A STUDY OF HIGH SCHOOL BIOLOGY STUDENTS ENGAGED IN A SCIENCE-TECHNOLOGY-SOCIETY (STS) LANDFILL RESTORATION PROJECT

by

Beatrice Dietering Taylor

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APPROVED:

George E. Glasson

G. E. Glasson, Chairperson

Jerome A. Niles

J. A. Niles

Jan Nespor

J. K. Nespor

Thomas G. Teates

T. G. Teates

John Cairns, Jr.

J. Cairns, Jr.

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Committee Chairperson: George E. Glasson
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(ABSTRACT)

The purpose of this study was to observe high school students as they progressed through a Science-Technology-Society (STS) project that involved the closing of a landfill. In this STS project, students investigated the best vegetation for reseeding a closed landfill. This project was initiated because a highway was to be built across the landfill to Explore Park. The director of Explore Park requested an experimental vegetation instead of the standard vegetation mixture. He wanted a vegetation that was aesthetically pleasing and environmentally acceptable.

The study investigated the involvement of students in the construction of knowledge of local environmental issues. Students shared their perceptions about the STS process through interviews, journal entries, a questionnaire, field notes, and written artifacts. All data were transcribed and coded for themes. Ethnographic methods were used to tell this story in twelve vignettes.

The results of this study are important because they show how educators can use local issues to build classroom curriculum. Students became actively involved in the learning process as they advanced through identified STS instructional goals. The first

goal was the *Foundations Level.* Basic content associated with landfill management and revegetation issues were introduced. Facts about garbage and the need for reducing, reusing, and recycling were investigated. The second goal was the *Issue Awareness Level.* This goal included becoming involved, identifying the players, and investigating values and beliefs. The third goal was the *Investigation and Evaluation Level.* Students were exposed to concepts and strategies necessary to investigate and analyze the issues and evaluate alternative solutions. This level encompassed designing plant experiments. The fourth goal was the *Citizenship Responsibility Level.* Students were introduced to strategies necessary for making responsible decisions concerning solutions to the issues.

The conclusions of this study suggest that for many students, the teaching of science through local technological and societal issues allowed them to become actively engaged in the learning process. Students who took ownership of their investigations created opportunities to enhance self-esteem, made connections, and enhanced their knowledge of scientific investigations and scientific content in the context of real life issues.

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I want to express my appreciation and gratitude to Dr. George Glasson who chaired my dissertation committee. As my advisor, Dr. Glasson helped me grow into a professional science educator. He helped to construct my program of studies so I received the necessary undergraduate science courses. He encouraged me through my freshman year of chemistry. He supported me as I tried to discover who I am, and for that, I thank him.

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A STUDY OF HIGH SCHOOL BIOLOGY STUDENTS ENGAGED IN A SCIENCE-TECHNOLOGY-SOCIETY (STS) LANDFILL RESTORATION PROJECT

Introduction

This is the story of a journey of twenty high school biology students and three adults as they progressed through a Science-Technology-Society (STS) study in landfill restoration. In this study, we investigated and designed experiments to determine the best vegetation to plant on a closed landfill. Students researched designs, closing procedures and problems involving landfills. We also interacted with community groups who had a stake in the closed landfill. Unlike most units taught in school, no one knew where this unit would lead. The adults constructed knowledge and learned to work collaboratively at the same time the students constructed their knowledge and learned to work collaboratively. The purpose of our journey was, in the words of one student, "to accomplish the task that was set before us -- [that of] making a difference."

We think we *did* make a difference. As you read the stories of the students working together in the Stories of the Field chapter and the students' own perceptions of the study in the *Analysis and Reflection* chapters, you will hear them proudly tell how: (1) they hoped their plant studies impact species selection for revegetation of the landfill; (2) working for the good of their community bettered their environment; and (3) their work might provide a foundation for other groups who might also wish to study landfills.

This project was designed to be an STS case study so that students could assist in the selection of species for landfill revegetation. The case study activities we did were issue-specific and tied into the viability of plant species on the landfill. As is characteristic of a case study (Ramsey, 1989), we established boundaries on the topics the students investigated: erosion, aggression, viability, and rooting depth. However, we did allow them flexibility in experimental design and choice of species for investigation. Students were aware of the standard and experimental mixtures, but could choose outside those mixtures what species they wanted. For example, even though trees are not allowed on landfills in Virginia, two boys from Patrick Henry High School (PHS) chose to do an independent study to investigate the growth of trees in landfill soil. The boys discovered their tree choices did not survive in landfill soil.

This study was done in two phases. The first phase was a pilot study completed in the spring of 1993 with the students from PHS. The second phase began the following fall and concluded in the spring of 1994. In this phase, students in a science class from the Governor's School were the main focus of this STS case study.

This story is about students who try to make sense of an STS problem while trying to help Mara, a biology master's student. Mara's job was to investigate and recommend the best plant species for revegetating the local landfill which was closing. Normally, a standard vegetation mixture is planted, but the landfill's location made it different. A highway spur had been approved to be built across the landfill to Virginia's Explore Park. The director of the park wanted a vegetation planted that met EPA closure regulations but was also aesthetically pleasing to tourists who enter the park. Under the guidance of Mara and the classroom teacher, students in this study learned about the social issues involving landfills; the opening, closing, and monitoring of landfills; the designing of plant experiments; and the presentation of information.

The findings of this study are related to the STS instruction categories as defined by Rubba (1987a,1990) and Rubba & Wiesenmayer (1988). These categories are:

(1) STS foundation activities and issue awareness activities

(2) STS issues investigation skill instruction

(3) STS issue action skill development activities

(4) Opportunities to apply STS investigation skills and action strategies

Each category will be described and the activities and student perceptions will be told to take the reader through the STS study as experienced by the participants.

In chapter I, "Science-Technology-Society," I will discuss the STS framework in science education as it pertains to landfill restoration, science literacy, STS instructional goals, problem solving, and collaborative learning. In chapter 2, "Methodology," I will discuss the ethnographic approach used to investigate the collaborative learning of the students, scientist, teachers, and myself. This chapter will include a description of the phase I pilot study and the changes in design which influenced the phase II investigation that took place during the 1993-1994 academic year. Included in the Methodology is a detailed discussion of student documentary materials and the analysis of data.

In chapter 3, "Stories of the Field," the story of students involved in a landfill restoration project will be told through a series of vignettes. These stories will be analyzed in chapter 4, Analysis, in relation to the STS instructional goals and students' perceptions of collaborative group activities.

Finally, in chapter 5, Reflections, the voices of the primary players involved in the project will be heard as they reflect on their learning about STS investigations. These players include the classroom teacher, scientist, students, and myself, the educational researcher.

As readers journey through this STS study, they will realize the vignettes are told in first person. This shift in voice from third person occurs so that readers are drawn into the classroom situation to feel the dynamics of the interaction. When writing the vignettes it was necessary to use descriptor words such as "teasing, patronizing, sarcastically, jokes, annoyed, and pesters." It is important to understand that these perceptions are mine and are based on tone or inflections of the voices from the audio tapes and my knowledge of the students. I felt it was important to include these descriptors for the reader to understand the dynamics of the various groups. Readers will also get a glimpse of the entire class through the sharing in the room or reflections written by the students. By the end of the story the personalities of several tables will be well known because of the audio transcriptions that have been shared. This is not just *my* story; it is also the students' and teachers' stories, because without them it would have never happened.

The journey was a delightful one. Many new friends were met, and things were seen differently through the eyes of the high school students. Being a learner beside the students was not the frightful experience always imagined. It was also shown that students, when challenge and helped to see the relevance of a project, soar *far* beyond where teachers ever imagine!

CHAPTER 1

SCIENCE-TECHNOLOGY-SOCIETY

Prior to this study, I knew little about the STS framework, landfills or landfill restoration. Although I am an experienced classroom teacher, I had not articulated my theoretical views on collaborative learning, science literacy, or problem solving. The readings in this chapter focus on these topics as they relate to this study. Literature will be reviewed in the areas of Science-Technology-Society projects, landfill restoration, science literacy, problem solving, and collaborative learning to show their importance to this study.

Science-Technology-Society Framework

As our world becomes more technologically oriented, we realize we have often paid a price for it in natural resources. It is noted as science advances through technology, the impact on society increases. For students to understand and operate within this growing complexity, NSTA introduced a position paper, "Science-Technology-Society: Science Education for the 1980's." It states:

> The goal of science education during the 1980s is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision-making. Such individuals both appreciate the value of science and technology in society and understand their limitations. (Yager, 1988, p. 17).

The STS movement is based on the principle of constructivism. According to Glasson & Lalik (1993), in constructivist classrooms, "students must identify and test their existing understandings, interpret the meanings of their ongoing experiences, and adjust their knowledge framework accordingly" (p. 188). Students did this last fall when they took the field trip to the landfills and listened to Jared Crane and Catherine Whitlaw explain closing and monitoring procedures. One student understood the importance of baling at the old landfill and tried to integrate that knowledge with her new information of why they were not baling at the new landfill. Aldridge (1992) states that students do this construction by creating and examining solutions to problems that affect them or their surroundings. The new information is interpreted and then integrated into that which is already known (Dana, Lorsbach, Hook & Brisco, 1992). For science to be learned, one must construct knowledge, identify problems, work out solutions cooperatively, and examine current knowledge for its viability.

Jenkins (1992) says there is no longer the traditional question of "is it good science," but rather, for whom is it good? (p. 232). Because of our exponential population growth during the twentieth century and our ability to transect the globe quickly, there are no longer *your* problems and *my* problems, but *our* problems.

Brunkhorst and Yager (1990) look at exemplary STS programs as identified and recognized in the NSF/NSTA Search for Excellence Program. They find that these outstanding programs are not limited to schools by size, location, or instructional level. Upon examination of these programs, the authors note that most have the following common characteristics:

(1) They emphasize science for all students

(2) They emphasize higher order thinking skills across content areas

(3) They are interdisciplinary in nature

(4) They are hands-on, student-centered, minds-on programs

(5) They include student action plans, projects, field experiences and field research

(6) They utilize many outside resources

(7) They tie STS issues to the traditional content of the course

(8) Evaluation tends to be structured very differently

(9) Evaluation includes awareness and reasoning components

(10) Tests are often designed to assess a variety of domains

(11) Students do as well as (if not better than) students in typical science courses when using standardized tests and/or textbook tests

According to Yager (1989), there are several positive outcomes by students in STS programs. He finds that students in STS programs:

(1) Demonstrate the ability to relate learning to new situations

(2) Understand the relevance of science processes to daily living

(3) Develop an interest in refining and developing those skills for further learning

(4) Carry and improve attitudes toward science across grade levels

Yager (1989) also discovers that students who are involved in STS studies have their curiosity "piqued" which gives rise to unique questions. These questions and original ideas, explains Yager, excite both the teacher and their peers.

One of the strengths of the STS program is that students are encouraged to investigate *local* issues relating to science and the environment. This promotes learning as "real, relevant, tangible, and interesting" (Ramsey, 1993). Students identify with the issues and take ownership of their solutions. Local issues can be followed by reading papers or watching television. Students have the opportunity to visit environmental sites, or participate in local meetings where differing points of view are debated.

Assessment of a curriculum that is integrated and performed without paper and pencil requires creativity. Teachers will be more active in constructing their own forms of assessment. Students should be able to use the information in new settings and identify related but divergent practices from a given situation. They should also be able to choose relevant information for solving a specific new problem and take appropriate action based on the new information provided (Brunkhorst & Yager, 1990). Teachers may use as part of their assessment, portfolios, scrap books, comic books, or home videos which are designed and assembled by the students to demonstrate their knowledge (Collins, 1992; Dana et al., 1992). It is important for the teacher to realize that "all students do not have the same knowledge, even though they all 'studied' the same topic" (Dana et al., 1992). Each student has different information they deem important and relevant. Assessment should continue to be a learning process with evaluations being done by the teacher, the student, and fellow classmates.

STS Investigative Sequence

The National Science Teachers' Association (NSTA) introduced a position paper in the 1980's on STS in which they stated that the purpose of science education was "to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision-making" (Yager, 1988, p. 17).

Studies were done in the 1980's using environmental education as a basis for teaching responsible environmental behavior (Sia, Hungerford, & Tomera, 1986). Hungerford, Peyton, and Wilke (1980) proposed a set of goals they felt would foster and encourage citizens to become involved in science-technological problems of society. Rubba and Wiesenmayer (1985;1988) took these goals, clarified them, confirmed the important of societial responsibility, and developed 53 learner competencies for secondary science instruction in Pennsylvania. STS literature today most often refers to Rubba and Wiesenmayer's (1985) four goals when talking about "STS instructional goals, or levels." Rubba and Wiesenmayer (1988) postulate that citizens who are involved in these four goals will become informed and environmentally active. The four STS Instructional Goals according to Rubba and Wiesenmayer (1988) are:

Goal I: STS foundations level

Students should gain a knowledge of the concepts in the natural and social sciences and the nature of science and technology. The characteristic interaction among science, technology, and society should be understood so informed decisions can be made. Rubba

(1990) states that foundation activities should give students a basis concerning the character of science and technology within the society so knowledge can be built. Ramsey and Hungerford (1989) refine this goal and state that the learner should obtain not only a broader knowledge about science, technology, and societial issues, but also knowledge associated with the specific issue in question.

Goal II: STS awareness level

Students will investigate how science, technology, societial interrelationships result in issues to be examined. All sides of the issues are to be examined. The issues as associated with the society's beliefs and values are to be examined, being aware of the effects of religion politics, economics and personal interest. Students will explore alternate solutions for a resolution to the issue.

Goal III: STS investigation level

Students will develop knowledge and skills which allow them to examine and investigate the issues. They will collect and interpret data. These data will be used to draw conclusions and make inferences. Consequences will also be predicted. Students will communicate their data through written or oral reports. As students work toward possible solutions, they will judge the feasibility of such resolutions with respect to the player's various value positions.

Goal IV: STS action skill development level

It is at this level that skills are developed so that students may take action, if they so choose. Students have the opportunity to work toward the resolution of the issue and evaluate its effectiveness. Students will determine whether the action to be taken is that of legal action, physical action, political action, or consumer action. Students also need to assess the consequences of the action they have chosen toward a resolution of the issue. The effectiveness of the actions need to be assessed and possible modifications made.

Importance of STS Instructional Goals

Studies from Sia, Hungerford, and Tomera (1986) show that citizens who demonstrate responsible environmental action have certain characteristics. They are: (1) knowledge of environmental issues, (2) knowledge of strategies that could be used to solve issues, (3) the ability to act on issues, and (4) particular personality characteristics that allows one to act. These first three constructs can be addressed in the classroom. What happens when teachers involve these components in their teaching?

Ramsey, Hungerford, and Tomera (1981) did a study that consisted of three treatment groups of eighth grade students. The first group had classes that included: (1) environmental foundations and (2) awareness of environmental issues. The second group had classes that included the topics of the first group, and added (3) issues investigation and (4) action instruction. The third group was the control and received life science instruction. Ramsey's et al. (1981) findings were that group two, which had the opportunity to investigate issues *and* act on them, showed "statistically significant higher levels of overt environmental action" than did the other two groups (p. 42). According to Rubba and Wiesenmayer (1988), Ramsey did a follow-up study of these participants three years later and discovered that the group differences in overt environmental action continued.

Landfill Restoration

Science-Technology-Society issues include man's use of the land and it's effect on the environment. Often this use has resulted in abuse of the environment. What are some of the factors that have contributed to this abuse? Exponential population growth is one. It has been estimated that the global population is increasing at approximately 92 million persons per year (Cairns, 1993). People must have a place to live and enough room to grow food for their families. Wetlands are being drained for development and forests are being cut for timber (Cairns, 1993a; Lovejoy, 1988). As a result, we are experiencing a lack of biological diversity because of these losses (Lovejoy, 1988). Cairns (1988) warns "that it is probably not an exaggeration to say that much of the planet is occupied by partially or badly damaged ecosystems"(p. 342). Lovejoy (1988) declared that we need to develop by 1998 a global environmental policy if we expect to enjoy our natural resources on a long-term sustained-use basis. Without some system or standards, he warns, we will see the loss and use of our forests and aquatic environments.

The result of our exponential population has been exponential garbage. Americans produce approximately 160 million tons of garbage a year. What are we going to do with our garbage? By 1992, one-third of our existing landfills were full; by 2010, four-fifth's of them will be closed (Grossman & Shulman, 1990). O'Leary, Walsh & Ham (1988) found that from 1981 through 1986, there were only 563 new landfills opened...a 35% decrease from the five-year period a decade earlier.

In addition to the lack of space for landfills are concerns for their byproducts: methane gas and leachate. Methane gas can seep to the surface, reduce the oxygen in the soil and poison the roots of the vegetation (O'Leary, et al., 1988) . Without vegetation, there is erosion (Duell, Leone, & Flower, 1986). Leachate occurs when water penetrates the landfill. The water becomes acidic because of various chemicals that may be in the garbage. Organisms that cannot tolerate these high acidic levels die, thus altering the immediate ecosystem (Nebel, 1990).

Population growth, solid waste problems, methane gas and leachate are words many people know. However, there is less understanding about the word, "restoration." According to Cairns (1991), restoration is "an attempt to return a disturbed ecosystem to a former natural condition". We need restoration projects because we are running out of land to support our expanding population. We have upset the ecological balance of nature through destruction of our natural resources. Landfill restoration projects are needed because in 1988 it was estimated that by 1993, we would close 1,200 landfills nationwide and the citizenry must decide what the land use will be (O'Leary, et al., 1988). Cairns (1993b) states we have three possible options in dealing with our ecosystems:

(1) continue as we are now in which the rate of destruction exceeds the rate of restoration

(2) develop restoration projects to equal the rate of destruction

(3) have the rate of restoration exceed the rate of destruction

This study hopes to bring students' awareness to the need to develop restoration projects to meet or exceed this rate of destruction. How can we restore landfills?

There are several unique landfill restoration projects that have been successful across the United States. At Belleville, Michigan (Logsdon, 1989), methane gas is being extracted for commercial heating purposes. Located there also is a hydroponic greenhouse which has returned the investment of $500,000 its first year through the sale of herbs. At Riverview, Michigan, they have made a ski slope from their landfill. They also extract methane gas for heating purposes. In Palm Beach County, Florida, they have constructed wetlands from a 450 acres landfill (Hess, 1992). In addition, Hess explains how San Francisco has shown its creativity through sculptures and designs atop their landfill!

How does one explain the values of landfill restoration to policy makers and the general public? One of the problems in dealing with anything on a large ecological scale is time. We are a nation of instant gratification...microwave meals, credit cards and modular homes. Young adults of today are likely to be unaware of the impact their lifestyle choices have on the environment. Some may feel "I'm just one person, what can I do?" However, there are students who are greatly concerned and eager to be actively involved in creating a better world in which to live. In reviewing the literature, several curriculums have been developed for schools to study waste management (Washington State Environmental Education, 1985; Ramsey, Hungerford & Volk, 1989). However, most curriculums only include topics concerning the three "R's"---reuse, reduce, and recycle. No curriculum addressed the issue of restoration once a landfill is closed. It is important to bring the public to an awareness of the issues surrounding landfills, their impact on the ecosystem, and the necessity to restore these lands.

Science Literacy

Recent discussions regarding scientific literacy have implication for students' learning about environmental and technological issues. It is important students become scientifically literate so they are able to function in a world that is dominated by technology and issues relating to the use of technology. Students in this study will enhance their scientific literacy through activities of this STS project.

