warming: these all affect human health and diseases.

Habitat and endangered species relationships (73% of students):

- Loss of habitat, deforestation, endangered species, and pesticide use: these have to do with wildlife.
- Loss of wildlife habitat, population growth, deforestation, and endangered species: population growth leads to deforestation, which leads to loss of wildlife habitat, which leads to endangered species.
- Loss of wildlife habitat, deforestation, and endangered species: Animals need to live on land or

they become endangered.

- Loss of habitat, deforestation, and use of natural resources: we use wood and trees and animals lose their habitat.
- Loss of wildlife habitat, endangered species: we need animals on the planet, because you could have a pet and some of our meat comes from animals.
- Loss of habitat, pesticide use, air quality, population growth and deforestation all go together and cause endangered species.

Energy relationships (33% of students):

- Solar energy, air quality, space exploration, global warming: these have to do with the atmosphere and space.
- Space exploration, global warming: these have to do with space.
- Energy resources and solar energy: these are about using and saving energy.
- Solar energy, energy resources, water resources: these give you energy to move around.

Transportation and air quality relationships (10% of students):

- Transportation and population growth: with more people moving to the USA and our city, it's going to be harder to get to places, because the streets and freeways are getting full.
- Transportation, global warming, air quality: too many cars cause pollution, which makes global warming.
- Transportation, air quality, global warming: it causes cars to crash and pollute the world, because the car's pieces fly around.

Population and world hunger relationships (<10% of students):

- Population growth and world hunger: if there are too many people, there won't be a lot of food for all.
- Population growth, world hunger, human health and diseases, nutrition and diet, transportation: these have to do with humans.
- Population growth and world hunger: too many people to feed

Environmental relationships:

- Water resources, recycling, use of natural resources, ground water contamination, hazardous waste: things humans do to the environment.

- Hazardous wastes, pesticide use, ground water contamination: the hazardous wastes become ground water contamination and hurt plants and animals.
- Water resources, acid rain, ground water contamination: these are all about water.
- Acid rain, hazardous wastes, pesticide use: these can damage our health and ruin the earth
- Hazardous wastes, recycling: problems with our landfills
- Recycling, solar energy, use of natural resources: ways that people can help the earth
- Energy resources, water resources, endangered species: things that should be saved
- Water resources and air quality: in order to live, people require fresh air and fresh water

Data Analysis

The students' rankings of the STS issues show relevance to the lives of the students, as well as insight into their thinking. Issues with which they are familiar and/or know to be important to survival were ranked high in importance. Four of the top six issues in importance to the students were related to health and the necessities of life: food (world hunger), health and disease, water resources and air quality. The rationale the students gave (see Appendix C) explained that they chose these issues as being the most important, because without them (food, air, water, good health) people could not survive. Many commented that they were bothered by air pollution. The other two issues important to the students were endangered species and wildlife habitat, both of which are familiar to students, and most students expressed concern about the welfare of animals. Other issues in the top ten were issues that students had some experience with, such as recycling. (For example, students participate in recycling at school.) Energy resources received a fairly high score, probably because many students were aware of current energy problems in the state.

Issues near the middle of the list were issues that most of them had heard about, and they were aware that there was some kind of societal problem involved, but they did not have a clear understanding of the problem, as evidenced by students' written rationale (see Appendix B). These were the issues of global warming, acid rain, solar energy, hazardous wastes, and pesticide use. Some of the students who gave rationale for their rankings gave good scientific reasons, but many students just omitted giving a reason for the ones they weren't familiar with. Students explained that they left no response if they did not understand the issue.

The issues ranked lowest in importance by the students were not necessarily those the students knew the least about. They often had strong opinions for putting an issue last in the ranking. In the cases of space exploration, population growth, transportation, and nutrition, the students were aware of the issues in a basic way, but did not consider them to be problems that needed to be solved, and thus they were given low rankings in importance (see Appendix B). Some student responses on population growth were, "We don't have to worry, because people have babies, and then people die," and "This is not a problem. Workers will build more houses." There was very little understanding shown of the relationships between population growth and most of the other issues on the list.