What is science literacy? Most definitions included common descriptors: (1) an understanding of the natural world, (2) man's involvement with technology, and (3) social responsibility. Researchers use these terms when explaining their view of literacy. Hurd (1992) describes science literacy as being able "to understand the interactions of science and technology as they influence human experience, the quality of life, and social progress" (p. 1). Literacy, according to Jenkins, (1992) "is about creating new knowledge or...restructuring, reworking and transforming existing scientific knowledge" (p. 236).

Yager (1989; 1991a) describes one who has scientific literacy as being able to think logically, having an interest in continued learning, appreciating the value of science and technology in society and understanding the limitations of science. A scientifically literate person considers the political, economic, moral and ethical aspects of science and technology as they relate to personal and world concerns, and offers explanations of natural phenomena that may be tested for validity. Ost and Yager (1993) assert that the society of the future will function heavily on technology and will be propelled by science. Will we be able to accomplish this? Hazen and Trefil (1991) document that fewer than seven percent of American adults have enough science understanding to be classified as scientifically literate. Students, as they engage in this STS study, will be exposed to scientific understandings they can use as citizens in their society.

Why do Americans need to be scientifically literate? Hazen and Trefil (1991) assert that national debates are becoming dominated more and more by scientific and technological issues. They say being able to comprehend these debates is becoming as important as being able to read. According to Ramsey (1989), it has been estimated that 98% of the students in school will not become scientists and engineers. However, that should not diminish our emphasis on science. He states,

> All students will become citizens, consumers of the products and services of science and technology. All will assume and be responsible for the benefits and the risks of scientific and technological knowledge, products, systems, and services. All will be decision-makers concerning matters of science and technology, either willfully via participation in democratic decision-making or apathetically via the lack of such participation (p. 40).

It is important for students, as citizens, to understand the balance and inter-connectedness of science if they are to protect and gain the most efficient use from its services.

It is estimated that students in school now will probably have an average of five careers during their lifetimes, and they must prepare for jobs that do not even exist today (Dung, 1989). Citizens are going to have to be prepared to deal effectively with science-related social issues, develop a sense of responsibility and realize that they have inherited the guardianship of the natural world (Harms & Kahl, 1981; Ramsey & Hungerford, 1989).

How are we accomplishing these goals? One way is through Science for All Americans, also known as *Project 2061* (American Association for the Advancement of Science, 1993a). According to Rutherford & Ahlgren (1990), Phase I of *Project 2061* was to "define the knowledge, skills, and attitudes all students should acquire as a consequence of their total school experience...." (p. 204). What knowledge, skills, and attitudes do we deem important for students to know? Phase II, which is currently in process, "...is to produce a variety of curriculum models that school districts and states can use as they undertake to reform the teaching of science, mathematics, and technology" (p. 205). What method [or methods] will we use to insure that students have the knowledge, skills, and attitudes of science? In Phase III, there will be a collaboration "...with scientific societies, educational organizations and institutions, and other groups involved in the reform of science, mathematics, and technology education in a nationwide effort to turn the Phase II blueprints into educational practice" (p. 205). Once methods have been determined, how are we going to implement them? The project is already in classrooms in California, Iowa, and Houston, with plans underway for Puerto Rico and North Carolina (Cullota, 1990).

A second major project was launched in 1989 by the National Science Teachers Association called *Scope, Sequence, and Coordination.* This program intends to address curriculum reform by coordinating the sciences in a sequenced delivery (Ramsey, 1993). Students in grades 7-12 will be heterogenously grouped and have classes in physics, chemistry, biology, and earth and space science several hours every week every year (Aldridge, 1992). Whereas *Project 2061* is a long-term reform for K-12 for improvement of science literacy, *Scope, Sequence, and Coordination* is a short-term restructuring of curriculum for the improvement of science education.(American Association for the Advancement of Science, 1993b) Projects are being located in Puerto Rico, California, Texas, Iowa, North Carolina, and Alaska (Aldridge, 1992).

A third project, the *National Science Standards*, was established in 1991 and is supported by the National Research Council (NRC). This project addresses the need to take the goals from *Project 2061*, *Scope, Sequence & Coordination*, state science frameworks and science standards from other countries and produce Science Framework Summaries (National Research Council, 1993). From this framework, the council hopes to have in place by the end of 1994 a means for judging science curricula, teaching, and assessment across America.

Problem Solving

One purpose of participating in an STS project is to give students the opportunity to improve their problem-solving skills. Barba (1990) states that helping students to become good problem solvers is "the most important product" of an educational system. She postulates that the ability to be a good problem solver has often been regarded as evidence of one's level of education. Barba also acknowledges that even though problem solving skills are often seen as the goal of education, these skills are difficult to define. In order to solve a problem, one must describe what it is. Webb and Ost (1978) state that students need to investigate problems that are real to them as based on where they live, their experiences, or their knowledge. Problems become real to the students only when they perceive that the problem is real (Ost & Yager, 1993). When problems are relevant to the learner, solutions become genuine, and students take an interest in them (Ost & Yager, 1993). How do students proceed to solve problems?

Ost and Yager (1993) state that problem solving is a "search for real alternative solutions" (p. 286). Barba (1990) describes it as a situation in which the means for attaining a goal is blocked so that other alternatives must be investigated. According to Gabel (1989), for one to solve a problem, one must understand the language of the problem, the information the problem gives, and what the problem wants to know. Not only must students have a knowledge of these skills, they must also have the opportunity to practice solving problems in order to be good problem solvers (Barba, 1990). As success is experienced, Ost and Yager (1993) declare that these students will gain a "unique self-confidence" in themselves and their problem-solving abilities (p. 286). Science literature endorses the process of problem-solving skills, but are science educators promoting these in their labs and lectures?

Problem solving in science labs

Snider (1989) did a study in 1966 of 17 classes in physics in which he looked at the verbal communication of the teachers. In lab, where one would expect greater problem-solving skills to be encouraged, Snider found that there was more one-way information, directions, and criticism than in the classroom. He also noted that there was less praise, acceptance of student ideas, and questioning during these labs. Snider explains that these findings are characteristic of the "verification labs" done in the 1960's, and he maintains they still continue at the time of his writing. Snider (1989) notes that P. F. Brandwein calls these labs, "problem *doing*" rather than "problem *solving*." This is because, he contends, the solution to the problem is already known. Snider (1989) states that even though "problem doing" may facilitate the development of concepts, it does little to develop problem solving skills. Ost and Yager (1993) believe that "classical" lab experiments are generally designed to have a single correct explanation. However, teaching where the answer is already known is not compatible with problem solving processes if students are led to believe there is only one right answer (Ault, 1989). Woods (1989) asserts that teachers should be facilitators and coaches, not lecturers and providers of information if they are to develop in students problem solving skills. The role of the teacher, according to Ault (1989) is to bring about a disequilibrium in the student. This disequilibrium causes the student to examine his/her personal beliefs and initiate problem solving (Ost & Yager, 1993).

Problem solving methods

Over time, teachers have tried many problem solving methods. According to Barba (1990), there have been:

(1) osmosis -- students will absorb "how to" if they are in a problem solving environment

(2) memorization -- students memorize facts and concepts

(3) imitation -- teacher is the modeler

(4) cooperation -- multiple minds can come up with a solution

(5) reflections -- students think about how they solved the problem

Many of these plans are still being used. Barba (1990) agrees that students need to be given a method for problem solving to be successful. Smith (1989) states that successful problem solvers tend to break down the process into several steps. Barba (1990) writes that George Polya has identified four basic steps to successful problem solving. They are:

(1) Understanding the problem to be solved

(2) Devising a plan for solving the problem

(3) Carrying out the plan for solving the problem

(4) Looking back to reflect on the process

Even with a method, practice appears to be a key ingredient to perfecting the process (Barba, 1990). Woods (1989) postulates that "knowledge and problem-solving are intimately connected" (p. 97). He states that how one learns determines how one organizes, retrieves, and creates representations of knowledge. In addition, storing information in memory helps determine how efficient one is as a problem solver. When information is placed in memory in an organized fashion, retrieval is easier. If information is placed in memory in a haphazard fashion with no links to existing knowledge, retrieval becomes more difficult, making problem-solving less successful (Barba, 1990).

According to Barba (1990), mathematics educators place problem solving in three categories. They are: expositional, guided discoveries, and open inquiry. In *expositional* problem solving, the student is given the problem, the way to solve it, and the solution. In *guided discovery* problem solving, the student is given only the problem. S/he is not given the way to solve it or the solution. The *open inquiry* problem solving is similar to conducting scientific research. The student is not given the problem, the way to solve it or the solution.

Ault (1989) writes of B. S. Thomas who found in 1968 that guided discovery was superior to expository methods when working with high- and low- ability eighth grade students in critical thinking and problem solving activities. However, when teaching factual or conceptual knowledge, Ault states that didactic methods were better. Helgeson (1989) writes of a similar study done by Davis with upper elementary students in 1979, eleven years after the Thomas study. In this study, the results are contradictory to the 1966 study in that the guided discovery method was found to be superior to didactic methods when teaching science content. Helgeson also states that those students involved in guided inquiry expressed more positive attitudes toward science than those who were taught with didactic methods. Glasson (1989) did a study with ninth grade physical science students and found that conceptual knowledge was learned by students equally as well when doing hands-on laboratory experiments as when teacher demonstrations were performed. He also noted that hands-on group activities significantly enhanced students' ability to solve word problems.

Characteristics of good problem solvers

Barba (1990) suggests that successful problem-solvers posses many of the same characteristics. He writes that good problem solvers are superior to poor problem solvers in that they:

(1) tend to use prediction

(2) find support for their predictions

(3) tend to have fewer gaps in their knowledge or content structure

(4) relay on information learned from the lesson

(5) make fewer mistakes reading and interpreting data

(6) rely less on memory

(7) express less doubt and confusion

(8) have fewer misconceptions

How do students come to possess these characteristics so they will be successful problem solvers? Woods (1989) offers suggestions to students who want to develop better learning strategies. He urges them to be in control of their learning. "No one else can be responsible for what you learn: It is your life and your learning" (p. 102). Woods also suggests that students look at the big picture and make written notes about what they are studying. He continues by telling the students to use whatever techniques necessary to identify the important facts and concepts. Woods (1989) finishes by advising students to relate what is happening now to past experiences.

Integrated problem solving

Another consideration when doing problem-solving in science is that of viewing the problem through an integrative lens. In integrative science, students must realize that in the real world, it is almost impossible to isolate and manipulate a single variable. Our planet is our laboratory and ecologically speaking, a misjudgment when "experimenting" could bring devastating results (Cairns, 1992). Every system is closely related and dependent on each other. It is important that students shift their perception from a reductive science in which hypothesis are proved or disproved based on the manipulation of a single variable to an integrative science in which relationships between ecosystems are valued. This approach may be viable as students solve Science-Technology-Society related problems.

Collaborative Learning

Manning and Lucking (1992) state that cooperating learning is currently gaining attention because (1) of the realization that within the school environments, students are encouraged to work competitively rather than cooperatively, and (2) cooperative learning environments may have positive effects on academic achievement, social skills, and self-esteem. There is also knowledge that peers can encourage learning in each other, in addition to providing a social support (Wilkinson & Calculator, 1982).

Social interaction

Lave and Wenger (1991) postulate that one cannot separate learning from social practice; it is a way of participating in one's world. They assert that there is no learning without "engagement" within one's social world. Collaborative learning appears to be especially beneficial when the student population has a high degree of diversity. Several benefits emerge when these populations work together. Students begin to see each other as collaborators rather than competitors (Manning & Lucking, 1992). Self-esteem and relationships among diverse cultural groups and special needs students are also enhanced (Wilkinson & Calculator, 1982; Manning & Lucking, 1992).

Participation within the group

Lave and Wenger (1992) write that learning occurs through participation, with meaning being negotiated by the perspectives of the participants. They note that participants move from being on the periphery of a group towards the center of interaction (Lave & Wenger, 1992). As newcomers enter a new "community," they come to understand how the group functions so they can participate and become full members. The newcomers' identities develop as they move toward full participation (Lave & Wenger, 1992). As students work within a community and move toward full membership, they learn how to perform tasks with the assistance of the group. Over a period of time, students become able to do more of these tasks on their own.

Zone of proximal development

Vygotsky (1978) describes the *zone of proximal development (ZPD)* as the difference between what a student can do unassisted in a problem solving situation and the potential of what s/he can do with adult guidance or more capable peer interaction. This difference defines the psychological "functions" related to problem-solving that are currently in a developmental state (Vygotsky, 1978). Newkirk (1992) explains that it is through collaborative feedback by peers that one's work improves as one moves through the ZPD. Chaiklin and Lave (1993) state that students are very "susceptible to influence" during this development. Students are still in the process of defining the learning tasks which closely relate to their identity (Lave & Wenger, 1991). The goal of the educator is to stretch the student's learning through assistance and peer interaction so a point is reached where s/he will be able to perform unassisted (Vygotsky, 1978).

Outcomes of cooperative learning

Johnson & Johnson (1992) list five positive outcomes of cooperative learning. They are:

(1) There is higher achievement when students are challenged to solve problems creatively, critically, and within a life context application. When teachers construct

classroom tasks that are challenging and collaborative, the group succeeds further than does the individual.

(2) The relationship between student and peers and student and faculty is more positive. Students and teachers realize that all people are learners. Power is more evenly distributed.

(3) Students have a positive psychological well-being, higher self-esteem, greater social competencies, and coping skills. Students feel better about themselves because they perceive what they are doing has value. The necessity to communicate when working collaboratively heightens social skills.

(4) Student attitudes toward science is more positive. Students are less afraid of science. When students and teachers work together there is less feeling by students that the teachers "know it all" and the students has to figure out what is important.

(5) Students have heightened interests to continue taking science courses. When the first four outcomes of cooperative learning are met, the desire to take other science courses is a natural outcome.

A goal of collaborative work is to produce a citizenry that will be able to function effectively as adults. Students who learn to work together successfully in classrooms will more likely to work together successfully in their community.

CHAPTER 2

METHODOLOGY

Choice of Method

Spradley (1980) likened beginning fieldwork to a map-maker who found himself on an uncharted island. The map-maker set out to find the riches of the island: lakes, rivers, volcanoes, and minerals. He didn't know what he would find, he only knew that as a map-maker, he would describe what he observed. Once around the island, he was sure he had probably missed some important features, but he would go back again and again and include more details. Like the map-maker, I have been around the island discovering and recording. Each time I revisited the island, I continued to explore and investigate. My map began to take form as I picked up details that I may have missed earlier. It was also important to put my exploring and investigations on paper.

I chose to write my explorations and investigations as an ethnography. Ely, Anzul, Friedman, Garner & Steinmetz, (1991) state "the writing of a qualitative research report demands the creation of a narrative. The writing of a narrative is the telling of a tale" (p. 169). I enjoy "telling tales," so an ethnography seemed an appropriate style for my dissertation. Hitchcock & Hughes (1989) state that the purpose of an ethnography is to "share in the experiences of those being studied" and to better understand how people view and "make sense of their world" (p. 52). The section of the dissertation, *Stories of the Field*, was written as a collection of vignettes. Erickson (1986) describes the vignette as not representing the original event. Instead, he writes, "..[it] is an abstraction...in which some details are sketched in and others are left out. Some features are sharpened...and other features are softened, or left to merge with the background" (Erickson, 1986, p. 149-150). Some parts of the stories are told in crisp details. Other events are mentioned only in passing. By writing a narrative in first person, I was the "active" participant observer in the center of the action. As an active participant, I had a job to do besides doing research (Ely, et al., 1991). I taught some lessons and sought to do what others were doing, not just to gain acceptance in the classroom, but also to better learn the cultural rules for behavior (Spradley, 1980). By writing in the first person, the reader was brought closer to the students and actions being studied (Ely, et al., 1991).

When this research began, the questions were very broad. What were the students doing and how did they make sense of things in the Science-Technology-Society (STS) learning process? Lincoln and Guba (1985) state that the researcher approaches the study "...not knowing what is not known" (p.235). That described me at the beginning of the study.

Background Information

I met Dr. John Cairns in the fall of 1992. He told about the closing of the landfill, of the Roanoke Regional Landfill Restoration Project, and his interest in involving high school students. The projected closing of the landfill was October 1993. Because a spur had been proposed to cross the landfill which would connect the Blue Ridge Parkway to Virginia's Explore Park, the director of Explore Park asked for assistance from Virginia Tech to help determine vegetation coverage for the landfill. Explore's director proposed using native vegetation species that would be aesthetically pleasing to tourists as they approached Explore Park. He suggested a possible prairie ecosystem where buffalo could graze.

A graduate student, Mara Sabre, was hired to assist in making vegetation selections. Mara's project was funded by the Roanoke Solid Waste Management Board with matching funds from DuPont and Mobil Education Foundations. Landfills were being revegetated with a standard Virginia Department of Transportation (VDOT) seed mixture that was used along roadways to help control erosion. This mixture contained non-native plant species that were very aggressive. In addition, the reintroduction of certain insects was not being promoted because of lack of food sources and habitat diversity. Butterflies and other insects did not have food available to attract them. Often animal species diversity was limited because of food variety. The limited variety of plants was due to the allelopathic substances produced by certain plants (Burchick, 1993). This happened when plants produced chemicals to inhibit the growth of other plants, thus enhancing the plant's chance for its own survival. Virginia Tech and Explore Park wanted to find an acceptable mixture to replace the VDOT mixture that met the criteria to increase species diversity, was native, controlled erosion, met state and EPA regulations, and was attractive.

Dr. Cairns expressed interest in how students could be part of the decision-making process in determining the vegetation and land use of the closed landfill. Since students from the Roanoke Valley Governor's School (RVGS) visited the landfill with the media when Dr. Cairns and Explore's director introduced the restoration project, he wondered if the students would continue participating in the project. I will tell about the students and activities that were done in the first phase of the study. I will also share reflections from the first phase and tell how it impacted the planning for the second phase.

Features of the Design

Phase I

Patrick Henry site. Phase I was conducted in the honor's biology class at Patrick Henry High School. The classroom at Patrick Henry (PHS) was large. There were five rows of desks with five desks in each row. Students sat in rows of individual desks facing the front of the room. There were three large science work tables at the back of the room. Each had electricity, water, and gas connections. The back wall of the room was lined with cabinets and counters. There was one Macintosh computer and printer at the front of the room on a desk located directly behind the teacher's area. A large aquarium sat beneath the windows on the right wall. A lectern was situated at the front of the room between the teacher's desk and the blackboard. There was also a storage and preparation room located directly behind the blackboard. A new temperature controlled greenhouse was attached to the room.

Classroom teacher. Ed McMichael taught the honor's biology class at Patrick Henry. It was through his efforts and cooperation that background information was gathered for use in the 1993-94 academic year. Ed taught health and physical education for three years at Huntington College before teaching biology in high school. He also taught at the Governor's School before transferring to Patrick Henry. Ed received his B.S. in biology from Lynchburg College and his M.S. in marine biology from the University of South Florida.

Students. There were thirteen girls and thirteen boys in the honor's biology class at PHS. Background information was not collected on the students. This was due in part to my inexperience in the field and the fact that I was primarily an observer in the classroom. It was from this experience the need for such data from the second phase of the study was realized.

Scientist. Ms. Mara Sabre was the scientist working collaboratively on this study. Mara was a master's degree student at Virginia Tech. She received her B.S. from North Carolina State University in biology and history in 1989. Mara spent two years in the Peace Corps in Honduras where she worked in water shed management and environmental education. As research associate/supervisor on the Roanoke Regional Landfill Restoration Project, she researched possible alternative plant species for revegetating the landfill. Mara developed site plots at the landfill to check seed viability.

Mara accompanied me to many of the classes at Patrick Henry. She gathered equipment, seeds, and spent numerous hours conversing with professionals at Virginia Tech in order to offer assistance to the students. Mara kept in touch with the students through e-mail on days she was not in the classroom. She also included me in the meetings she had with regulatory agencies outside the university. She supplied the project with numerous articles concerning landfill restoration issues. Her specific science background in landfill restoration gave invaluable guidance to this study.

Guest speaker. Virginia (Ginny) Laubinger, Environmental Educational Programs' Director from Virginia's Explore Park, shared information with the students during this study. She was chosen because of her ability to communicate with the students as evidenced through the work she does in education and her interest in the issues of landfill restoration.

Ginny spoke about visions for the park and her interest in environmental issues. Because of Explore's location downstream from the landfill, Mrs. Laubinger also addressed the landfill's impact on Explore. She brought to the classroom a variety of experiences. Her B.S. was in forestry with a minor in environmental science. Her M.S. was in forestry with an emphasis in environmental education. She has taught at the middle school, high school, and college levels. Mrs. Laubinger has been director of several camps sponsored by the U.S. Forestry Service. She was also a Bayteam teacher for the Virginia Institute of Marine Science.

Educator researcher. This was my first opportunity to be involved with high school biology students. Even though I have taught for twenty-four years, the majority of my experience was at the elementary level. I taught fourteen years in grades one, two, and three; six years in preschool; and one year in grades four, five, and six as a science enrichment teacher. Being a science enrichment teacher heightened my interest in science and led to the desire to further my education. In the three years prior to beginning my doctorate, I taught seventh grade life science, as well as a theater and drama class. As a full-time graduate assistant, I supervised student teachers at the elementary and middle school levels. I received my B.S. from Auburn University and my M.E. from George Mason University.

In the fall of 1992, I asked Dr. Cairns to direct an independent study for me as part of an ecology requirement. This study coincided with his becoming involved with the landfill restoration project in Roanoke. Working with Dr. Cairns and Ms. Sabre, I realized landfill restoration integrated many of the biosystems taught in the seventh grade. I felt that students must understand and respect these biosystems because they are the same biosystems necessary for global sustainability. My interest in the project was related to the relevance of the subject and the opportunity that was seen for students to become actively involved in an aspect of citizenship as they dealt with these issues.

Schedule of activities. Phase I consisted of working with students from Patrick Henry High School (PHS) for six weeks in the spring of 1993. (See Appendix A for schedule of activities.) Ed McMichael, the teacher, agreed to involve his high school honors biology class in doing research about landfills and laying the groundwork for Phase II. These twenty-eight students were involved in the first two categories of the STS investigative sequence as defined by Rubba & Wiesenmayer (1988). They were:

(1) STS foundation activities and issue awareness activities

(2) STS issues investigation skill instruction

This phase consisted mainly of research for a group presentation. The class was divided into four collaborative groups and assigned research topics. Students did research and presented papers to the class on topics of:

(1) Construction and maintenance of landfills

(2) Closing and monitoring of landfills

(3) Procedures for opening new landfills, and restrictions for restoring closed landfills

(4) Previous restoration methods, Explore's stake in the Roanoke Regional

Landfill, and restoration plans for the Smith Mountain Gap landfill once it is closed

Students contacted local, state and national organizations to receive materials on their topics. They followed newspaper articles about the construction of the new landfill and made phone calls to civic leaders to gather information. The teacher and I also constructed our knowledge because neither of us had previous information or experiences upon which to draw.

In addition to the papers the students did, we also had a guest speaker and took a field trip. Ginny Laubinger from Explore Park spoke to the students concerning garbage issues. She focused on topics in solid waste management concerning reusing, recycling, and reducing. We also discovered that we could visit the Roanoke Regional Landfill [the "old" landfill], the transfer station, and the Smith Mountain Gap Landfill [the "new" landfill]. Students completed the study by giving their group presentations on their research topics.

Reflections. Phase I was analyzed with the teacher at Patrick Henry. It was concluded that a group of six or seven students was too big. The students, by their own admission, felt they did not know how to divide the responsibilities and coordinate the results. Several students said there were not enough jobs for seven people to share, and it was difficult to get that many people to agree on anything.

The students from PHS gave presentations at the end of the first phase. A syllabus had been made by the teacher in which he listed concerns and issues the students should research (See Appendix B). Under each of the four issues were several questions. Students did library searches, called resource people, and wrote agencies for information. The was little prior knowledge of where to direct the inquiries as teacher, researcher, and students were collecting data sources simultaneously. When the students made their presentations, they answered the questions listed under "issues." There was little, if any, additional information given beyond what had been specified. In the process of doing hands-on activities and in writing research papers, students produced many documentary materials which became a part of the data base of the study.

The field trip was obviously the highlight of Phase I as noted by adults and students. It put things into perspective and made the study "real" to everyone. Students returned from the field trip with heightened enthusiasm and eager to talk about their experiences. They concurred with the importance of taking the field trip early in the study so that their readings could be linked with experiences.

At the end of Phase I, a questionnaire was constructed with eleven discussion question to get feedback from the students about the project (see Appendix A). Students said they got most of their information from people, rather than from printed material. They suggested that the class next year be more aware of articles in the paper that dealt with the landfill. The students also recommended visiting the landfills early in the study so links could be made with what they were reading. They overwhelmingly commented on the positive impact the visit to the landfills made. Prior to this trip, students said they never realized how much trash was produced by Roanoke and how much of that could be recycled. Without the experience of seeing the landfills, students had difficulty understanding the baling process, the need for a liner, or the magnitude of the physical area of the landfill. Students also said that their buying habits had changed as they became more environmentally aware of the garbage issues.

Summer gave us a natural break between Phase I and Phase II. Mara and I met separately with each teacher to plan for the next phase. Each school would design the study to meet the goals and needs of their students while collaborating with each other on field trips and guest speakers.

<u>Changes in design</u>. The first phase helped to frame the second phase of the study that began in the fall of 1993. There was a better knowledge base: Mara knew more about

the classroom environment, and I knew more about the scientific aspect of landfills. John, the teacher at the Governor's School, was just beginning to build his knowledge. He admitted knowing very little about landfills prior to this study. Construction, maintenance and monitoring procedures were new to him.

Several changes were made in the study based on what was learned from Phase I. For example, the Roanoke Regional Landfill and the operations connected with the Smith Mountain Gap Landfill were visited much earlier in the study than was done in the spring. The field trip was used as part of the introduction to the study. This allowed the students an experience to which they could relate their readings and research.

The need for additional planning in the fall was also recognized as the designing of the plant lab would be added to the study. Planning for the activities was more detailed and collaborative. In Phase I, Ed taught and I observed. In Phase II, John, Mara and I divided the teaching of different lessons among the three of us. John included Mara and me in active interactions with the students. We taught lessons and he assisted. John set up the physical equipment and interjected questions or clarified directions during the lesson if he thought it necessary. The dynamics of "team teaching" flowed from one person to another.

Our planning and execution of plans were better in the second phase because we had time to plan. At the Governor's School John taught only in the morning, which allowed him to be free to assist in administrative duties in the afternoon. John, Mara, and I often sat down immediately after class to plan for the next segment of the project. During Phase I, Ed always had several students in the room or a steady stream of students coming to seek assistance. After school planning was often not feasible because of his other school commitments.

During Phase I, the class was divided into groups of seven or eight students. This number was too large. The students said that it was too many to work together, and they didn't know how to divide the responsibilities among so large a number. Ed and I decided for Phase II the number should be limited to groups of four. A smaller number would allow everyone a voice and a responsibility. Ed and I also decided, based on the limited data given in the group presentations, to have broader topics for students to investigate in Phase II. This would allow students during Phase II to choose topics they found interesting which would foster ownership of their projects.

Ginny Laubinger was an excellent choice to speak to the students about the issues surrounding garbage. However, Ginny and I decided in Phase II her focus would be more on the landfill's impact on Explore Park. Ginny said she would use her camera during the summer to take pictures at Explore of things she thought represented the problem.

Phase II

Scenario. Phase II was supposed to have included a middle school, a high school, and the Governor's School. The middle school teacher decided in September she did not have enough time to give to the project and withdrew.

Originally, when planning with the teacher from Patrick Henry, we had decided that the students in Phase II would build upon the information gathered by the Phase I students. These students would be exposed to the same two STS investigative levels as Phase I students:

(1) STS Foundation Level

(2) STS Issues Awareness Level

However, the last two categories were added (Rubba & Weisenmayer, 1988). These categories were:

(3) STS Investigation Level

(4) STS Action Skill Development Level

However, Phase II never materialized with the students from Patrick Henry High School. Because of a conflict of science fair dates and the teacher's obligation to that program, students from Patrick Henry participated only in the introductory activities that included concept webbing, Ginny Laubinger's talk, and the landfill field trip. Five students chose to do independent investigations incorporating the landfill restoration project with their science fair projects. No detailed data, other than project results, were collected.

Students from Dr. John Kowalski's biology class at the Governor's School were the central focus for study in Phase II. They had full participation in all activities and proceeded through Rubba and Wiesenmayer's (1988) four categories as they related to the STS investigative sequence. This second phase was introduced into the classroom the first week of October 1993.

Schedule of activities. Mara Sabre, Dr. John Kowalski, and I met in September 1993 to plan the different activities. (See Appendix A for schedule of activities.) As John had a program of studies to follow, and Mara and I were not available to be in class every day, we decided to weave the landfill project with his regular studies. Students would have "regular" class days and "landfill study" days. On October 4 and 5, the project was introduced. A concept webbing map was done to establish the students' knowledge about landfills. The Governor's School and Patrick Henry shared a bus and went on the field trip on October 7 to the Roanoke Regional Landfill, the transfer station, and the Smith Mountain Gap Landfill. On October 8, Ginny spoke to the students at PHS and then to the students at RVGS about landfill issues. She showed pictures of the landfill's impact on Explore and addressed Explore's ecological interest in the landfill.

John had arranged a field trip with Ginny for the students to visit Explore Park on October 12. The purpose of this trip was to meet with representatives from the Society of Foresters and hike the trail they had built. On the hike, the foresters talked about the importance of forests, specifically the forests around Roanoke. Students completed several activities in which they estimated the height of trees and estimated age with tree borings. At the end of the hike, the students returned to the settlement area and had a tour of the house, garden, and barn. Even though this was not a trip that had been planned as part of our restoration project, it gave those students who had not previously visited Explore an idea of the mission of the park.

On October 15, Mara spoke to the class about her plots on the landfill and explained her concerns regarding the revegetation process. The students designed a use for a closed landfill and discussed the strengths and weaknesses of their design. Mara returned on October 18 and gave additional information about species choices for the students' experiments. With this lesson, Mara gave the students the tools they needed to work toward a resolution of the issues (Rubba, 1990). She gave students a list of topics to consider so they could design their experiments based on their concerns. Mara also gave the students the names and background information on the standard VDOT mixture and her experimental seed mixture. Students designed experiments they thought interesting and chose seeds to test.

On October 19, a lesson was taught on Issues and Values (Ramsey, Hungerford & Volk, 1989). Current newspaper articles about local area's concerns about landfill issues were used. Each table read an article and identified the issue, players, beliefs, positions, and gave a solution (see Appendix C). On October 29, the experiments began to be set up. An assignment was also given in which the students wrote a letter to the director of the Roanoke Valley Resource Authority reflecting on things they had seen or articles they had read (see Appendix D). The letter was due November 4. John had the students exchange letters in class and write a response to the letter they received. On December 3, Dr. John Cairns from Virginia Tech visited RVGS and spoke to the students about ecosystem services and issues that go beyond landfills. Students wrote reflection papers to Dr. Cairns, and he responded in turn (see Appendix D).

Students had a group presentation on December 14. The topics were: (1) Closing, monitoring, and reclaiming a filled landfill; (2) Opening and monitoring a new landfill; and

(3) Alternatives to landfills (see Appendix E). On December 16, a post-webbing activity was done, and the students completed the questionnaire (see Appendix F).

When John, Mara, and I planned for this study, we thought we would be finished by the December break. When December came, Mara realized we did not have enough growth on the plants to draw conclusions. We jointly decided to extend the study. The students agreed with us because they were not ready to stop either. However, we faced the problem of "Intercession." [RVGS uses the month of January as a time away from the standard courses to allow students to investigate other areas of interest. Students choose to study different topics during this four week "mini-course."] John agreed to check on the plants and water them while the students were gone. However, the winter this year was unusually severe, and students missed many days of school. In order for Intercession to get its full 20 days of teaching, it was extended into February. Additional bad weather in February further delayed the return of regular classes until February 14.

The day students returned to class, we began to examine the plants. Mara showed the students who were studying rooting depth and biomass how to pick out the roots. The next several days were spent carefully breaking apart the containers and using dissection probes to dig out the roots. Shoot height was measured and plants counted.

On March 17, John and Mara were interviewed about their perceptions of the study (see Appendix F for questions). Some of their comments were used to construct interview questions for the students. The students were interviewed on March 21 and 29. On March 31, the students gave their final group presentations before their peers and representatives of Virginia Tech, Explore, Roanoke Valley Resource Authority, and the Roanoke County Board of Supervisors. (See Appendix G for culminating presentations and activities.) The students wrote reflective papers on the project after their final group presentations (see Appendix G).

Roanoke Valley Governor's school site. The primary study site in Phase II was the Roanoke Valley Governor's School for Science & Technology (RVGS). The campus of RVGS is composed of a brick building that houses five classrooms and administrative offices, a modular unit that has three math classrooms, and a materials engineering lab that is located in a technical school. The main building is surrounded on one side by Patrick Henry High School, and on another side by a technical school. It is also located across the street from an elementary school. The students who attend RVGS are in grades ten through twelve and come from Roanoke City, Roanoke County, Salem City, Bedford County, Franklin County, Botetourt County, and Craig County. Patrick Henry students may attend in grade nine. The school is for students "who want to learn all they can about science, mathematics, computer applications, and technologies." (See Appendix H for data about the school.)

The local school district selection committee selects students to attend RVGS on a competitive basis. Roanoke City and Franklin County provide transportation for their students. All other students must provide their own transportation. The Governor's School has classes in double shifts. Students attend a morning shift at RVGS from 8:15 until 11:00 and attend afternoon classes at their home school. Other students attend their home school in the morning and are at the Governor's School from 12:15 until 2:35. This double shift allows for a total enrollment of 201 students to attend the school and keeps the cost of tuition to a minimum.

The biology classroom at RVGS is of medium size and well-equipped (see Figure 1). The teacher's desk faces a wall in a corner at the front of the room. There is a computer for the teacher's use. In the middle of the room are three rows of two tables each. These square wooden tables each sit four students comfortably. [Tables are identified by topic of investigation for each group.] There are three science work tables on each side of the room that extend into the room: each has electricity, water and a sink. At the end of each table is a Macintosh computer. The students also have access to the Wilson General Science Index and Readers Guide through a DOS computer. There is also an Image Writer and color printer in the room. A laser printer can be accessed through the network in the computer lab. At the end of one table is a "River Aquarium" which has multi-leveled banks so that water pours over the banks and into pools. It houses frogs, newts, chameleons, and several fish. The aquarium simulates the ecosystem of a river.

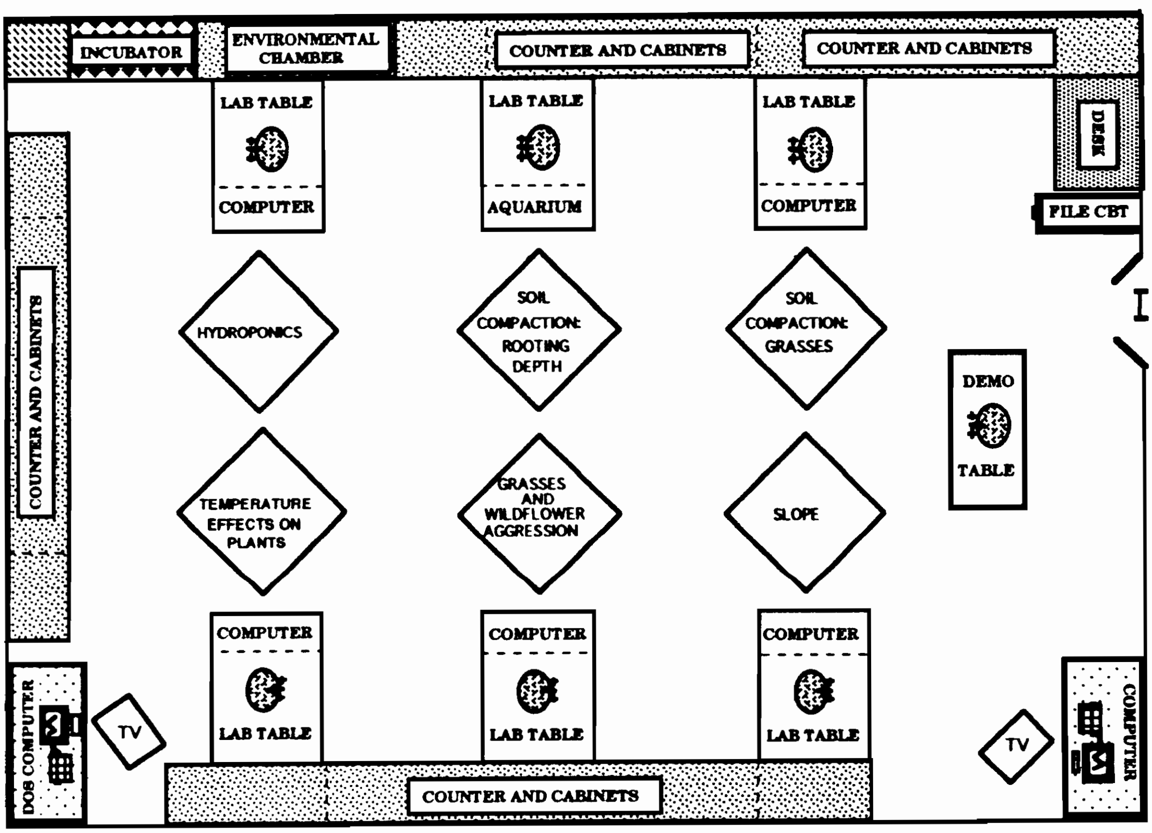


Figure 1. Governor's School classroom diagram.

Each side of the room has cabinets and counter space with bookcases or cabinets above the counters. Two bays of grow lights for plants hang under the cabinets. A four-foot plant environmental chamber is on the counter at the back of the room. Next to the chamber is a large incubator. In the back right corner stands an anatomical model where students can study the different human systems. At the back of the room, next to a sink and bottle rack, is another large aquarium. Fish and various aquatic plants are in it. Attached to the ceiling at the back and front left corners are TV monitors. Messages are flashed to the students from the office, or students can view videos and laser discs on these monitors. There is also a video microscope cabled to the TVs so the class can view microscopic specimens. A standard science demonstration table is at the front of the room, and behind it is a dry eraser board. Next to the board are colored photos of activities the students have done during the school year.

At the front of the room between the entrance door and the teacher's desk is a door leading into a workroom which is shared with the biology class next door. Located in this room are a refrigerator, a crushed ice bin, cabinets for storage, work area with a sink and a Laminar flow hood for collecting gases. This storage and work area can be used by teachers and students. Other equipment available for use by the students includes: a shaking water bath, electrophoresis equipment, micro-pipettes, a skeleton, bacteria fermentor apparatus, Spectronic 20 spectrophotometers, an autoclave, analytical balances, pH meters, portable water quality testing equipment, CDs, computer software, and a large collection of laser discs and a microscope slide collection. The students also have available a small reference library and several biology-related journals and magazines.