The groups that the students clustered the STS issues into showed that students have developed some conceptions and understandings of related issues. For example, they have a good understanding that human health and disease are related to nutrition and diet. 55% of the students had a grouping related to human health. A common statement made was that humans need to eat well to be healthy. Also included in this grouping was world hunger. Although several students wrote about air quality, pesticide use, and hazardous substances as having an effect on human health, most did not include it in their "health" groupings. Another group chosen by many students (73%) was one relating to endangered species, habitat loss, and deforestation. Students also grouped natural resources and population growth with these issues, but to a lesser degree. Again, very few students grouped population growth with the issue of loss of habitat or endangered species. One student, about population growth, wrote, "This is not important, because there is enough room in the world," and on the issue of habitat loss he wrote, "If we keep cutting our trees, the animals will die."

In many cases the rationale given for groupings showed where student understanding was unclear. For example, one student response was, "Space exploration is a solution for overpopulation." Another student wrote that, "We need endangered animals for pets and meat." Students grouped water related issues together, only saying, "These are about water." Many students, in their attempt to explain environmental relationships, put the issues into large groups with the rationale, "Things humans do to the environment," or "Ways people help the earth." Other small clusters were energy groups (33% of the students) and transportation groupings (10%). After finding that students seemed to be unclear about many environmental issues and their relationships, a teacher may choose to guide instruction into these areas to build students knowledge.

Follow-up Study

After analyzing the data, a follow-up study was completed on one of the classes (Class A). Because of the energy crisis in California, many students have been exposed to information about the severity of the energy shortage in the newspaper, on television, at home, and at school. All the students had been informed about the energy crisis at school in directions from the school and district office to conserve energy. This follow-up study was designed to see if exposure to information about an issue changes students' perceptions of the issue importance. The students were given the same list of twenty issues and asked to rank them again, from one to twenty as on the previous survey. The results of the new student rankings are shown in the following table (see Table 2).

The issues with the biggest increases in the student rankings were population growth, pesticide use, transportation, and energy. The issue about energy probably did not increase as much as I expected, because students had already ranked it fairly high the first time they completed the survey, although it did move up in their rankings, in front of air quality. The issue showing the greatest gain was population growth. Students reported hearing a lot of news on TV about the census and California's increasing population.

Table 2. The Results Of Class A's Ranking Of The Issues In February And April

STS ISSUE	Feb. 9	Apr. 5	Increase or Decrease
World Hunger	5.6	5	+0.6
Water Resources	6.7	7.6	-0.9
Air Quality	7.1	8.2	-1.1
Wildlife Habitat	7.1	6.7	+0.4
Health & Disease	7.5	5.1	+2.4
Endangered Species	7.9	7.2	+0.7
Recycling	8.7	8.1	+0.6
Energy Resources	9.0	7.9	+1.1
Natural Resources	9.6	12.3	-2.7
Ground Water Contamination	10.5	10.9	-0.4
Deforestation	10.9	12.9	-2.0
Global Warming	11.3	14.5	-3.2
Solar Energy	11.3	11.4	-0.1
Hazardous Wastes	11.4	10.7	+0.7
Nutrition	12.2	12	+0.2
Acid Rain	12.9	12.8	+0.1
Population Growth	13.0	10.1	+2.9
Pesticide Use	13.6	11	+2.6
Transportation	14.4	13.1	+1.3
Space Exploration	15.4	14.9	+0.5

The issue showing the biggest decrease in ranking was global warming. In late January, students had read and discussed a chapter in their science book on a weather topic. Included in the chapter was a diagram and explanation on the topic of global warming. My hypothesis is that students remembered that in February for the first survey, but the issue had faded in importance two months later. Many of the students didn't remember what it meant.

Also, their initial responses showed they didn't have a clear understanding of the issue on the first survey (see Appendix B). One student wrote, "The world is hot enough," and another student, who ranked global warming as important, said, "I like it warm." According to one student, global warming is "why we have summer."

Unlike the first survey, this time the students were not asked to give a rationale for their rankings, but they were asked to explain where they learned about each issue, or at least the ones they felt were most important. Student responses to the question of where they learned about each issue showed that they learn about issues in a variety of ways, most of which were not school related. They learned about these real world problems outside of school, in the real world. The source most often mentioned was television. Students get their information from the television news, programs, movies, and commercials (see Appendix E). Several wrote that they knew world hunger was important, because they saw commercials about starving children from other countries. Other students also mentioned that they hear about health and diseases on commercials and on the news on TV. A few students cited the movie Erin Brockovich as their source of information on ground water contamination.

One subject that students do seem to be learning about at school, as well as on television, in books, and in movies is the issue of endangered species. This isn't surprising, since students expressed a high interest in anything related to animals, and as the research shows, students will learn about what they are interested in or that has relevance to their lives (Yager & Blunck, 1995).

CHAPTER FIVE

IMPLICATIONS

This action research project has implications for teaching and curriculum development in science. Student responses showed that they have developed concepts and understandings of STS issues that have high student interest and personal relevance to their lives, such as issues relating to health or animals. Research shows that student knowledge and understanding of science is directly related to the personal experiences of students, so the issues students had knowledge of were issues with which they have had meaningful experiences (Colburn, 2000; Lord, 1998). Those issues, of which they had little understanding, were issues with which they had the least personal experience. Although, even with the STS issues which were ranked high in importance, deeper and more complex relationships among the issues were usually not apparent. This process of examining students' ideas about STS issues gave evidence of student prior knowledge and understanding, as well as information about inconsistencies in their thinking and apparent misconceptions students had.

For example, the majority of students were concerned that loss of habitat would lead to more animals becoming endangered. Many of the same students wrote that population growth was not a problem. Many were concerned about air quality, but few students related that to the transportation issue. Student responses did not show that they knew what caused poor air quality. The teacher could make use of this valuable information in planning instructional experiences for the students.

Another finding arising from the student responses concerns where students learn much of their information about issues. The students reported learning most of what they know about the given STS issues from television: news, commercials, programs, and movies. Very few students reported learning about the issues from school related activities. Since students seem to be learning from real world sources, one implication may be that teachers need to bring real world resources into the classroom. Science education needs to extend beyond the classroom, into the community and homes of the students. As students investigate STS issues, they need to use outside resources, such as news, current events, field trips, etc. to bring the real world into the classroom and make learning about science relevant and meaningful.

STS issues which are discovered to have high personal relevance and interest to students can be used to teach science content and process skills. In the National Science Education Standards (1996) it states, "Students learn science by actively engaging in inquiries that are interesting and important to them. Students thereby will establish a base for understanding science."(p.13) When topics that have a personal, relevant context are used, students will be able to apply the science learned in real life situations and maximize their learning.

The process described in this study, identifying topics relevant to students, can provide direction for standard-based instruction. In the context of learning with STS, student questions, not science content drive the instruction. Students learn science by engaging in meaningful, problem-solving situations (AAAS, 1993). The science content emerges as the students gather information, investigate, conduct experiments, develop hypotheses, predict, communicate, etc. These activities will require that they learn the big ideas in science, as they will be a necessary component of their problem-solving investigations. Although the National Science Education Standards do give content standards that should be taught, they are broad definitions that match the teaching strategies of STS. The standards call for less emphasis on the traditional science outcomes of knowing scientific facts and information, activities that verify science content, process skills out of context, and getting an answer. The standards call for more emphasis on understanding scientific concepts and developing abilities of inquiry, activities that investigate and analyze science questions, process skills in context, and using evidence and strategies for developing or revising an explanation. (p.113) STS meets all of these recommendations.

The California Science Content Standards (CDE, 2001) are much more specific, with an emphasis on facts, concepts, principles, theories, and process skills all students should learn at each grade level. The draft of the California Science Framework (2001) also states that, "Students need to be able to connect the science content in the standards to technology and societal impacts to be fully science literate. (p.3) Even with a strong emphasis on content, there is the realization that there still has to be a STS connection for the student to achieve science literacy. It is especially important that the teacher identifies student needs and interests to help guide instruction in a standard-based classroom. Knowing the science concepts that need to be taught, the teacher can find areas of student interest within the required subject matter and have students build on those areas of interest to encompass more of the content that is described in the standards. Teaching to the standards, while ignoring the interests and needs of the students, will not result in meaningful science learning.

APPENDIX A:

STUDENT SURVEY

What do you think is the most important issue? Please number them from 1 to 20 according to their importance to you. Put a "1" by the most important, a "2" by the next most important and so on. Please tell me your reasons for your choices.