Classroom teacher. Dr. John Kowalski is a biology teacher for the Roanoke Valley Governor's School. He has a strong belief that students needed to be actively involved in science through local issues. John helped in planning, investigating, and facilitating the unit. He also understood that flexibility and discovery were necessary for both students both students and adults. John has taught at the Governor's School since 1986. Before teaching in Roanoke, he taught biology at the State University of New York at Brockport and at George Mason University in Fairfax, Virginia. John received his B.S. and Ph.D. in biology from the University of Notre Dame.

Students. There were twenty students in the class; fourteen girls and six boys. These juniors and seniors came to the Governor's School from eight different home schools. The majority of these students had attended RVGS previously. The students sat at six tables (see Figure 2). To better distinguish and construct an identity for the groups, they are referred to throughout this document by the plant experiments they designed for this study.

Three girls, Kusum, Divya, and Kavita sat at table one (*Soil Compaction: Grass Table*). [All student names are pseudonyms.] They are from an East Indian background. Divya and Kusum are sisters. At the second table (*Soil Compaction: Rooting Depth Table*) were two boys, Mark and Bob, and two girls, Corrine and Ruth. Ruth and Bob came from the same home school, and Mark and Corrine came from the same school. Karen, Judy, and David sat at the third table (*Hydroponics Table*). They were seniors and also came from the same home school. Karen, Judy, and David had all their courses together at both the Governor's School and their home school.

At the first table on the left (*Slope Study Table*) sat Syann, Karla, and Linda. Linda and Syann were from the same home school. The second table on the left (*Grasses and Wildflower Aggression Table*) had four girls: Karol, Ethel, Doris, and Ann. They were also seniors. Ann and Ethel came from the same home school, as did Karol and Doris. Bill, Jason, and Jon sat at the last table on the left (*Temperature Effects on Plants Table*). They each came from different schools. Except for the three girls of East Indian heritage, and a boy who is an African-American, all students are Caucasian. At the beginning of the semester, the students were allowed to choose where they sit as long as they worked constructively. Students were permitted to change seats again at the beginning of the second semester.

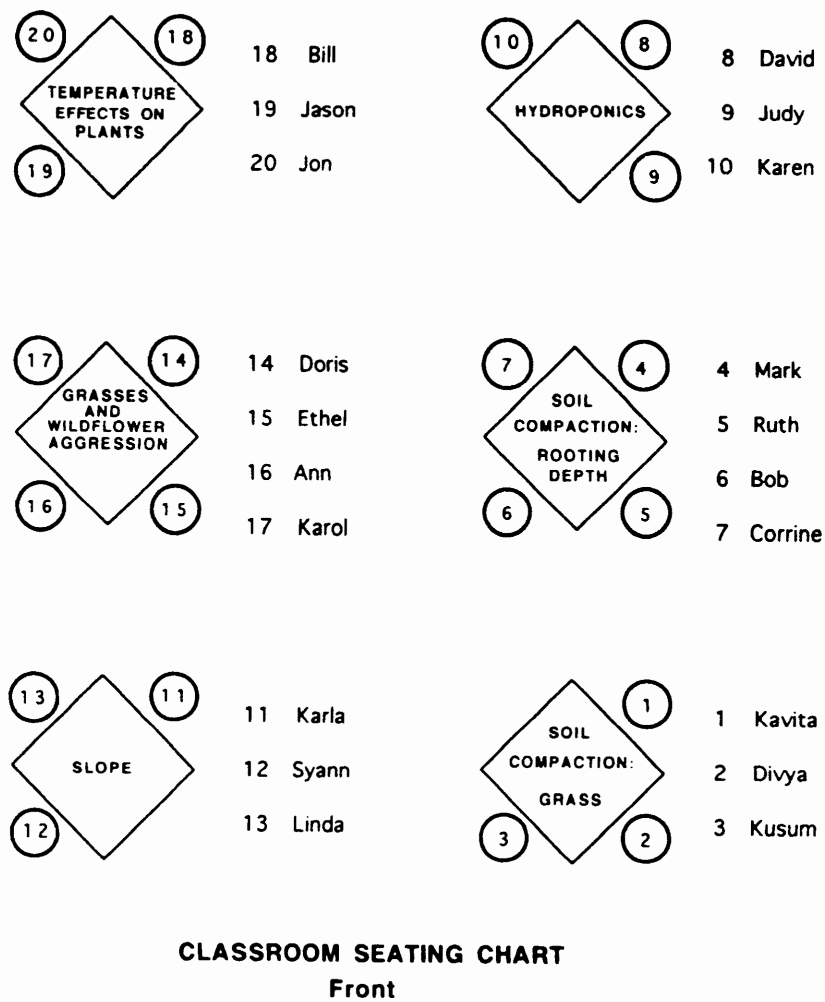


Figure 2. Governor's School seating chart.

Student perceptions. Why did these students choose to attend the Governor's School and leave their friends at their home school? I asked this question as part of an 18-item questionnaire given near the end of the study in December (see Appendix F). Students gave a variety of answers. They felt courses at the Governor's School would be interesting, fun, and challenging. They knew it was a way to meet people from other schools. Students also recognized that attending the Governor's School would be beneficial for their college application process. Several of the students admitted they were unhappy with their home school and wanted another environment. However, two students stated they were not sure why they selected to attend the Governor's School.

How involved were these students in clubs and organizations from their home school? Students named over thirty-five different clubs and organizations in which they participated. On the average, each student was a member of at least four organizations. Which clubs had the highest membership? Fifteen students were members in a foreign language club, eleven students were members in a science related club, and ten students were in the National Honor Society.

What did these students choose to do with their time outside school? Their interests and hobbies were probably similar to those of most students in the eleventh and twelfth grades: organized sports (tennis, volleyball, running, football) and environmental sports (hiking, camping, fishing, etc.); music (piano, band, flute, violin, guitar); crafts (painting, drawing), reading and writing. And of course, talking on the phone and sleeping!

When asked what type of work or career they wanted to do as an adult, a majority of the students listed science related careers. Eight students listed careers connected to the medical field and seven listed environmentally related work. One boy was interested in a career related to the stage. One girl said she would like to be a teacher. A career in business interested another boy. Two students had not narrowed their choices; one boy was interested in being a bioengineer, physician, or actor, while one girl was trying to decide between a career in international studies, law, or medicine.

<u>Guest speaker</u>. Dr. John Cairns, Jr. also spoke to the students during Phase II. He is a University Distinguished Professor of Environmental Biology, Director of the University Center for Environmental and Hazardous Materials Studies at Virginia Tech,

and a member of the National Academy of Science. He received his Ph.D. from the University of Pennsylvania. Dr. Cairns has received numerous environmental awards and has been a consultant to and researcher for the government and private industries. He has written 1085 publications, of which 51 of those are books. Dr. Cairns became involved in the landfill restoration project when Explore Park asked him to direct a study to help determine the best species for revegetating the landfill once it is closed. Through continued contact with the director of Explore Park, and Ms. Sabre, Dr. Cairns has remained actively involved in the landfill restoration project.

Student Documentary Materials

Documentary materials were very important to this study. Many different activities were happening simultaneously, and it was impossible for the researcher to be in all places. Therefore, assistance from audio and video taping devices were necessary.

Erickson (1986) states that field notes, videotapes, and interview transcripts are not data. He contends these are "documentary materials" from which we build data. When this research began, I had no idea what forms the documentary materials would take. As the study evolved, variety of documentary materials were incorporated. This section describes these documentary materials.

Audio taping. Audio tapes were used at PHS, and at focal tables at RVGS. This appeared to be the least intrusive method for recording student dialogue. Ely, et al., (1991) and Hitchcock & Hughes (1989) indicate that after an initial period of adjustment, people relax and are not aware of a tape recorder. That was true for the *Soil Compaction: Grasses* table and the *Hydroponics* table, but not for the *Soil Compaction: Rooting Depth* table. The *Soil Compaction: Rooting Depth* table continued to turn the recorder off at specified times during the study through the last taping. Written notes were not taken while in the classroom as this was a time of building rapport with the students. There was concern that the setting would be too formal if notes were written in their presence. Students' conversations might have been artificial and events might also have been missed when note taking (Hitchcock & Hughes, 1989).

Taping began at RVGS on the first day of class with one small portable tape recorder. However, the dynamics at several other tables also appeared to be interesting. There were three tables I wanted to follow: two tables of boys and girls, and a table of East Indian girls. A second recorder was bought and shuffled among the three tables. The cost of the tape recorders prohibited the purchase of one for each table.

The tape recorder was a good way to capture group interaction as it allowed me to watch what was going on and add those impressions to the transcriptions. Conversations and planning sessions with the classroom teacher and the scientist were also taped. In addition, field trips, guest speakers, and selected classroom activities in which the students were making presentations were video taped.

Video taping. Whereas the audio tapes worked better for small groups, the video tape was found to be an excellent source for data collection when doing an activity with the entire class. Pictures of the field trip, class sharing sessions, special speakers, and formal group presentations were taken. It was most helpful to watch the video before transcribing the audio tapes. Sometimes words that were inaudible on one type of tape would be audible on another. It was important be inconspicuous when taping the students' sharing and giving group presentations. I felt the video camera was more intrusive than the tape recorder.

Video taping is akin to photography. Bogdan & Biklen (1982) state that a photographer can neither observe nor interact well when taking pictures. When video taping, most of what was seen was through the viewfinder. The video tape was used only once when students were doing individual activities. From that experience, I felt the video tape put distance between the students and me. After that, the use of video tape was reserved for whole class activities of presenting and sharing.

Photo pictures. The camera was another piece of equipment that went constantly to school. It came in handy in the classroom, on field trips, or when stopping at the landfills. The camera did not appear to pose the same barrier as did the video camera. The camera was an intermittent barrier brought up and down while the video camera was held up constantly. There are approximately 60 - 70 slides that tell a detailed story of this study from start to finish.

Classroom activities. There is a wealth of information from the written artifacts by the students. In several activities students drew pictures with magic markers. These included pre- and post-webbing maps and drawings of restored landfills. The students enjoyed using this medium as a means of expression.

Large newsprint [36" x 24"] was used for several activities. One activity was an "Issues & Values" chart the students compiled after reading newspaper articles. The newsprint was large enough for each person at the table to participate. The paper was also big enough that the class could see when it was shared in group presentations.

Simulated letters. One of the activities that gave insight to the students' thinking was the simulated letters to the director of the Roanoke Valley Resource Authority (RVRA). In these letters, the students asked questions, made observations, and voiced their concerns about their trip to the Roanoke Regional Landfill and the Smith Mountain Gap Landfill. John had the students exchange letters and respond as they thought the director of the landfill would have responded. These letter exchanges showed that students were aware of the political, social, and economic issues that affected the construction and management of landfills (see Appendix D).

Reaction papers. On several occasions, students wrote reaction papers to a guest speaker or to taking a trip. These papers were usually one page and did not require research. John had the students write what they liked and disliked about their field trips to the landfills and to Explore Park when we did the Society of Forester's hike (see Appendix D). Students also wrote their reactions to Dr. Cairn's speech and to the final day when they gave group presentations before the guests (see Appendix C).

Journals. Students were asked to keep reflective journals (see Appendix D). They wrote in journals each week at the beginning of the study. As we progressed, it was decided that reaction papers written immediately following an activity served the same purpose. The journal writing was stopped as students became involved in other activities of the study. We tried to be cognizant of the amount of paper work the students were asked to produce and be reasonable in our expectations.

Group reports. The students had two group reports. Their first report was due December 14 on the "Closing, Opening & Alternatives to a Landfill." Two tables had the same topic but each table did its own research. The topics were: (1) Alternatives to Landfills; (2) Closing, Monitoring & Reclaiming a Landfill; and, (3) Opening & Monitoring a New Landfill. These topics covered basic information about landfills. The students gave their presentations using overheads and posters. They also turned in a written report (see Appendix E).

On March 31, the students gave their final paper and conclusions. This final report detailed the purpose of their experiment, method, data, and conclusions. Each table had approximately 5 minutes to present their report using a visual aid. This presentation was done as the culminating activity. Representatives from Virginia Tech, Explore Park, the Roanoke Valley Resource Authority, and the Roanoke County Board of Supervisors joined the class for the presentation and discussion. (See Appendix G for a copy of their report).

Exit slips. In Phase II, students at Patrick Henry did exit slips after the webbing activity, the field trip, and Ginny's talk. On these exit slips, students could ask questions, make observations, or give opinions about the class. Students did the exit slips in class and turned them in as they left. No other data except research data that was used by Mara was collected from these students in Phase II.

The Researcher's Journal

A journal was kept that included reflections on each trip taken to the Roanoke Valley Governor's School, Patrick Henry, the landfill, or when meeting with Explore or Roanoke Valley Resource Authority. (See Appendix A.) In the beginning the journal was a factual account of what happened. However as time passed, it became more reflective and as the story was being written, these notes were important in remembering events and impressions. The journal, audio tapes, and video tapes assisted in reconstructing the activities and events.

Questionnaire

A questionnaire was constructed for the students at the end of the study (see Appendix F). Questions about their life history and how they felt about the study, collaborative work, and STS projects were asked. It had already been decided to extend the plant lab when the students were given the questionnaire. Some thought was given to waiting until we really "finished," but it was decided that some of the intensity of the students' feelings might be lost while they were out for the remainder of December and the month of January for Intercession. Answers the students gave on the questionnaire helped to formulate questions for the interview.

Interviews

In addition to a questionnaire, interviews were also conducted with the students (see Appendix F). The purpose of interviewing the participants was to have another way to see the world through the eyes of the people studied (Ely, et al., 1991). John and Mara had questions they wanted included in the interviews.

The interviews were semi-structured. Questions had been designed to obtain certain needed information with the realization that the opportunity to see how the interviewees would structure the topic might be lost (Bogdan & Biklen, 1982). However, if the interviewees shifted the conversation, the questions followed the shift (Hitchcock & Hughes, 1989). The interviews initially began as individual interviews. This was done on days the students were doing informal activities so as to not interfere with their class. Eventually, it was decided because of time constraints, to interview each table collectively. In some groups, students who dominated the table conversation during activities also tried to dominate the interview. This is not an uncommon occurrence in group interviews (Bogdan & Biklen, 1982). The questions were purposefully structured so each person had an opportunity to speak. In other groups, the dynamics of the group moved the interview along and stimulated talk (Bogdan & Biklen, 1982). Even though all tables in the class had not been a focus in the study, all tables were interviewed. This was done because everyone had something to say, and it was important for no table to feel they had been "slighted" during this study (Bogdan & Biklen, 1982).

Making Sense of the Analysis

What is Analysis?

What is analysis and how to do it are questions most doctoral students ask. Bogdan and Biklen (1982) state, "Data analysis is the process of systematically searching and arranging the interview transcripts, field notes, and other materials that you accumulate to increase your own understanding of them and to enable you to present what you have discovered to others" (p. 145). My goal was to make sense of this study and present it to others.

This study was a combination of looking both at the surface of cultural meanings and a few selected domains in-depth (Spradley, 1980). Those who advocate an in-depth analysis believe cultural meaning is complex and if we look at everything, we never look deep enough to understand (Spradley, 1980). At the other continuum, advocates of surface analysis declare that ethnographers need to look a culture "holistically." They believe if one looks at the whole picture and see relationships, one can go back and look with more detail...if time permits (Spradley, 1980). In this study, the surface culture of junior and senior biology students and how they made sense of an STS project was observed. That same culture as it pertained to collaboration, constructivism, and problem solving was also investigated.

A large portion of the data consisted of 60 audio tapes which have been listened to, transcribed and analyzed. These audio tapes have also been triangulated with other data sources. Eight video films were viewed and notes made about the sequence of events and evidence of cultural patterns. In addition, the students turned in eight sets of papers and four large newsprint sheets they used in group work. The next section explains the method for analyzing the audio and video tapes, and written artifacts.

Analyzing audio and video tapes

Mara accompanied me to Roanoke on most days. On the way home, the tape was played on the car tape player. This allowed a familiarity to be gained with the tape before transcribing or formal analysis (Hitchcock & Hughes, 1989). Mara and I talked about what happened on the tape. No written notes were made at this time, but mental notes were made concerning students' language and behavior.

If a video tape was made of an activity, it was watched to understand the sequence of events. General notes were made on the computer, and cultural patterns of the students were noted. "Culture," according to Spradley (1980), "is an organization of things, the meaning given by people to objects, places, and activities." This video was not transcribed for what was said, but what action took place.

I returned to the audio tape and transcribed it while remembering the sequence seen on the video tape (see Appendix A). Many of the audio tapes were very difficult to transcribe because there were several people at each table, sometimes more than one talking at a time. There was also often background noise from other students. During the early transcribing process, it was very difficult to determine who was talking. The students were not well known to be identified by their voices.

Once a hard copy was made of the transcript, it was read and analytic memos were written in the margin. It was important to go beyond the descriptions of what happened and look for cultural meaning in the students' behavior (Spradley, 1980). The focus at this time was still broad. Next to the cultural scenes in the transcriptions were written questions, themes, or other events with which there were connections (Spradley, 1980). Reoccurring themes and categories were related to the research questions (Hitchcock & Hughes, 1989). Insights were also tested by talking to or formally interviewing the students (Delamont, 1992). As I participated in data analysis, the focus shifted when other relevant questions appeared (Ely, et al., 1991). As data was compiled from transcriptions, written artifacts, and talking with participants, the focus became more refined (Spradley, 1980).

Because of the number of transcriptions, the hard copy was rarely returned to until the vignette was ready to be written. The exception was if a suspected connection needed to be verified. When all the transcriptions were completed, they were read through again, pages numbered and an outline made. In the outline was the name, date, and page number of each event. Under the name, a list of the comments and possible themes were written. This gave a quick reference to all materials in the project's transcriptions when locating events. (See Appendix A for transcription outline.)

Often several weeks transpired between transcribing a tape and writing the narrative. When ready to write, if there was a video, it was watched again. This helped to "relive" the experience. Using the hard copy as a reference, the audio tape was listened to again. Having some time away from the transcription was important. Student voices were distinguishable and the material was more familiar. Words that been unintelligible before could now be understood. Listening to the inflection and tone of the voices, new meaning and insight was gained into the students' dialogues. This helped to construct themes, patterns, and categories of events and activities (Hitchcock & Hughes, 1989). As I read and listened, the focus was refined to look at social construction and language discourse as it happened in this STS project. Once themes had been established, confirming and disconfirming evidence were identified (Erickson, 1986). This evidence might modify interpretations as a result of the process. As the story was written, events were chosen that linked the themes with the experiences.

Analyzing Written Artifacts

The students' artifacts included journals, reflection papers, assigned group reports, letters, and drawings. These artifacts were read to get a general idea of the content. After reading papers from the entire class, reoccurring themes that crossed all papers were mentally formulated and recorded. Artifacts were re-read and analytical notes, comments, connecting events, and themes were written in the margin of the papers. The students' written artifacts were typed verbatim and the passages coded. Once all the passages from that assignment were typed, they were sorted by the computer. It was easier to construct themes when they could be seen and manipulated.

To physically manipulate the material, a copy of the sorted data was printed and each complete passage cut apart so there was one strip for each passage. These were placed according to category and manually manipulated into columns of logical sequence. The focus of each theme was reduced further by looking for "key linkages" or generalizations within the case (Erickson, 1986). Passages with disconfirming events were laid at a 90^o angle to the other papers of the same theme. As the passages were read again, the theme might be changed and placed in another stack, or a new theme began (Ely, et al., 1991). An explanation of events was developed to better understand the patterns and reasons for social behavior of the students (Hitchcock & Hughes, 1989). Once the data had been worked with and physically sorted, writing was ready to begin. My goal was to tell a story, make my project credible, and have something "worth paying attention to" (Ely, et al., 1991, p. 156). In order to have a story to tell which is credible and "worth paying attention to," the trustworthiness of the research process must be considered.