_______ Population growth ____

_______ Air quality ____

_______ Space exploration ____

_______ Use of natural resources ____

_______ Loss of wildlife habitat ____

_______ Global warming ____

_______ World hunger ____

_______ Human health and diseases ____

_______ Solar energy ____

_______ Hazardous wastes ____

_______ Acid rain ____

_______ Transportation ____

_______ Ground water contamination ____

_______ Nutrition and diet ____

_______ Endangered species ____

_______ Pesticide use ____

_______ Water resources ____

_______ Energy resources ____

_______ Deforestation ____

_______ Recycling ____

APPENDIX B:

STUDENTS' RATIONALE FOR RANKING THE ISSUES

These are representative samples of students' written rationale for their rankings of the Twenty STS issues:

Population Growth:

- I think this is important, because if there are too many people in the world that means they'll have to cut down trees.
- There are not too many people in the world.
- I am not too worried about population growth, because I don't think that it could happen.
- We do need to have less population, but right now we shouldn't worry about it too much.
- A lot of people are good, so no one is lonely.
- Why should people worry about population growth when we have enough stuff to keep everyone alive?
- This isn't too important because people die.
- It doesn't matter how many people we have on Earth.
- Not that important because there is enough room in the world.
- This is not much of a problem. People are coming, but there are lots of homes being built.
- There are too many people on Earth.
- Not a problem. Workers build more houses.
- We don't need to worry because they have babies and then people die.
- Too many people are being born.
- I think population growth is important, because one day we will have too many people on Earth.
- Now California is getting so populated, the prices go up.
- More trees get chopped down for more houses.
- Too many people, less energy.
- People should live in areas where there are no forests. I think they should live in the desert.

Air Quality:

- This is important, because if our air is polluted it means we will get sick and may die.
- Our own air quality keeps getting worse.
- We need to stop polluting the air.

- There is a lot of smog in the air late in the afternoon.
- We need good air to stay alive.
- People shouldn't pollute our air.
- We need to plant more trees so more people could live better.
- Pollution can affect the way you live and your health.
- Our air must be clean for us to breathe and be healthy.
- People shouldn't pollute our air, because people and animals get sick.
- This is not as important, because not too many people pollute the air.
- We need good air, so people and wildlife will live a long time.
- We could get cancer.
- We are getting sick because of our air.

Space Exploration:

- I think this is in the top 10, because the nation could save money and get things everybody needs.
- I am interested in space, but we should worry about our own planet first.
- We need space exploration to save the world from asteroids.
- We should be sending more people into space.
- We have too many space shuttles in space.
- This is not important. Not everybody is going to go to space.
- I think we should have a lot of space trips, even if it costs a lot of money.
- We should wait until the future to explore, because we will have better technologies.
- This is not an important problem. There are a lot of things more important.
- Space exploration is costing millions of dollars.
- It is important to learn about space, because we don't actually know what is out there.
- We need to know more about space.
- We need more exploration to learn about the universe.
- We should use the money for food and shelter instead.

- We need homes more than spaceships and satellites.
- We need to see what is in space.

Use of Natural Resources:

- I think they should stop cutting down the trees.
- We need to save our environment.
- We need more air from the trees.
- People should take a little bit of the resources, but not a bunch, unless they recycle it.
- They shouldn't cut down rainforests, because we need the oxygen.
- We need trees to live. People cut them down for nothing.
- We should care more for animals and where they live.
- Animals need a place to live, and we shouldn't ruin our environment.
- People should use things properly and not waste things they have.
- We won't run out of them, if we use them properly.

Loss of Wildlife Habitat:

- Loss of wildlife habitat could result in more endangered species.
- We need to protect our animals.
- People should save trees, because they help us and the animals.
- The animals are living just like us.
- If we keep cutting trees, our animals will die.
- God made animals to live on earth, not for us to exile them from nature.
- Saving wildlife habitat would help us, because of the Circle of Life.
- People are building so many new houses that animals don't have any place to live.

Global Warming:

- I'm afraid that global warming could mean many changes.
- That's why we have summer.
- People should not worry about global warming.
- The world is hot enough.
- The atmosphere is colder.
- Our ozone layer is disappearing and heat is also getting trapped around us.
- Our air is fine and so is the global warmth. It is not that important.
- I like it warm.
- If the earth gets hot, ice caps melt, oceans rise, and there is less land.
- We need to stop pumping carbon dioxide into the air.

World Hunger:

- This is important because people don't deserve to starve when most people have food everyday.
- We need to donate more food to homeless people.
- A lot of families are poor and have a little bit to eat and they can die of hunger.
- People need food and good nutrition, so they can be healthy.
- The less fortunate should be helped to live longer.
- A lot of people die in other countries, because of hunger and wars.
- People shouldn't go hungry. We should feed homeless people.
- This is important because a lot of people are dying in Africa.
- People don't get as much food as they need in other parts of the world.
- There is enough food for everybody.
- There are too many people to feed.
- I think this is the most important thing, because all people in this world should be fed.

Human Health and Diseases:

- People need to be healthy to live longer.
- We need to learn information about diseases.
- We need to find cures for diseases like cancer and aids.
- This is really important, since many people die each year from diseases.
- We should all take care of ourselves to be healthier.
- People are drinking and eating the wrong things.
- We need more medicines.
- This is important because some diseases are contagious.

Solar Energy/ Alternative Energy Sources:

- The sun is really big. We wouldn't have to worry about it.
- This is important, because the sun shines almost everyday.
- We don't have enough power plants.
- The energy is important, especially the sun's, because it helps plants grow and feed other animals, which feed us.
- We need more energy. We are using too much of it up.
- We need more energy so that we won't have so many blackouts.
- If we used solar energy, it wouldn't make the air quality worse.
- This is a great way to get electricity.
- I think we should probably switch to solar energy to save oil.

Hazardous Wastes:

- This is important because people pollute rivers and oceans and it hurts out environment.
- People can get sick if we don't clean up hazardous wastes.
- It is dangerous to put toxic hazards in the trashcans.
- Pollution is a problem with oils and poisons getting into our oceans and lakes.

- We could bury it in a deep hole.

Acid Rain:

- Acid rain is dangerous and should be taken seriously. It can kill plants.
- Acid rain pollutes the water.
- This is not too important. Only some people can be hurt by the water.
- Acid rain is bad. It burns leaves and rots them.
- It can kill the trees and hurt wildlife.
- I think people should not put too much wastes in the water, so when it rains it won't be acid rain.

Transportation:

- More people should use bikes or walk instead of polluting the air.
- Not a problem; we have enough cars and already have trains and stuff.
- The pollution from cars is poisoning our air.
- The freeways and streets are crowded, but that is not too bad.
- There is too much traffic.
- It's polluting the earth, but we get there faster.

Ground Water Contamination:

- We need to be careful not to pollute water that we drink.
- People can get sick from drinking well water.
- Trash can get into our water supply.
- This is important because everybody needs fresh water to survive and be healthy.
- When it rains, wastes wash down into our water system and into our drinking water.
- Things we throw on the ground can get into our water and oceans.

Nutrition and Diet:

- People eat too much greasy food and it is bad for their health.

- We need to eat right to be healthy and live a long life.
- People should be able to eat whatever they want to.
- It is important to know how to get healthier.
- I think it is important because everyone eats junk food, and no one is healthy.
- If people don't eat right, they can get high blood pressure.

Endangered Species:

- We need to protect our endangered species more, or they will become extinct.
- People need to stop hunting animals, or we will only have a few types left.
- Animals that are endangered can't live if people keep taking their homes.
- We need animals to survive, but we shouldn't kill endangered ones.
- People should take care of our animals and not hunt them for their teeth or claws.
- They should keep endangered animals in zoos to protect them.
- Species deserve to live in their natural home.
- I don't want humans to be the only species on earth.

Pesticide Use:

- Pesticide use has a chain reaction that not only kills the bugs, but birds die from eating the bugs.
- Pesticides can hurt people.
- We don't have a bug problem.
- Sometimes people get sick from the things they spray on fruits and vegetables.
- We need to kill bugs that carry diseases.
- If it kills insects, it could hurt animals or us.

Water Resources:

- We need fresh water more than anything else.
- We need to be careful not to let anything get in our water.
- Because water is so important, we have to be careful

how we use it.

- All people, animals, and plants need water to survive.
- We need to conserve water.

Energy Resources:

- Energy is important so we are not in the dark.
- Energy is important, especially in California right now.
- We need more power plants.
- We need to save energy.
- We should use our energy wisely, because we don't want power blackouts.
- We should use the sun more for solar energy.

Deforestation:

- We need to save animals and their homes.
- Deforestation causes a loss of animals' habitat.
- Forests should be protected, because the trees give us oxygen.
- You shouldn't cut down trees, because later we might not have enough trees.
- We need cities, but we should save some of the forests and rainforests.
- Too many plants and animals are disappearing.

Recycling:

- We need to reduce trash and waste.
- We need to recycle to save money and resources.
- Landfills are filling up, and if we recycle we can keep the world cleaner.
- We really need to recycle or in the future we will have no place for our trash.