Trustworthiness

"Trust" is a word that had meaning early in my life. Above all, my parents instilled in me the need to be "trusted." That meant not telling a lie and doing what I said I was going to do. It was their knowing when I said something "it was so." In much the same way, trustworthiness in an ethnographic study is making sure one carried out the research fairly, and the results reported represent as closely as they can what actually happened in the field (Ely, et al., 1991); in other words, that "it is so." Lincoln and Guba (1985) say to establish trustworthiness, a researcher must spend adequate time in the field, do persistent observation, triangulate, search for negative cases, experience peer debriefing, and check with those you have studied. I will address each of these characteristics and show how this study achieves trustworthiness.

Time in the field. This study began when I met Dr. Cairns in October 1992. I did not enter into the classroom at this time, but began meeting with Mara Sabre to learn the language of restoration ecology. Both she and Dr. Cairns gave me many articles to read to learn the discourse and become a part of their community of learners. I entered into the field at Patrick Henry High School in February of 1993 and stayed until June 1993. I again entered the field at the Governor's School in September 1993 and stayed until March

31, 1994. Patrick Henry was the primary field site from February to June 1993. Roanoke Valley Governor's School was the primary field site from September 1993 to April 1994. While in the field I participated in many activities and recorded many observations.

Observations. Time in the classroom at the Governor's School was flexible, depending on the activities that had been scheduled and John's teaching schedule. Because of the schedule at RVGS, the students were not in biology on Wednesdays. There was extended time in the classroom on Thursday which allowed lengthier activities. I was in the classroom an average of 2-3 times a week throughout the study. Once initial activities were completed and the seeds planted for the experiments, I did not go as often. At the end of the project I was again in the classroom 2-3 times per week in order to observe the students take the plants apart and collect the final data.

Triangulation. Ely, et al., (1991) states "triangulation can occur with data gathered by the same method, but gathered over time," or it can be "the convergence of data gathered by different methods" (p. 97). I established a "between methods triangulation" by using a variety of methods to collect data (Hitchcock & Hughes, 1989). The students in the classroom and resource people who came to share information were both audio and video taped. The students also answered a questionnaire (see Appendix F). Interviews were conducted with John, Mara, and the students (see Appendix F). Numerous written artifacts were collected that the students had produced as part of the project such as journals, reports, reflections on trips and speakers, and drawings (see Appendix D).

Determine referential adequacy. Initially, my purpose was to look for events to constitute a theme. A tape was listened to for the first time to get a feel for what was happening. Next, the tape was transcribed (see Appendix A). When the transcription was read in its entirety the first time, identifiable themes were marked. Upon re-reading transcripts, the commonalty of one event with another event was connected. Repeated patterns were soon seen and credence given to repeated themes. Tapes were listened to more than once during this process. They were listened to when they were initially transcribed, and then listened to several months later when the vignette was being written.

. Experience peer debriefing. There were several groups or individuals with whom I talked about my study and tried out themes. According to Ely (et al., 1991), a theme is "a statement of meaning that runs through all or most of the pertinent data" (p. 150). Mara and I had time when traveling back and forth to Roanoke to discuss students and events. Her opinions and comments were found to be of great help. She knew both the students and the events intimately. The process of analysis was also assisted and enhanced in the early stages by a five member group of doctoral and masters students from Virginia Tech who were learning to analyze and write ethnography. We became a support group for one another. Ely, et al., (1991) calls such a group a "life line" (p. 99). Ely suggests that support groups can consider findings, suggest other explanations, and act as "auditors" of the process.

Search for confirming/disconfirming evidence. As the transcriptions were read and re-read, they were looked at for commonalties and themes. Once themes had been established, there was a search for confirming and disconfirming events (Erickson, 1986). Interpretations and themes were modified. It was important to listen to the tapes again over a period of time. It was a new experience to look for disconfirming evidence. My natural instinct was to look for information that confirmed pre-existing beliefs.

Check with those studied. "Member-checking" (Bogdan & Biklen, 1982) was done with Mara, John, Ed, Ginny Laubinger, and Dr. Cairns. Each person read the vignette that told about their activity and made comments on its authenticity. By having each of them read their story, a concern was reflected about capturing their perspectives accurately (Bogdan & Biklen, 1982). Lincoln and Guba (1985) state if the people who provide the information "honor the reconstructions; that fact should also satisfy the consumer" (p. 329). It is felt that these participants "honored the reconstruction."

CHAPTER 3

STORIES OF THE FIELD

First Day in the Classroom
October 4, 1993

This is my first day in the classroom. John and I decide to begin the unit with a webbing activity. It is 9:30 a.m. and John is at the front of the room greeting the students as they arrive. There is light chatter as the students enter the room. It surprises me to see baseball caps worn in the classroom and soft drinks placed on the table along side their books. The atmosphere is very casual. I sit silently at John's desk in the front corner. As soon as he speaks, the room becomes silent.

Introduction of the Study

John begins the study, "Where Does All the Trash Go? Landfill Issues in the Roanoke Valley" by handing out papers that introduce the different people the students will be meeting during the next few weeks (see Appendix E for assignments). John explains there will be several written projects due throughout the unit. The first project will be a response to an article from the April 1990 issue of the Smithsonian, "I learned that it just keeps getting deeper." This humorous article introduces the students to the issues surrounding landfilling. The second assignment is one in which students are to make a lecture outline for giving a 45 minute presentation to their home school. In this presentation, they will discuss solid waste management, landfills and recycling. They are to address scientific, social, political, and economic issues. The third assignment is a group project in which each table selects a topic, writes a paper, and does a presentation to the class. Each table may choose from (1) Closing, monitoring, and reclaiming a filled landfill; (2) Opening and monitoring a new landfill; or (3) Alternatives to landfills (see Appendix E). John takes almost thirty minutes explaining what we are going to do. He finally introduces me as "this is Ms. Taylor from Virginia Tech, and she is going to be working with us while she is doing her dissertation."

Webbing Lesson

Nervously, I leave John's desk and walk to the front of the room. I tell the students it excites me to work with them on this unit for the next several weeks. I ask the students how many have done a webbing activity before, and only two of them raise their hands. I show them what a web looks like, using myself as an example (see Figure 3).

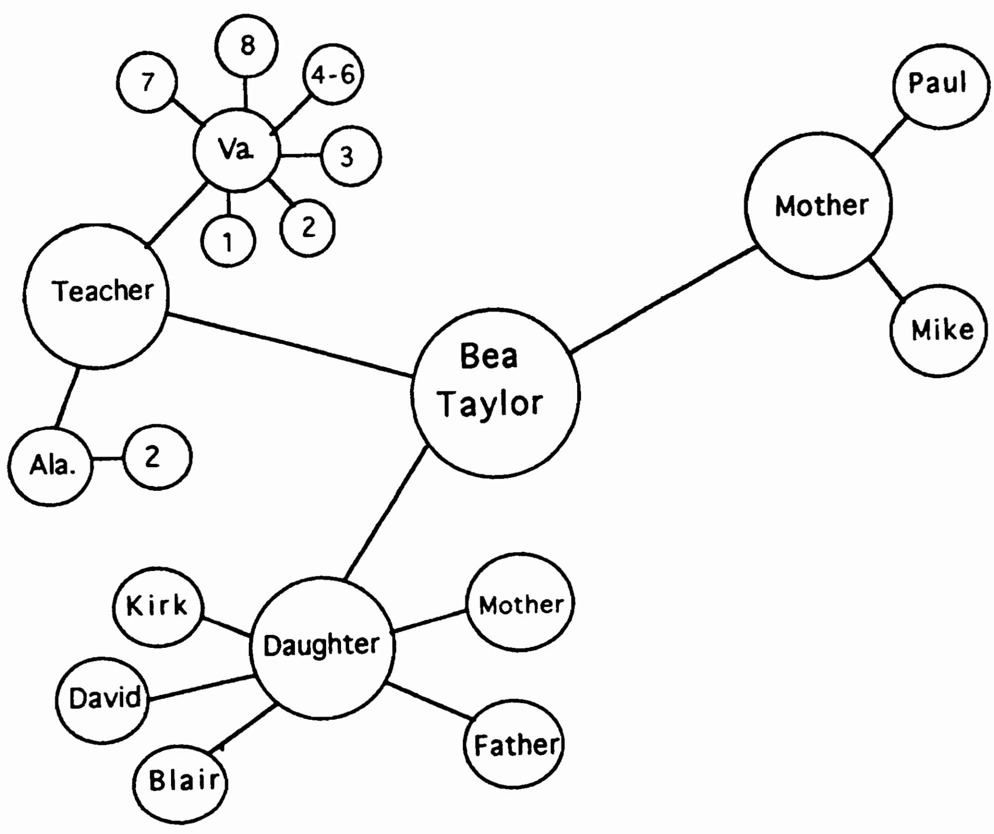


Figure 3. Webbing example.

This allows the students to get to know me, and it doesn't require them to have prior knowledge. I draw a circle and put my name in the center. In each of the other circles I write one word: mother, daughter, and teacher. I write the names of my nuclear family from the circle that says "daughter." I web my sons from the "mother" circle. I also list the states and grades I've taught from the circle that says "teacher." I explain that the second group of circles I drew were all descriptors of the main circle. I ask if they have any questions. There are none, so we begin.

I hand out a large sheet of paper for each table and magic markers for each student. I tell the students to draw a large circle in the center of their paper and write the word "landfill" in it. I want them to web anything they know about landfills. We will take about ten or fifteen minutes to work and then share what we've written.

The students begin to work immediately. I walk around the room and listen as students discuss what they think should go on their papers. The exchange of conversation tells me no one person dominates the group. The talk is fast and students often finish one another's sentences. One student suggests an idea and another student adds to it. Each drawing begins to reflect the personality of the students at that table. The girls at the *Grass and Wildflower Aggression* table add pictures to their web. [Tables are identified by topics they will later investigate.] The *Soil Compaction: Grasses* table makes their web very orderly and easy to read. The *Temperature Effect on Plants* table's web looks as though their goal is to fill up all possible space on the paper. As I stand over the table looking at their drawing I see "chicken noodle---mm', mm' good!---twice the meat---and noodles!" It will be interesting to look closer at this drawing! Jon, a boy from the *Temperature Effects on Plants* table says he thinks landfills are "awesome." I ask him if he has ever been to one before. He says "no." I tell him the new landfill is the biggest hole I've ever seen, and it is "awesome." He says, "Wonder what else you could put in that hole?" I respond, "I don't know, but if you didn't put trash in the hole, where would you put it?" He says that he doesn't have enough background information to answer that right now. "Hold that thought," I tell him, "because I will ask you that question again at the end of the unit." At the end of fifteen minutes each group is still busy discussing and drawing. After extending the time to almost twenty minutes, I tell the students to stop. One student from each table stands and tells about their map.

Sharing Webbing Maps

Soil compaction: Grasses table. Divya, Kusum, and Kavita sit at this table. Divya and Kusum are sisters. The girls are very antimated as they talk and laugh about what they want to put in their web. They stand to share their concept map (see Figure 4).

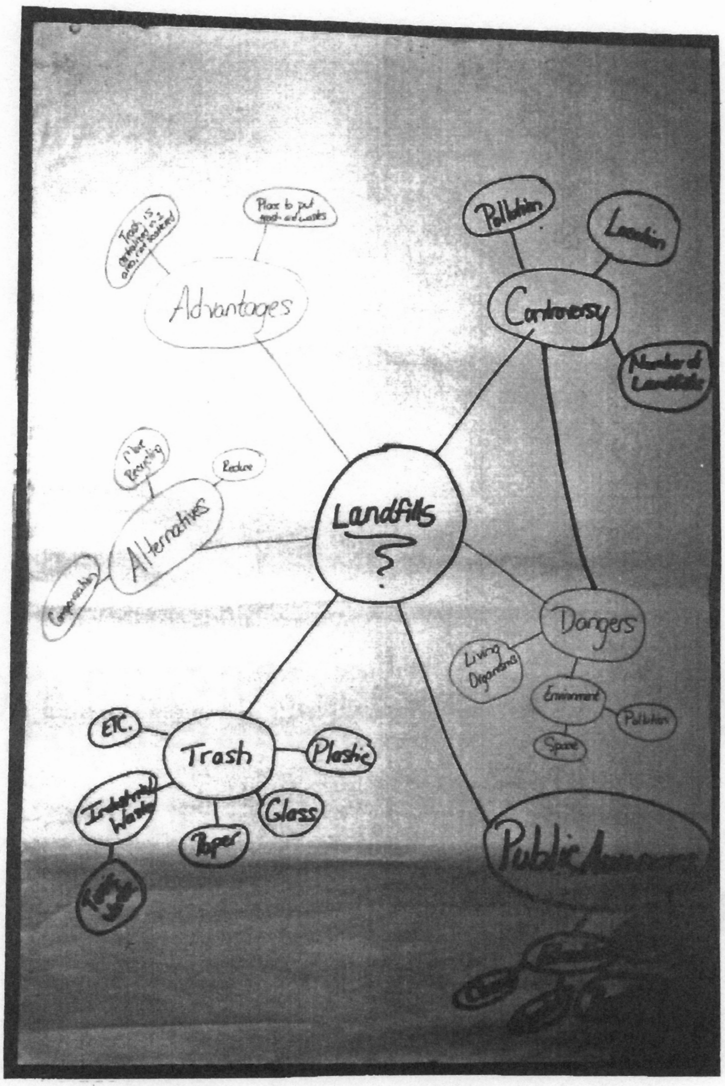


Figure 4. *Soil Compaction: Grasses* Table Webbing Map

Kusum is the spokesperson for the group. This table has six primary categories extending from their "landfill" circle. Their list includes: advantages, dangers, trash, public awareness, controversy, and alternatives. Their first concern is the controversy surrounding landfills. Kusum says that people do not want landfills near their home, nor do they want too many of them. Part of the controversy is the dangers of a landfill. She states there are dangers to living organisms, humans, and the environment. Landfills also cause pollution. The girls list different types of trash and the need to reduce, reuse, and recycle. Kusum also says that there should be some type of compensation for recycling efforts. Even though it appears everything this table has said has been negative, Kusum wants the class to know they believe there **are** some advantages. They list two: (1) landfills provide places to put trash, and (2) landfills make for a centralized place so everything is "not scattered about everywhere." The girls also see the importance of public awareness. This is so people can learn the "good" and "bad" things about landfills. Kusum suggests education classes, speakers, pamphlets and field trips as ways of accomplishing awareness.

Soil compaction: Rooting depth table. Bob, Ruth, Mark and Corrine sit at this table. They list their knowledge about landfills as: equipment, land, trash, effects, and usage (see Figure 5). Corrine is the spokesperson for this group. She doesn't elaborate much about their web, but only lists what they have written. Their concerns are: the scenery, the space a landfill takes up, and the destruction a landfill brings to habitats, ground water and the soil. They also list the economical effects that are both positive and negative. Corrine says that a positive effect is that landfills create jobs. She says the negative effects are the cost of land, equipment, and supplies. Another concern of this table is the effect of pollutants and fertilizers on the environment. They list trash as biodegradable, non biodegradable, and toxic waste. Corrine points out that we cannot use a landfill once it is closed, but while it is open, it is in continuous use.

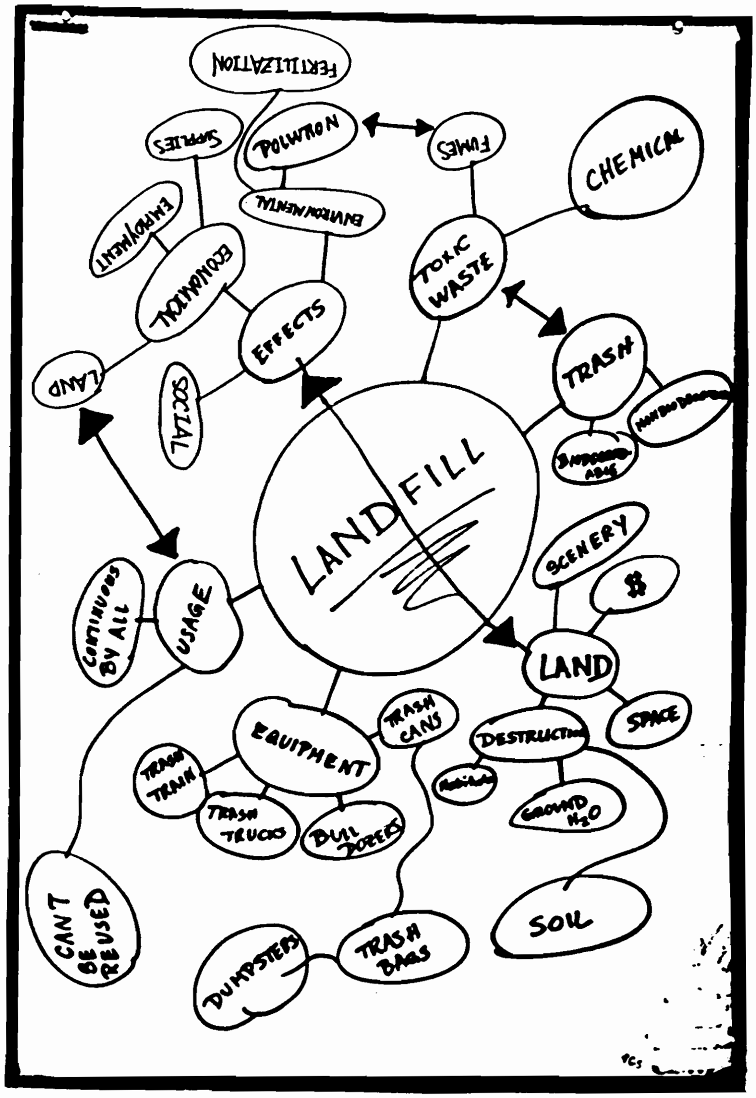


Figure 5. *Soil Compaction: Rooting Depth* Table Webbing Map

Hydroponics table. At the *Hydroponics* table are David, Karen and Judy. They list their knowledge about landfills as: environmental hazards, alternatives, government control, reuse of old landfills, and jobs (see Figure 6). Karen is the spokesperson for the table. They begin with the things most people are familiar: dumpsters, garbage collection and garbage trucks. They are also aware of the environmental hazards of leaching that can affect both soil and water supplies.