APPENDIX C:

RESULTS OF STUDENT RANKINGS OF SCIENCE,

TECHNOLOGY, SOCIETY ISSUES

CLASS A: FEB. 8, 2001

Population Growth	Air Quality	Space Exploration	Natural Resources	Wildlife Habitat	Global Warming	World Hunger	Health & Diseases	Solar Energy	Hazardous Wastes
13	7	20	19	16	18	4	1	17	10
13	3	19	16	4	2	5	12	18	8
			9				1	6	
13	5	20	6	1	18	2	3	19	7
6	20	19	10	8	7	9	11	1	13
8	1	6	18	12	19	2	11	15	10
17	3	18	2	15	4	9	8	13	7
3	6	4	14	18	17	7	1	5	16
5	10	2	17	12	16	1	8	19	9
7	2	19	3	1	6	5	8	10	13
20	9	18	11	6	15	17	10	14	12
		20				1	2		5
6	7	9	5	10	12	20	17	1	18
17	5	9	18	3	2	1	5	18	15
20	17	18	1	2	5	3	4	9	10
14	13	15	6	7	4	3	9	2	18
17	12	20	3	2	16	4	5	14	6
18	11	20	16	5	17	5	8	15	10
20	1	18	5	9	10	3	2	11	7
10	1	8	9	5	11	4	13	14	12
17	4	20	11	10	6	5	16	1	7
20	10	19	12	3	13	1	11	12	8
12	11	9	10	8	17	4	3	7	18
15	3	16	2	4	8	5	15	19	20
2	1	20	3	6	12	13	9	5	10
19	8	20	14	3	17	7	2	18	16
13	7.1	15.4	9.6	7.1	11.3	5.6	7.5	11.3	11.4

Acid Rain	Transportation	Ground Water	Nutrition & Diet	Endangered Species	Pesticide Use	Water Resources	Energy Resources	Deforestation	Recycling
10	20	9	17	1	6	14	15	7	11
	7	8	3	10		4	5		2
15	14	8	17	4	16	9	10	11	12
12	17	15	14	18	16	4	3	5	2
7	16	9	20	13	14	3	4	5	17
14	19	15	20	1	16	10	5	6	5
10	19	12	2	15	13	12	11	9	11
15	7	8	18	11	20	6	3	18	20
12	20	13	17	15	14	11	18	4	4
4	16	9	19	1	7	2	13	8	16
11		5	4		14	3			3
10	13		4	15	16	2	8	19	
11	17	16	15	7	13	4	13	14	3
20	14	6	7	8	12	19	15	16	11
7	19	6	5	11	18	17	10	12	12
13	19	8	15	1	14	10	11	9	1
12	19	8	7	4	17	1	2	3	13
20	14	9	19	8	16	4	6	16	12
19	3	13	17	6	13	2	18	19	15
14	15	15	8	9	12	2	14	18	7
20	15	3	13	7	16	5	6	4	12
11	2	9	14	15	7	5	6	13	2
19	16	19	13	10	14	1	9	11	1
15	18	12	16	4	9	7	8	11	6
9	13	17	10	1	14	5	6	12	15
	8	11	3	2		11	6	12	4
12.9	14.4	10.5	12.2	7.9	13.6	6.7	9	10.9	8.7

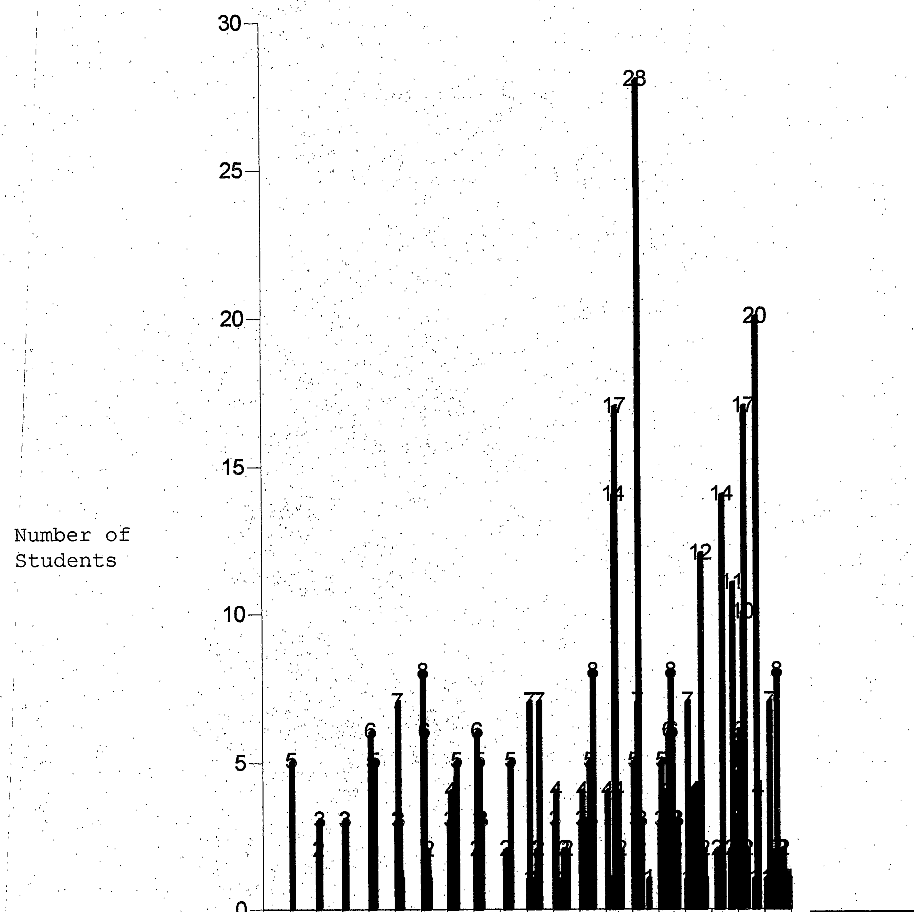
CLASS B: FEB. 8, 2001

Population Growth	Air Quality	Space Exploration	Natural Resources	Wildlife Habitat	Global Warming	World Hunger	Health & Diseases	Solar Energy	Hazardous Wastes
6	2	20	7	15	4	1	9	19	11
3	8	10	16	17	7	4	2	19	1
7	13	17	18	16	6	1	4	11	8
6	14	15	1	7	20	4	11	12	17
11	13	19	9	2	14	3	4	15	5
10	6	17	18	8	1	12	13	4	11
7	4	13	5	6	16	7	1	8	15
20	5	18	12	4	14	2	3	17	16
1	2	14	15	8	19	4	5	9	17
15	6	19	16	5	18	1	2	14	7
5	6	2	14	13	2	7	8	10	9
20	19	18	9	8	17	7	1	16	12
15	6	19	16	5	18	1	2	14	7
4		3			2	1	9	7	5
7	19	13	12	11	10	18	4	20	9
18	6	17	16	4	15	2	1	15	12
12	7	11	13	14	8	1	4	18	3
20	19	18	17	1	2	3	4	16	14
18	1	19	2	3	4	5	6	7	8
11	2	6	16	4	8	1	7	15	5
12	13	15	1	2	17	3	4	14	16
19	3	20	4	6	16	19	9	18	15
12	2	3	13	4	14	5	15	16	17
17	1	10	14	18	6	3	5	4	19
11.5	7.7	14	11.5	7.9	10.8	4.8	5.5	13.3	10.8

Acid Rain	Transportation	Ground Water	Nutrition & Diet	Endangered Species	Pesticide Use	Water Resources	Energy Resources	Deforestation	Recycling
20	9	8	7	13	16	12	11	14	2
6	18	1	7	8	9	19	20	10	11
12	14	11	7	5	10	13	1	8	2
18	19	6	11	10	5	7	8	9	20
9	18	10	13	12	19	17	14	3	20
9	20	10	17	11	12	13	14	15	16
13	15	8	7	5	9	10	11	6	12
5	19	6	2	17	9	16	10	15	20
11	7	8	14	3	9	13	5	10	19
3	14	15	16	5	17	2	6	8	1
8				10			6		11
8	20	9	10	3	11	4	13	12	17
11	15	14	13	2	6	5	10	4	3
11	3	4	1	15	17	19	18	16	20
8	20	9	10	3	11	4	13	12	17
10	11	18	16	3	13	12	7	6	20
6	13	9	10	7	19	1	8	15	20
9	14	17	12	18	19	3	2	10	11
5	15	10	14	2	9	19	20	3	16
10	18	6	11	1	12	7	8	17	16
19	10	9	18	13	16	3	5	8	2
10	15	5	20	19	12	2	14	9	3
11	14	9	12	18	6	5	13	15	20
10	8	16	12	13	17	3	5	18	14
10.1	14.3	9.5	11.3	9	12.3	9.1	10.1	10.6	13