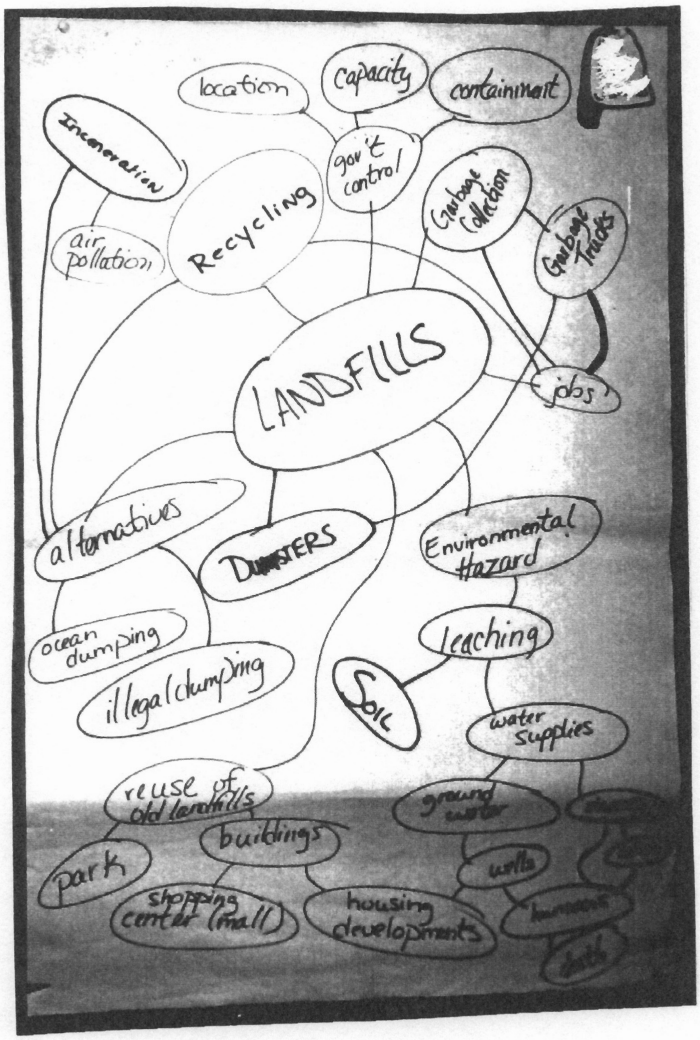


Figure 6. *Hydroponics* Table Webbing Map

Karen explains that with the water supply, the ground water goes to rivers, lakes and to water wells. The final recipients of water are humans. This can lead to our death, Karen says, if the pollution is extreme. Karen's table listed possible uses for a closed landfill. Karen says we could use a landfill for a park or build buildings on it, such as a shopping center or a housing development. They also link the land use to their concern about polluted water supplies.

Karen asks rhetorically, "How can we have a shopping center or housing development if we have polluted water?" She explains that alternatives to landfilling are ocean dumping, illegal dumping, recycling, and incineration. Karen states, however, that with incineration, air pollution will increase. This group is also aware of how the government controls landfills: their location, their capacity, and their contents. Karen explains that landfills also provide jobs for people. These include people who drive the garbage truck and provide the garbage collection, people who work with recycling efforts, and the people in the government who control landfills.

Slope study table. This table has three girls: Syann, Linda and Karla. They list as their concepts: alternatives, problems, construction of landfills, and types of trash (see Figure 7). Karla is their spokesperson. This table has three alternatives to landfilling: composting, recycling and burning. Karla says their greatest concerns are the problems that surround landfilling. She lists pollution of ground water and location of landfills.

Karla says that they recognize no one wants a landfill in his backyard because it detracts from the beauty of the area. Because of these problems, this table doesn't think there is room for landfills. These students are also aware of some of the aspects of constructing a landfill. Karla states there is a nightly capping of dirt over the trash, with a final capping over the entire landfill once it is closed. The girls are also aware that the old landfill in Roanoke is closing and a new one is being constructed. Karla comments that landfills are for trash, and trash smells bad. She believes there is danger to animals and other organisms because of pollution problems. "However," she says, "we must have some place to put our trash, and landfills are better than outright littering and dumping trash everywhere."

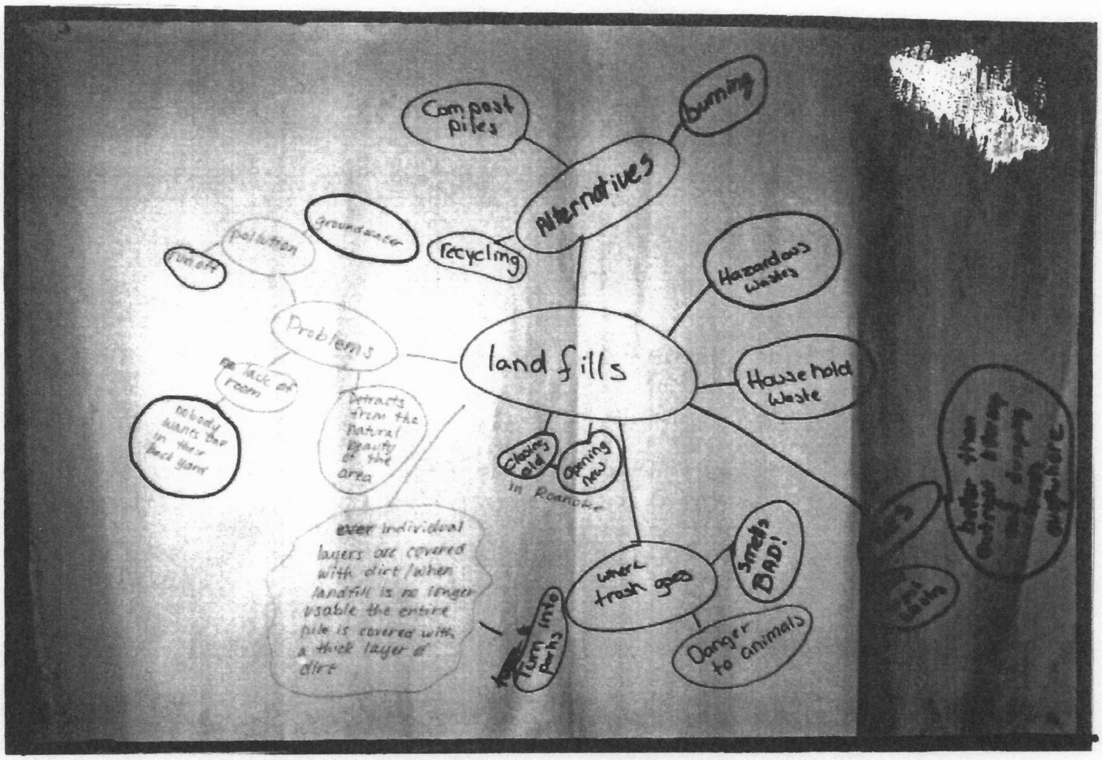


Figure 7. *Slope Study* Table Webbing Map

Grass and wildflower aggression table. Karol, Doris, Ann, and Ethel sit at the *Grass and Wildflower Aggression* table. This table gives more specifics about landfills than any other table. Ann is the spokesperson, and she says that Karol volunteered for the Green Valley Council this past summer and has made a trip to the new landfill at Smith Mountain Gap. "Because of her previous experience, she knew a lot of things we didn't know," says Ann.

This table's list contains: problems, alternatives, the new landfill, and EPA standards (see Figure 8). Ann says they realize problems with a landfill include health hazards and pollution. One of their concerns is the contamination of rivers, streams and wells. Ann says there is opposition by the community because of the belief that landfills have an ugly appearance and the concern that property values will go down. This opposition results in a N.I.M.B.Y. (Not In My Backyard) attitude. She says that taxpayers worry how they are going to pay for the landfill. This table says that tipping fees at a landfill lead to illegal dumping.

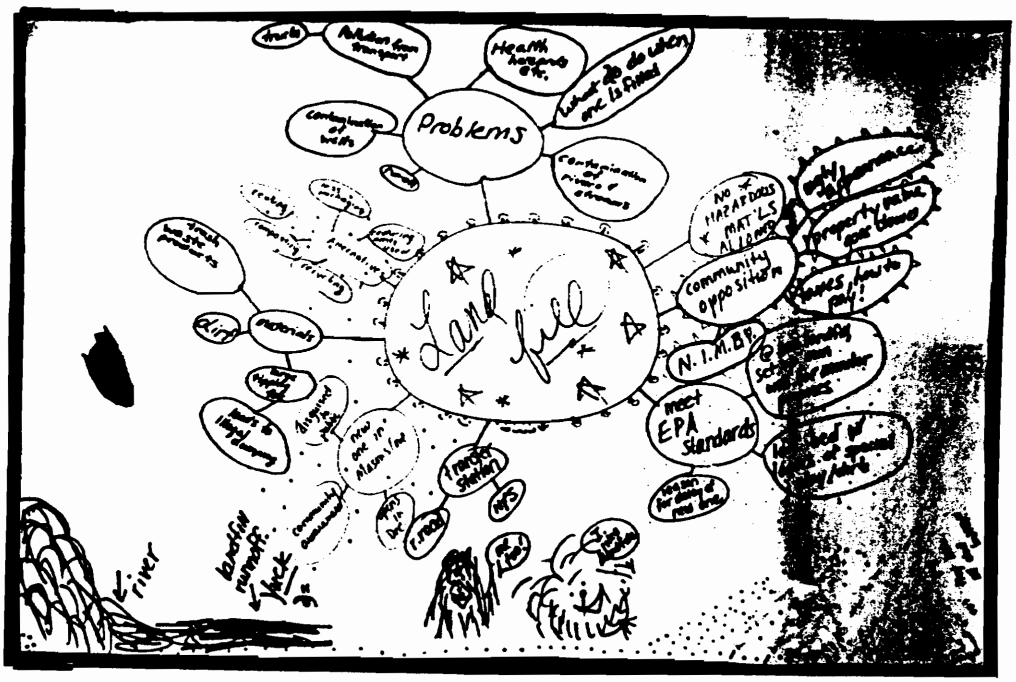


Figure 8. *Grass and Wildflower Aggression* Table Webbing Map

The girls list different alternatives to landfilling that include less packaging, reducing, reusing, composting and recycling. Ann says Karol told them that the new landfill will have a transfer station in Roanoke and Norfolk Southern railroad will be operating the railcars. Karol also told them that the new landfill will have its own water well, and the operators will monitor the neighbor's wells. The new landfill will have the bed lined with special layers of clay and dirt. Ann says the location of the new landfill will be in Mason's Cove [Smith Mountain Gap] and will be "disguised to the public." She has read it will open in December. Ann says they also believe there should be more community awareness about landfills.

Temperature Effects on Plants table. Jon, Jason, and Bill sit at this table. The boys stand to explain their concept map, and the class breaks into laughter. Lines, which connect concepts, go all over their paper. There is not an empty space! (See Figure 9). I noticed earlier that Jon and Jason had continued to add things to their paper while other tables were presenting. The boys seem to enjoy the attention. Jon and Jason begin by trying to explain their webbing.

Jason says to Jon, "This is your doing." Jason starts to explain, "Okay, we started with landfills. We came up with old landfills first and then...Well, you [speaking to Bill] wrote this so you've got to know it." The class laughs again. Jon agrees, "Yeah, yeah, he knows this stuff." Bill, unaffected by the laughter, explains the webbing. Bill lists the problems with landfills. He talks of bad odor, the leaching of soil and water, pollution from burning, and landfills that are full. "To help alleviate the problems," he explains, "we recycle, which means we must have recycling centers." However, Bill brings up the question of what happens when landfills are full. His concern is one that many municipalities have been struggling with. "Do you take it in your own state or send it out somewhere else and make it someone else's problem?" he asks. With that, Bill stops and abruptly says, "The rest is theirs."

Jon and Jason try to follow a couple more of the concepts, but are not very successful. "We kind of got off the subject over here. We got into actual trash and various kinds," said Jon. There was laughter again from the class. The boys are right. They have listed every item they can think of that might go into a landfill and any connecting thoughts: "Pepsi---catch the wave, crystal clear, you've never seen a taste like this; tires--- Michelin, off road, on road." When following all their lines becomes too much, Jason and Jon just laugh as Jason says, "And there's a whole bunch more." The class laughs with them, and they sit down. This is the last table to present.

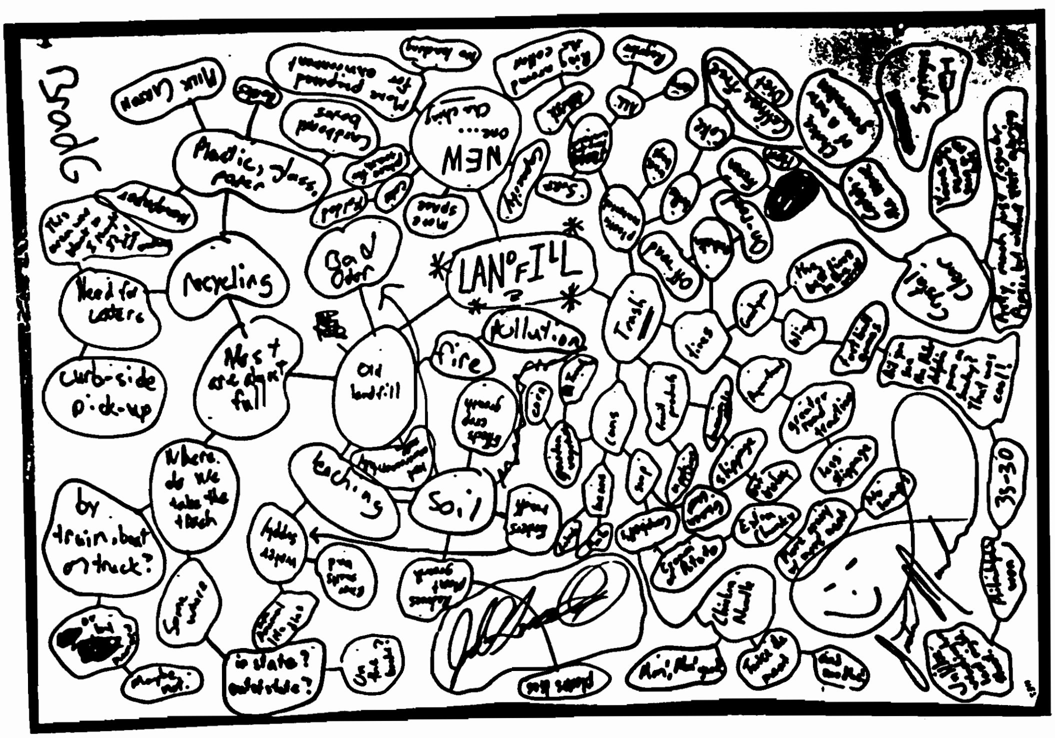


Figure 9. *Temperature Effects on Plants* Table Webbing Map

Since the webbing activity was designed to allow me and the students to see what they know about landfills, I did not elaborate on what they said. I did comment that we all started with "landfills" in the middle and there were some common themes generated by the class. I also told them I saw additional themes that some people were aware of from reading the newspaper or by listening to others talk. I told the class they have a good beginning on the definition of a landfill and what issues surround them. I explain that we will be expanding on these concepts during the next two months.

Slide Presentation

The focus of the class now moves from finding out what the students know to giving them some specific information. I share a slide presentation that includes data about landfills and pictures made last spring at the landfill and at Explore. As I show the slides and talk, I also ask questions. The students are good about answering.

I began by talking about the amount of waste each one of us throws away. It has been estimated that each person in the United States throws away three and one-half pounds of garbage every day. I ask why do they think that is so? Karla says, "It's because we buy more stuff." Bob says he thinks it's because we just put our trash out on the street and then don't have to think about it any more. "It's not in our way," he says. A girl adds that she thinks it because we have so much packaging. I ask the class why is it that other countries don't have as much packaging as we have. Karla answers, "They don't have regulations." The students decide that other countries don't obtain food in the same manner as we do. Much of our food is bought, whereas much of other countries' food is produced by the families. We talk about the amount of packaging that shipping necessitates.

As I show a picture of garbage collecting, I tell of the program Blacksburg has been experimenting with in their garbage collecting. In one neighborhood, the residents place a sticker on each 20 gallon container. In another neighborhood, residents weigh their trash and place a sticker on each 10 pound container. I ask the students what percentage of our trash do they think we recycle? A boy answers correctly, 10%. As I show pictures and ask questions, I find that the students know about the numbers on the bottom of plastic containers, that paper is the largest item in landfills, that EPA stands for Environmental Protection Agency, and that trash will not decompose without oxygen. I discover that the students do not know the cost of the old or new tipping fees at the landfill, why the old landfill is being closed, or about methane problems.

I explain the new discipline of "Restoration Ecology." I tell them that in restoring, we try to re-establish a disturbed ecosystem as nearly as possible to its pre disturbed state. Sometimes we may even make it better. In restoration ecology, it is important to look at animal systems, plant systems, water systems, and all the inter-relationships.

I tell the students about Explore Park and explain it is an outdoor living history museum. I show pictures of the Hoffauger house and the Wrey barn. I also show slides of aerial views of the landfill and Explore. I inform the students there will be a spur built across the landfill from the Blue Ridge Parkway to Explore Park. I explain there is a study in process that is trying to decide the type of vegetation to plant on the landfill. The director of Explore Park wishes the vegetation on the landfill to be aesthetically pleasing and in keeping with the historical museum theme. The landfill authority, however, has a standard seed mixture they have been using and would like to continue using.

I explain to the students, "We will be looking at these two different seed mixtures and designing experiments for either of these mixtures." Mara, a biology student, will be working with us and will get us our seeds. She will also speak to the class about the problems she is having with the experiments she is presently doing on the landfill. Mara would like to have some controls done in the classroom so she can compare what she is seeing with the results we get.

I tell the students another facet we're looking at is what can we do with a landfill once it is closed. I show photographs of different places in the United States that have done unique things with their closed landfills. In Florida, they turned a 450-acre landfill into a wetland. They also transplanted some 600,000 trees and put in ponds. In California near San Francisco, they covered their landfill with grass and put sculptures on top of the mounds. They thought the unusual terrain lent itself to an art form. Michigan decided to put a "floating" greenhouse on one of their landfills. They made a lightweight structure so it could move with the shifting ground. In their greenhouse they grow herbs hydroponically and sell them. Michigan also uses the methane from the landfill to heat the greenhouse. At another landfill in Michigan, they built a ski slope. I tell the students we will spend time in class looking at ideas they design with that we might do on our landfill.

It is almost time for the class to be over. I feel we have accomplished much on this first day. We have done the webbing activity, and the students have shared. I have shown my slides and have begun to lay the foundation with data and information about the study. John and I quickly hand out the permission slips, and I explain the necessity for the slips to be signed. The bell rings, and the students leave.

Landfill Field Trip
October 7, 1993

It has taken much planning to get ready for our field trip today. John, Ed, and I decided to take the field trip early in the study because we felt the students would understand better the nature of the trash and revegetation issues once they saw the sites. Last year, Ed and I didn't realize a field trip to the landfills was possible until we had almost finished our unit. After the students had visited the Roanoke Regional Landfill and the new one under construction at Smith Mountain Gap, they were able to make sense of the articles they had read. This year, we are taking the field trip within the first week of the study.

The biology class from Patrick Henry and the biology class from the Governor's School will be going on the bus together. We have approximately fifty students and five adults. The adults are Ed, John, Catherine Whitlaw, Ginny Laubinger, and me. Catherine is the executive secretary and education director of the Roanoke Valley Resource Authority (RVRA). She is accompanying us to share information about the landfills. Ginny Laubinger is the Environmental Educational Programs' Coordinator for Explore Park.

Governor's School

I arrive at the Governor's School at 8:30 to meet the class before we leave. John has asked me to talk about the journals and what I expect in them. The students are sitting at their tables when I walk into the room. I explain the journals will be a way for students to reflect what they have seen and read, and for us to dialogue. I tell them if they ask questions, I will try to find the answers and respond. I may also ask questions and would like for the students to respond. Someone asks, "How long should our entries be?" "Write until you're finished," I say. John impresses upon them the activities in this study are for grades, and just a couple of lines will not suffice. I ask the students to turn in their first journal entry next Tuesday. They will have much to write about because by then we will have introduced the unit, gone on a field trip, and had Ginny Laubinger from Explore speak to us. It is getting close to time for the bus to arrive.

As we walk out of the Governor's School and across the parking lot to Patrick Henry, I see a group of students standing on the sidewalk. I am "Ms. Multi-media" with my video camera slung over my shoulder, a 35mm camera dangling from a strap around my wrist, and a small tape recorder in one pocket with extra tapes in another. As we stand waiting for the bus, there is some conversation between the two classes of students, but for the most part, they stay separate. Catherine joins us and has folders with data and pictures of the new landfill for everyone (see Appendix H). The bus arrives and we get on: students in the back by classes, and adults in the front. Teachers count their students, and we leave for the Roanoke Regional Landfill.

Roanoke Regional Landfill

Catherine tells the students we will visit the "old" landfill first, the transfer station and then the "new" landfill at Smith Mountain Gap. It takes about fifteen or twenty minutes to get to the landfill. Jared, the manager, is at a meeting so Russell, an assistant, will narrate our visit. Because it is a working landfill, Russell does not allow us to get off. I have met Russell before, but have never seen him with a group. He is very nervous.

We go first to the baling building. It is a large warehouse with huge double doors at the side. There are mounds of trash on the floor. A large front-end loader is moving the trash. Russell's voice is low and difficult to hear. He tells us they weigh the garbage trucks when they first enter the landfill. After being weighed, the trucks come to the baling building and dump their trash on the floor. A front-end loader pushes the trash onto a conveyer belt that feeds into the baling equipment. The baler compacts the trash into an oversized bale of hay. Each bale weighs approximately 3,000 pounds. We are looking at the top level of the building. Russell tells us that we will return later to see the baling process on the lower level.

The bus moves on, and we pass the tub grinder that is not in operation today. It is a piece of equipment that grinds wood waste, brush and tree limbs into mulch. Free mulch is available to residents who wish to use it in their yards. Russell says that this is one way the landfill authority tries to keep unnecessary wastes out of the landfill and conserve space.

We drive to the active part of the landfill. Russell tells us these are the wastes that cannot go through the baling process: construction debris and demolition wastes. He explains that they have large machines that run back and forth over the trash to compact it. However, the large machines with sprocket-like metal wheels are not in operation either today. "At the end of each day they put a cover on top," says Russell. We see large pieces of wallboard and plywood lying on the ground. There are also several tires sticking out of the dirt. Ginny asks if the tires must be slit before being brought here. Russell says they do not require the tires be slit, but they prefer that they are. One girl comments that there is no smell and wants to know what it is like in the summer. Russell tells her it smells in the summer because of the increased temperature. John asks how deep is the trash? "Approximately 150 to 200 feet deep," answers Russell.

We come back to the main road and drive to the maintenance shop. Russell is talking as he looks out the front of the bus. I explain to him that he needs to turn around and face the students for them to hear. Ed hollers at the students in the back. Everyone gets quiet. Russell tells us that the repairs are made in the maintenance building. To the left of the bus, we see the bales stacked from today's trash. Further down on the left are the areas that are full. The final cap of dirt is being put on it. One of the students notices some big birds on part of the landfill that has been closed, but not revegetated. Ginny sees them and says that they are wild turkeys which are common here. Russell points to some of the first areas used for trash when the landfill opened in 1975. There is a tall stand of green vegetation on it. I ask him to explain the final capping process. He tells the students that they put "so many feet of clay...three to four feet of clay and then another two feet of topsoil on top."

I ask Russell which direction is the river from here. He points to where the land falls in the distance. I tell him the students need to know which direction the river is. Ginny stands up and relays that information to the students. She points out where Smith Mountain Dam is and that Explore Park is behind them. Ginny makes a sweeping motion with her hand to show us the direction of the Blue Ridge Parkway and the area where they expect to build the spur. There are little orange flags sticking out of the ground, and we assume the flags indicate where they are drilling and testing for the road.

John comments he thinks it will be an engineering problem to try to put a road on top of the landfill. The area is not stable, and he is afraid it will shift over time with the weight of traffic on it. Ginny tells him that is why they have been doing drillings to determine the stability. Russell points to a virgin area. This is the portion of the landfill that doesn't have trash on it. This is where we see the little orange flags. Ginny says she thinks the road is going over both the virgin part and some filled areas. Russell confirms that the road will cross both areas. We turn around beyond the maintenance building and start back.

As we drive back, we stop where they are depositing the bales. It is an open-faced wall of bales stacked on top of each other. With the different types of trash and colors in the bales, it looks like a mosaic. A layer of dirt is on top of the bales. Russell tells us they leave the working faces open so they can add to them each day. Ed wants to know how many bales do they drop off each day. Russell says there are approximately twenty-five truckloads with twenty bales in each truck. This comes from 700 tons of refuse. Russell explains that the effects of recycling efforts can make their daily tonnage fluctuate.

We ride back to the baling building to see the lower level. This is our last stop. I ask about the monitoring of incoming trash. Russell says they give specifications to the garbage companies so they have "clean loads." If it is "mixed," they ask the people to separate it. Russell explains there is no separation of trash here. However, it might be something they will do in the future when they move over to the transfer station. I continue to ask for clarification, "What happens if they see something that they think is hazardous? Do they just put it in the landfill?" "They just pull it out," Russell responds. "They set it aside, or have the people that brought it in, take it back with them."

I ask Russell to give the students some facts about the landfill. He tells us:

* there are approximately 300 vehicles that enter the landfill daily
* total amount of tonnage is between 700 to 800 tons of garbage
* approximately 50 tons of that is wood waste
* current rate per ton for commercial waste is $55 per ton
* municipalities pay $50 per ton
* cost for waste that goes to the tub grinder is $35 per ton
* mulch is free
* $5 flat fee for homeowners bringing their own wastes

Russell is not certain about the daily capping amount, but says he thinks it is two to three feet. He finally decides it is two feet of daily cover, with the final cap being somewhere between four and six feet. I ask for clarification again, and he says that each evening there is about two feet of dirt placed on the trash. One boy asks, "Where do they get the dirt?" "It's pulled off site," responds Russell. When they open a new site and dig the hole, he explains, they save that dirt to use each evening. Another boy wants to know how deep is the trash. Russell estimates it to be from 150-200 feet, with it being approximately 200 feet at the deepest point. John asks, " How big is the landfill?" Russell tells him the total acreage is 250 acres, with the usable acreage for landfilling being somewhere around 170 to 180 acres.

I ask about the information Jeff gave us last year about hay being grown on the landfill and then being sold. Russell says they grow hay on both the virgin area and the closed landfilled areas. Whoever rents the land, sells the hay.

John continues, "How long did it take to fill this one up?" Russell tells him they have been here since 1975. They estimated the landfill would last for twenty years when it first opened. The Landfill Authority installed the baling and compacting equipment in 1983 to try to extend the life of the landfill. "Before the baling system," Russell tells us, "all the trash went to one area and the machines compacted it by running over it."

"What about pollution control and leachate?" asks John. "They do environmental testing on a regular basis: ground water monitoring...." says Russell. I ask him to tell the students about the sediment ponds that are around the landfill. Russell explains there are four or five sediment ponds located at the base of the fill. When it rains, they catch the runoff. The Landfill Authority must establish a pond for each number of acres they open. They dredge the ponds once they are full, the material is brought back to the top of the landfill to dry out, and the process starts over. "Do you have anything like gas monitoring here?" I ask. "There is nothing right now," answers Russell. "When the landfill closes, they will be monitoring for methane gas. I think the regulations call for monitoring up to twenty years after it is closed." John asks what the plans are for use of the landfill once it is closed. "Well, the Explore River Parkway will come through...and the status of that, I'm not really sure. There'll be some type of recreation area...a park, a zoo, or whatever."

"How much trash dumped here do you think could have been recycled?" asks Karen, a student from RVGS. "Oh," responds Russell, "probably 10%-20% would be a pretty close estimate." One of the boys inquires, "Do you have any way to prevent chemicals from getting into the ground...any prevention?" Russell says at the bottom of the landfill is a compacted clay liner that is suppose to help. "Most of the prevention is done before it's dumped, trying to monitor what's being unloaded, but people do throw things into the trash...old paint cans, aerosols and chemicals that we really don't know. We try to do our best," he says.

"Well, what **should** be done with that stuff?" asks the boy. "The homeowner usually stores it, and then they have a hazardous waste collection day," says Russell. Ginny joins in and explains that the Junior League and other organizations sponsor it. "You can take batteries, paint, pesticides, insecticides, and anything else that doesn't belong in the landfill to have it chemically neutralized so it can be properly disposed or recycled," she explains. Catherine says that the Resource Authority is planning to have a hazardous waste collection day in May. She tells us the cost of having a hazardous waste collection day for 5-6 hours is approximately $150,000.

The tour of the old landfill seemed to be over quickly. I hope the students have a feel for what happens at a landfill. It was disappointing to see everything from the window of the bus. How I wished we had been able to walk into the baling room and watch the trash being compacted and then tied with baling wire. I also wished that the tub grinder and the compacting machines that run over the open landfill had been in operation. I felt we had "been there" but hadn't experienced all the activities on the landfill that I had hoped we would.

As we head out of the landfill, we see two older men wearing orange safety vests and picking up trash with a pole. Mara told me on a previous trip these were volunteers who live nearby and pick up the trash so it doesn't blow onto their properties. They wave to us as we pass.

I'm not sure what the talk at the back of the bus is, but the adults at the front are discussing closing procedures and monitoring. We are trying to make sense of the facts Russell gave us.

Transfer Station

In less than fifteen minutes, we pull outside the big fence that encloses the transfer building and surrounding grounds on Hollins Road, just off Orange Avenue. We see it is one of the nicest buildings in the area. The bus stops just inside the gate, and Catherine gives some facts about the building. She says the total cost of the project is $42 million, with the transfer station costing $6 million. [There is a whistle of disbelief from one of the students.] She tells us that it is being paid for by revenue bonds and tipping fees from the people who bring in trash. Catherine says that Roanoke City, Roanoke County and the City of Vinton make up the Roanoke Valley Regional Authority (RVRA). One must be a member to bring their trash here. A seven member board of directors govern the RVRA. The members also choose the representatives to be on the board.

Catherine tells us there are 22 acres on this site. RVRA is building the transfer station to look like an old Norfolk and Southern railroad shop. She continues to give facts about the building and the disposal procedure. In the front of this building will be the administrative offices. In the back, the trucks will empty their trash. Workers will weigh the trucks before they enter the building and dump their trash on the floor. Inspectors will also look for hazardous materials to pull out. A large machine will then push the trash into a rail car that runs underground at the base of the floor. This building is called the "capping building" because this is where the boxcars will have the lid "capped" on before they leave. Catherine points to several large green boxcars sitting near the building that have "Wasteline Express" written in yellow letters on their sides. She tells us, "The train, carrying about seven cars, must leave here by 7:00 p.m., go to the landfill, drop the cars off, pick up clean cars and return here by midnight. The next morning at the landfill the cars will be dumped, the trash will be inspected again, loaded into haul trucks and taken to the landfill." Catherine says that they will not bail trash at the new landfill. "They have discovered that it really decomposes better if it is left loose," she says.

The students sit quietly as they listen to the information. We have been on the bus for over an hour, and I am ready to get out. I am also hoping we are going to see something up close. The bus pulls closer to the building, and we finally disembark. Catherine announces that this is a "hard hat" area, and we must stay in the parking lot. The students wander around the bus as they look at the building and the boxcars. They talk among themselves and ask Catherine questions.

Someone brings up the topic of recycling. Catherine tells them when the facility first opens, they will only have a place to drop off recyclables. As the transfer station become more developed, they hope to be able to incorporate recycling into the whole process.. "So you're saying again 'it won't be gone through up here'?" asks Tim, a student from PHS. Catherine tell him the only thing they will look for when the trucks dump their garbage will be hazardous materials. "Just hazardous?" he asks. "Will there be mulch here?" asks another. Catherine says there will be mulch available to the citizens and they will incorporate more recycling as the process becomes more developed.

Tim is looking toward the boxcars. Catherine has been talking about the lids on the boxcars. He asks, "It has a clamp-like lid, like a Tupperware lid?" Catherine responds, "More of a gravity..." "Oh, oh, oh, okay," he answers. He evidently still can't picture everything so he asks again, "So what are those girders right there? Will they actually hold the lid up, the cargo is underneath? You drop it down on top and it gets up there and maybe a 'mag' or something lifts it back up again?" Catherine casually answers, "Yeah, yeah." He understands now. "That's a neat idea! Neat!"

One of the girls joins the group. "Where did the concept of this [trash train] come from?" she asks. Catherine tells her that they studied different transfer stations at different places. Tim is already ahead of her, finishing her sentence, "And they just took the one that was the best?" He continues to ask another question, and then answers it himself. "Those trains are going to replace how many trucks? I was thinking about 300, 200." Catherine again answers him with "Yeah. Yeah." Tim continues talking, "I was just thinking about gasoline, petroleum, and air pollution, tires, and having to get behind one on the way to the park."

Catherine mentioned earlier that this project costs $42 million. She explains the cost of this project is high because this is a one-of-a-kind system in the United States. It is the first **total** rail haul system. She tells us, "RVRA is trying to change the image of waste disposal because our environment is important, and people need to put the money into the environment to protect it. Since there is a **NIMBY**(Not In My Backyard) attitude, it is important to make the buildings and area as aesthetically pleasing as possible. RVRA doesn't want the buildings or landfill to be a detriment to the surrounding neighborhood."

The economics of the new project interests Pete. He asks, "How many jobs are going to be here?" Catherine explains that there were originally twenty-three employees at the Roanoke Regional Landfill, and they will be hiring another thirteen. "These will be mainly machine equipment operators and laborers," she says.

As Catherine continues to talk, more students and adults join the circle around her. John asks about the process of inspecting for hazardous wastes once the trucks have dumped trash on the building floor. He wants to know if people will visually inspect the trash and then pick them out. She says, "People will be trained to spot the hazardous materials, will pull them out and then the people will have to take them back that brought them in." Workers record the name and weight of each truck before it dumps the trash. If there is unacceptable material, the inspectors will know from which truck it came. Catherine reinforces this again when she says, "If somebody brings something that they shouldn't bring, it is their responsibility to take it back."

Tim is trying to sort everything. "You're talking about commercial here, not household, right?" he asks. Catherine responds, "You're talking about all of it, commercial and household." Tim's raises his voice as he probes further, "Well, what about the stuff **I** throw away at my house? How are you going to trace it back to **me**?" Catherine explains that they will not be looking for things like aerosol cans because they will not be able to pull all of that out. She then tells him the RVRA hopes to have a place where people can deposit daily their hazardous material, rather than a yearly pick-up, as it is now.

Someone asks, "What will they do with the appliances and things like that go to the landfill? They won't come here, will they?" Catherine says that everything will come here; they will accept nothing at the landfill. Tim asks whether there will be someone who will take the copper piping out of the appliances for recycling. Catherine tells him, "Yes." She says that freon and "that kind of thing" will have to be taken out.

Karen asks about the beginning of this project. Catherine tells her the initial planning began about four years ago. She says the RVRA met with citizens to get their ideas; they looked at different sites for the landfill and transfer station. Board members also visited other cities that had transfer stations, although none of them used a rail system to haul trash to the landfill.

The discussion moves to who makes up the membership of RVRA. Catherine tells us jurisdictions who are not members must apply and be voted in unanimously by other board members. She explains that the jurisdiction must also pay a certain amount of money to "buy in." RVRA will not accept either commercial nor household trash from jurisdictions that are not members. Catherine states there is room for eight or nine different members, depending on their size.

Ginny points out a difference between RVRA and the Franklin County landfill where she lives. She explains whereas RVRA will take no trash unless it is from a member, Franklin County takes trash from anyone who is willing to pay the tipping fee. She says they have trash coming from New York and New Jersey. While the tipping fee at the new landfill will be $55 a ton, the tipping fee in Franklin County is just $37 a ton. That difference in cost makes it worth the drive from New York and New Jersey to put trash in the Franklin County landfill.

We look at our watches and realize it is time to board the bus again for the trip to Smith Mountain Gap. It is eighteen miles and takes about a half hour to get there by bus. The students board and we're on our way.

Smith Mountain Gap Landfill

The bus takes Interstate 81 and gets off on the Ironto exit. As we make a right turn onto Bradshaw Road, the warmth of the sun and the lush foliage of the trees are enticing. There are small, neat rambler homes along the road. The rolling hills and the flat pastures seem to play tag with each other. A stream meanders on the right side of the road, swelling into pools and then disappearing to shallow riffles. The first indication of the landfill is a cut in the mountain to our right where the rail line is laid. Even though I've been to the landfill four or five times, I never quite anticipate it's entrance. It's just a graded road lined with small white pines that appears beyond a white bungalow house with a garden in its side yard. There are no signs to tell you it's there.

The bus strains up the incline as we continue on the road through the trees to the top. We come into a large opening. As we stop, the students look down towards a large skeleton of a building. There are large steel girders around two huge black circles. The circles are standing on end. I can see where the rail lines come into the building. Some of the men stop and look our direction. A school bus among the construction equipment must look unusual.

Catherine begins to talk about the building. She points out the five tracks that come into the building. The "huge, black circles" are the rail car dumper, which will be inside the building. The dumper will pick the rail car up, turn it upside down, and dump the trash onto the floor. She says that workers will visually inspect the trash again before it is pushed into haul trucks that come into the building on the lower level. The haul trucks will take the trash its final distance to the open landfill. Catherine reminds the students this is like another transfer station. The actual landfill is up the road. She continues to talk about the landfill's operational design.

Catherine tells what they are going to do with the leachate from the transporting process so there is no negative environmental impact. She says when the floors of the building or the railway cars are washed, they will collect the water and store it in leachate tanks. The train will carry the leachate to the sewage treatment plant and will clean it before the water is returned to the environment.

The students are sitting quietly and listening. Catherine asks if they have any questions. No one speaks. I ask Catherine if she will share with us some of the things the RVRA has done to make sure the neighbors who live near here are happy with the landfill. Catherine explains that people moved to the Bradshaw Road area because it is a beautiful area and it is away from everybody. She talks about the importance of planning with the neighbors and listening to their ideas and concerns. Catherine says the RVRA meets regularly with the neighborhood, takes them on tours, and keeps them informed.

Catherine explains that the RVRA has put into effect many policies for the homeowner's protection. One of those is the protection for their water. People who live within 1,000 feet of the landfill will have their wells tested quarterly. People who live within 5,000 feet will have their wells tested before the landfill's opening. This gives a baseline in case there is a problem later on.

Another protection is for people who live within 5,000 feet and decide to sell their property. If they cannot get the appraised value, RVRA will either offer to pay the difference, or will buy their property. This assures the homeowners they will not lose value on their property.

Catherine says the landfill is designed to not interfere with the neighborhood. People driving on Bradshaw Road will not even know it is here. All truck traffic will be confined to the roads within the property. Operations will begin early in the morning, and will cease in the early evening. Community rooms have also been designed for use by the neighborhood so they can have parties. This brings a ripple of laughter from everyone on the bus. We can't imagine going to the landfill for a party. Catherine says that someone has already approached them about having a wedding reception here.

RVRA owns 1200 acres at the landfill. This allows a large buffer zone around the active section that is approximately 350 acres. RVRA has discussed the possibility of having picnic tables and hiking trails on the property. The neighbors decided they don't want them as they are afraid the park amenities would attract more people to the area. Ed comments that the old landfill has lasted approximately 20 years. He wants to know how long they expect this one to last. Catherine replies, "Sixty to seventy years." A whistle of disbelief goes up from the back of the bus. No one asks any more questions. The driver starts the bus, and we continue up the dirt road to the open landfill.