APPENDIX D:

FREQUENCY OF STUDENTS' PERCEPTIONS OF SCIENCE, TECHNOLOGY, SOCIETY RELATIONSHIPS



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. pop growth		5	2	3	6	3	8	3	2		1	3	3	4	5	3	1		6	1
2. air quality			3	3	5	7	6	4	6		7	4	4	1	3	5	7		4	1
3. space exp.						3			3											
4. natural resources					5		1		5	2			3		7		1	2	1	7
5. habitat loss						1	2	1	3		1				2	4			1	1
6. global warming							1		3		1	1	2		2	1		1	2	
7. world hunger								5				1	2	1	3	2	4		2	
8. health & disease										5	2	2	5	1		6	4			1
9. solar energy											2						2	1		2
10. hazardous wastes											7		3	4		8	1			8
11. acid rain												2	8			6	4			
12. transportation														2						
13. ground water															1	3	1		1	2
14. nutrition																2				
15. endangered species																3	2	2	2	2
16. pesticides																	1		4	
17. water resources																		1		1
18. energy resources																				
19. deforestation																				1

RELATIONSHIP OF STS ISSUES WITH EACH OTHER

APPENDIX E:

STUDENT RESPONSES ON WHERE THEY LEARN INFORMATION ABOUT SCIENCE, TECHNOLOGY, SOCIETY ISSUES

These are representative responses from student surveys on where they learned about the STS issue.

Population Growth:

- I saw it in the newspaper, in the Saturday morning Daily Bulletin.
- It was on the news.
- On the news on TV. They were talking about the census.
- From my mom and dad.

Air Quality

- I hear about the smog on the news at night.
- I see the polluted air.
- We need good air and people have polluted it. I've seen it.

Space Exploration

- We learn about this at school.
- My parents talk about this.

Loss Of Wildlife Habitat

- I've been reading books on animals at school in the library.
- From animal shows on television.
- I learned about this last year in 4^{th} grade. We learned that if we lose plants and habitat, we could lose some cures for cancer.

World Hunger

- My parents have talked about this.
- On B.E.T. TV and on commercials.
- I watched it on the NBC News.
- It was on the news. It is bad that people have to die of starvation.

- People are starving. I saw it on a TV commercial.
- Without food people will die and I see this on the TV to donate.
- I heard about this at church.
- My grandmother is from Viet Nam and she said that because of all the wars people starve. Wars also cause human diseases.
- From commercials about little poor kids.

Human Health And Diseases

- It's on the news and on commercials.
- I watched it on the news.
- It is on the news. People should have a healthy life.
- There are commercials about human health and diseases.
- We need cures for diseases. I see this on the news and commercials.

Hazardous Wastes

- I saw commercials on TV about hazardous wastes.
- In the newspaper and on TV on "The Simpsons."
- I hear about hazardous things in DARE.

Ground Water Contamination

- I learned about this in the sad movie Erin Brockovich.
- I saw this in the movie about Erin Brockovich.

Nutrition And Diet

- I hear it a lot on commercials.
- My mom said we always have to watch what we eat.
- My parents talk about this.

Endangered Species

- We learned about the poor animals in 3rd grade.
- I watch animal shows on TV, especially Animal Planet.
- We learn about animals in school.
- There were articles about it in the newspaper. They might try to clone endangered animals.

- Animals are very important. I see this on the news and in the movies.
- I heard on Animal Planet that people are killing sharks for luxuries.
- I learned about this in science movies on TV and at school.
- TV- animal shows

Water Resources

- On the news
- I hear about it from my parents. They say not to waste water.
- We talked about it at school. We made posters for the water contest.
- We need good water to drink. I learned this at school.

Energy Resources

- It's on the news every night.
- I heard it on the NBC News and Nightly News.
- My parents talk about it. They say not to no waste electricity.
- I heard about this in the newspaper, from my parents, at school and on TV.
- I learned this from the news and from my family. We had a blackout and couldn't cook the dinner.
- I learned about this at school and at home when we had a blackout while we were at the mall.

Recycling

- We recycle our lunch trays at school and we recycle at home.
- We studied it on Earth Day last year.
- Reduce, Reuse, Recycle is on a lot of commercials.

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