As we move toward the top, there are drainage ditches on the side of the road. Periodically, the ditch widens and there are pools of water. At we near the top, the trees give way to an open space. It looks as though sky and earth meet. Only after we reach the top and have driven several yards around the rim can we see the excavation of the entire area. The sight impresses me each time I see it. The students "oooh" and "aaah" as they look out the side of the bus. We see trucks and people moving in the bottom of the pit and on the other side.

We decide it is easier to give facts and data to everyone while we are still on the bus. Catherine begins by telling us we're looking at one of four sections. Each section will last approximately twenty years. They will develop the other three sections later. Ed asks, "Are they as big as this and they're just hiding somewhere out there?" Catherine points to the location of the other three sections. She explains to use what they are doing. "Right now in order to meet regulations," she says, "they are lining the landfill with two feet of clay. On top of that will go a gravel liner and a plastic liner. They are working on this 'cell' in sections." Catherine uses a large map to show the location of the completed areas and the location of the cell we're looking at.

She says, "Once the liner is in place, the leachate pipes go in. A drainage system connects the pipes to storage tanks. The leachate is then transported by rail cars to the sewage treatment plant for processing." I point out that we have gone from a no leachate collection system in the old landfill to a very sophisticated collection system at Smith Mountain Gap.

Catherine also explains that in building this landfill they have had to be creative in ways other than just the rail haul system. It seems there was not clay on site for the liner, so RVRA was going to have bring in thousands of truckloads of clay. Instead, they have developed a method for making the clay on site. The workers are taking shale from one section, grinding it up, and adding materials to it to make the clay. Catherine hopes this process will be helpful to other landfill sites that don't have the clay to meet the regulation.

Catherine tells us they will begin to line the landfill as soon as the plastic liner is in. We do not see it while we are there. Ed wants to know what has been done with all the dirt that came out of the hole. "Are we sitting on it?" he asks. Catherine tells us they have taken out about two million cubic feet of dirt and have one million cubic feet stockpiled for daily capping. She also says that as soon as they finish the rail line, which will be in approximately two weeks, they will use the train to bring in the gravel for the roads. This will take the trucks off Bradshaw Road.

As we look at the trucks moving back and forth in the bottom of the hole, there is still confusion about the sequencing of the bottom layer of liners. Catherine gives the sequence again. There will be clay, the plastic liner, leachate pipes, and gravel. Bids for the gas monitoring system will go out in about two weeks. There will also be monitoring wells around the landfill for monitoring the ground water. Catherine now invites everyone to get out and "take a look."

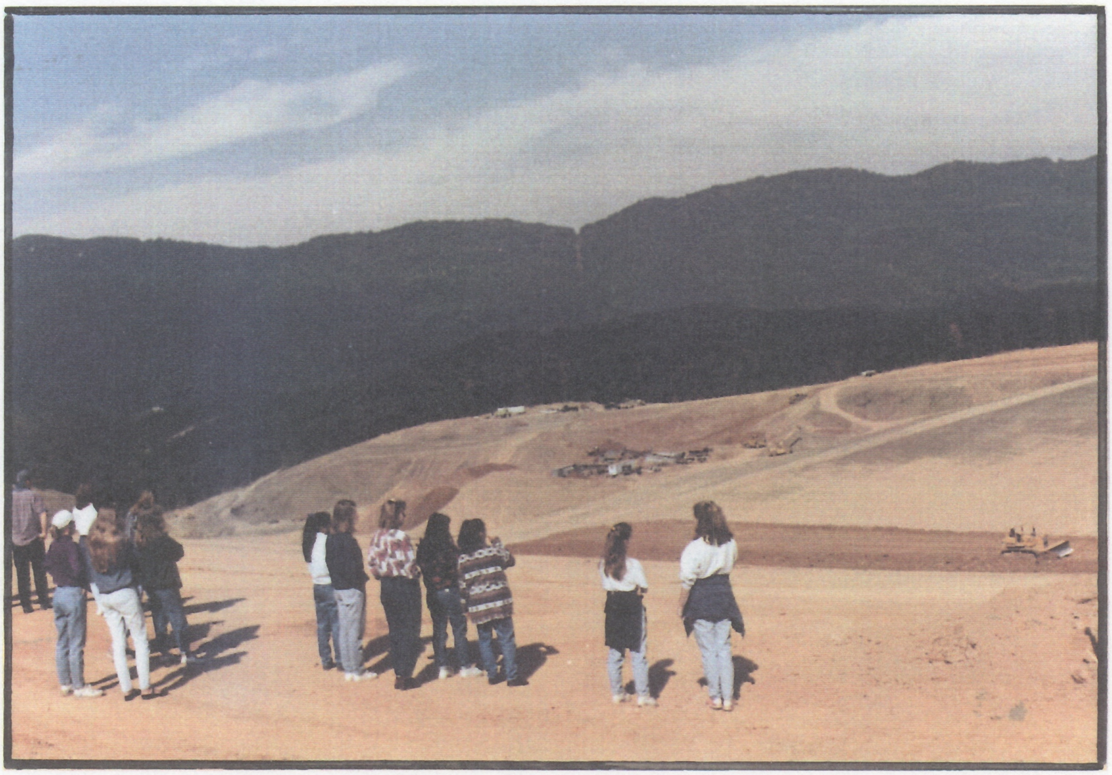


Figure 10. Students Looking at the New Landfill

The students walk to the edge and peer down. The adults cluster in groups of two near the bus. I am right behind the students alternating taking pictures with the 33 mm camera and the video camera. Divya, Kusum, Kavita, and Karen are standing together talking rapidly. They are discussing erosion.

Divya: Okay, once they have filled this up and put the plants and trees and everything, what happens to the erosion stuff?

Kusum: Yeah?

Bea: Erosion is one of the things Mara is looking at because you can't have erosion, so you're looking for a type of vegetation that...

Kusum: Prevents erosion. That's good.

Karen: Do they plant it immediately?

Bea: They plant it shortly after they have done that. Yes. At the old landfill they do it with a hydroseed.

Karen: Right. Do they have any plan if it doesn't take place...do they have any idea what they would do?

Kusum: Oh, no! [A big earth mover roars behind us on the road.]

[Catherine walks over and joins us.]

Karen: Would they fill it up one pit basically at a time? Or would they put a little in each?

Bea: My understanding is that it would be one section at a time.

Karen: One section at a time?

Bea And then when they fill it up...

Catherine: Yeah, they do one area at...

Karen: While they are filling it up they are digging another out?

Catherine: Well, this one will last about 20 years and they'll get most of it ready...

Karen: about the last year...

Catherine: and do sections of it and then as it gets closer to the time...

Karen: So this is the first one to fill up, then?

Bea: (to Catherine) They had a question on erosion.

Divya: We were wondering ways to prevent erosion, what things you all plan on doing to prevent erosion?

Catherine: We have sediment ponds. In fact, we've done a lot of work on them lately [laughter] because we had a real bad rainstorm out here and with this being such a big site, it can be a real problem. We have special ponds, you can't really see them here, but there is one down in there. There are several around here, sediment ponds that collect the runoff and then they are cleaned out just like they were at the other one.

I ask Catherine for clarification on planting the vegetation on a closed landfill. My understanding is that there is a daily cap until they reach a predetermined height. This height decides when an area is "full." They then seed the area. I wonder if that is what going to be happening here. Catherine says they will cap this one like they cap the Roanoke Regional Landfill. Then they will seed it using grasses. They will not use trees because they can get through to the liner.

Divya: Do you have any idea what you **would** do if erosion took place and things started coming back up?

Kusum: Yeah.

Catherine: I don't think that is going to be a problem. It's been scientifically studied and I don't think...we've met all the regulations for holding the dirt, the capping, once we've sealed it off...I don't think it would be a problem.

Bea: I guess what they're asking is if it **did**, what would you end up having to do?

Catherine: Whatever happens, we have to fix. If something goes wrong, we have to fix it. If something is put in here that is later declared something you can't put in a landfill, then we have to dig it out. So that's why you have to be real careful about what you put into the landfill.

The discussion turns to trying to understand the composition of the plastic liner. John says one of the students wants to know how thick it is. Catherine tells us," It's real heavy material, not really hard, but it's real heavy." "Are the strips sealed together somehow?" asks John. Catherine says workers will place the plastic over the entire area. They will roll it out. She was hoping that they would have started it so we could see it today, but they haven't. One of the boys asks, "It won't rip?" Catherine tells him it is very heavy and it doesn't bend a whole lot...very firm. "Oh," responds the boy, "like hard plastic." "It's not like your plastic bags type," responds Catherine. She walks to another group of students. Ed asks if the plastic comes in rolls? "Yeah," says Catherine. "It comes in real big rolls...I don't know where it is. It's real thick. It's hard, like a board, almost." Ed says, "I was picturing it as being kinda 'trash-baggish'."

Jim asks Catherine if the trash coming into this landfill will be in those "blocks" or will it just be "thrown in there?" She says they will just dump it all in. "Well, will it be compacted?" he asks. She says, "No, they will just run over it with bulldozers."

We continue to stand and look into the hole trying to comprehend its size and imagine it being filled with trash. John says the scene reminds him of a strip mine he has been to...kind of bare. "How long did it take to dig this hole?" asks Jim. Catherine says they have been working on this for probably a year and a half. "God!" he responds. As the students begin to look away from the hole and at the mountains around them, they notice that two houses have a view of the landfill. They figure the people in those houses must not be too happy. "It sucks," says one boy. Ed asks, "Are all four holes as big as this that you're going to be using?" Catherine nods yes. I comment, "There is no way you can imagine how big this is until you come out here." "I can't picture filling it...with just trash," replies Ed. "I can't imagine...I'd like to sit in the bottom in the deepest part and look up," says Jim wistfully. "It'd be good for sledding!" says another boy. "Huh! I'd like to bring my 4-wheeler out here!" retorts another.

Another look at our watches tells us we will need to leave to have time for lunch and return to school by 1:30. We load into the bus and head back toward Roanoke. The discussion for where to stop and what to eat replaces the earlier discussions of landfills and trash.

Explore Park's Perspective
October 8, 1993

It is 9:30 Friday morning, and Ginny Laubinger's talk to the students will be the culmination of a busy week. We have introduced the unit, gone on a field trip to the landfills and today Ginny, who is the Environmental Educational Programs' Coordinator from Explore Park, will speak to us about issues surrounding landfills and Explore Park's stake in this project. Ginny has brought slides to share with the class. Even though she accompanied us on our field trip yesterday, I'm not sure the students realized who she was. Ginny went with us because she had not seen the new transfer station and the landfill at Smith Mountain Gap. She thought the field trip would enhance her knowledge and help her better structure her talk to the students.

John introduces Ginny. She walks to the front of the class and shares with us some of her background in science and in teaching. "I was asked to talk about the effect that the landfill has on Explore Park." She briefly describes the location of Explore Park saying they are "downhill from both the landfill and the sewage treatment plant." She states the effect of the landfill on Explore Park is much more apparent than the effect of the sewage treatment plant. She says she also believes the water in the Roanoke River is fairly healthy because of the wide variety of fish they see in the river that runs two and one half miles through the park.

Ginny begins by addressing questions she heard raised by students while on the trip yesterday. A student had asked about odors coming from the landfill. Ginny says that Explore does not have any problems with odors. Even though the landfill is only one mile away, Ginny thinks the odors have dissipated by the time they get to Explore.

Someone also asked yesterday what effect does the landfill have on wildlife. Ginny tells us that it is not unusual to have a variety of animals come to the landfill to see what they can find. However, the nightly capping with dirt is intended to discourage animals from scavenging the trash. Ginny reminds us of the turkeys we saw yesterday at the landfill. She says the turkeys were looking for food. Ginny goes on to tell about other animals in the area. She says that workers at Explore have also found two turtles that have deformities. Ginny is not sure if the deformities are genetic or due to something else. They continue to check the turtles they find at Explore.

Ginny's Slide Show

Ginny begins to show her slides. She explains some of the problems they have being "neighbors" with the landfill, including the problem of tires dumped in the landfill. She tells us that in Franklin County, they slash their tires before being landfilled. Ginny asks the students if anyone knows why. One of the girls comments that air gets in them. Ginny explains when tires are not slashed, they slowly work their way back to the surface. She voices her surprise when Randy said yesterday that the Roanoke Landfill does not require their tires to be slashed. Ginny explains tires are a problem on Explore property. She estimates there to be between 500 to 600 tires in the woods between the landfill and the Roanoke River. Many of them fill a ravine and are very unsightly.

Ginny shows pictures of the topography of the surrounding area. She talks about the importance of slopes on the landfill being "engineering stable," even though they may not necessarily conform to the topography of the land. Because of the steepness of the slope, erosion will often occur before workers plant grass on the slopes. She explains even when grasses have been planted and have germinated, they may have difficulty growing. Often the water runs off the slope with such force that it bends the grasses over.

Ginny reminds us what Randy said on the field trip about runoff. He said that to address the problem of runoff, sediment ponds have been installed around the base of the Roanoke Regional Landfill. As the water runs off, it carries with it dirt and silt. Ponds are periodically dredged to keep them from filling up with silt. They take the silt to the top of the landfill and deposit it. Ginny explains the problem. Where there are no ponds to catch the runoff, water carries the silt into the Roanoke River. Silt that is not carried into the pond or river may be carried down the slope toward the forest. When it reaches the tree line, the water slows and deposits silt around the base of the trees. This covers the roots and eventually smothers the trees. Ginny shows pictures of trees on Explore's property that have silt deposited at their bases.

Another problem with the landfill, Ginny tells us, is the blowing of lightweight plastics. The air carries the plastics into the river or the woods. We see pictures of plastic hanging in trees and sticking out of the ground. In April of 1992, Explore had a clean-up day. There were sixty people working both sides of the Roanoke River for a one-mile section. Ginny says they picked up nearly 6,000 pounds of trash. Some of this trash was wind blown, some of it dumped, and some of it carried down by the river.

Ginny also tells us that Explore has two ponds that have felt the effect of the landfill. The two ponds are connected by a stream, and there is a dam at the base of the second pond. The top pond catches the effluent from the landfill. "When we had the heavy downpour in April 1992," she says, "there was so much water from the landfill it blew out the dam of the lower pond. The pond is not as deep as it originally was, and succession is taking place." Ginny shows another picture of the second pond where it runs into the Roanoke River. She is concerned because it has a milky sheen on it. When students came out last year to do the *Save Our Streams* program, they found no macro-organisms in it.

Ginny also knew John had two students who studied these ponds and streams in Explore last spring. She asks him what they found. John says they did a pesticide analysis and did not find anything in the water. He acknowledges maybe it is an intermittent problem. Ginny agrees saying it is important to test an area more than once.

She strongly encourages someone to take this stream as a project and monitor it on a regular basis.

Ginny says she cannot tell what the long-term effect of the landfill is going to be on the area around Explore until they do some soil testing and ground water sampling. This will be done once they close the landfill. If pollutants are found, the Resource Authority will be responsible for cleaning them up.

Recycling

Ginny feels recycling could handle many of our trash problems. She asks for a show of hands of students who recycle at home. A majority of the students raise their hands. She talks about recycling glass and aluminum. She explains that glass is 100% recyclable whereas aluminum is 95% recyclable because some is lost in the process. Ginny talks about the process of recycling paper. She tells us that it can be recycled; but each time it is, the fibers get shorter and shorter. Since short fibers don't "hook together very well," virgin paper must be added to give the recycled paper strength. Ginny asks for a show of hands of students who are writing on recycled paper. A number of hands go up, but not as many as when she asked who recycles. Ginny explains it is good to recycle, but there must also be a market for it. If we don't buy recycled products, there will be no outlet for the things we take to the recycling center.

Ginny talks about the numbers on the bottom of the plastic containers. She asks the students how many different numbers are there? They do not know. She tells them there are seven. Ginny explains these numbers represent seven different categories of plastics. She asks, "What kind [of plastic] does Roanoke allow you to recycle?" The students tell her numbers one and two. Ginny says Roanoke no longer takes number two colored plastics because there is no market for them. "Right now," she says, "we can recycle number ones and clear number twos."

The problem of over packaging is another issue in landfilling. Ginny tells us some products have several different layers of packaging. She gives an example of packaging for macaroni salad. She explains, "There is the cardboard box the macaroni comes in, the plastic bag in which you boil the noodles, the aluminum lined package which the seasoning comes in, a metal can with vegetables, and a plastic container that has mayonnaise in it." She continues, "There are five things to throw away; we are a 'throw away' society. It is going to take a different mind set and a changing of your concept as to the materials that go into that landfill."

It surprised Ginny yesterday when Randy said that the Roanoke Valley Resource Authority was not going to go through the trash at the transfer station for recyclables. They are going to rely on the consumers to pull out the recyclables at home. She tells us that in New York, they are trying to cut down on the amount of garbage by limiting the amount the residents can throw away. Above a certain amount, the homeowner is charged extra, but they are not charged for the collection of recyclables.

John asks Ginny if she thinks closing the landfill will solve most of Explore's problems. She answers, "Yes." She also says that the problems with the dust will be gone once vegetation is planted. Ginny explains that erosion will be stabilized because "mother nature finds just the right angle that is necessary to keep erosion from taking place." Once grasses are established, the sedimentation problem will correct itself. Ginny is mainly concerned with the ground water and the long-term effects on it. People throw away things without thinking about their impact: fingernail polish remover, hamburger helper that has heavy metals in it, and car oil.

Karen asks, "Who will maintain the land or the use of the landfill once its..." "been capped and closed over?" finishes Ginny. It is Ginny's understanding that Explore will be given use of the surface of the landfill, and the Roanoke Valley Resource Authority will continue to monitor what is going on underneath. They will monitor both gas and ground water.

Articles on Landfills

Ginny asks John if he has shared with the students any articles about studies on landfills. He says he has not so Ginny continues to tell us about several. One is the archeologist from Arizona who has been studying landfills for years. He digs up newspapers from the landfill that date back to 1952 and finds they are still intact and easy to read. The archeologist has also found corn on the cob from the same layer as the 1952 newspaper. Ginny tells about other exciting things happening at landfills, such as using methane gas for heating. She asks how many students have heard of the controversy involving Tarmac Cement Company. No one raises their hand. Ginny discusses how Tarmac wants to burn tires, which produce high BTUs. The ash from the tires will be taken to the landfill. The energy produced will be used to run Tarmac's generators, and any surplus will be sold to the electric company. She says this will benefit everyone because it will get rid of the tires, reduce what is going into the landfill and produce energy. However, the people who live near Tarmac do not want this operation near them because they are afraid to take a risk with air pollution from the incineration.

"So," Ginny asks, "what are you going to do if you can't incinerate, and you're running out of landfill space?" The alternatives are reusing, reducing, and recycling. She tells about one person who has figured a way to reuse. He takes milk bottles and melts them down to make long thin threads. He then weaves the threads together to make cloth, and from the cloth he makes clothes. These clothes are soft and have the feel of cotton. They do not wear out and do not stain. When you get tired of them, you take them back to the store and they buy them back. They melt the clothes down, thread is made again, and the cycle starts over.

Ginny recalls an incident when she taught school several years ago. One of her students suggested a method of reuse. This student suggested taking refillable containers back to the store and filling them up. The product would cost less because the consumer will be given credit for reusing your container. I interject that I was in a grocery warehouse in Nova Scotia in 1987 where you could refill your 2 liter soft drink bottles and syrup bottles. Ginny says it is also being done in the states, but she doesn't say where.

Ginny finishes by saying we're going to have to look for alternatives because we are limited by the things we can do on top of a landfill and no one wants to live near one. She predicts plastic clothes and refillable containers are in the near future, and students from this class will be the generation that will have to help solve the landfill problems.

Field Trip to Explore Park

The remainder of the class period appears to be a departure from the trash and landfill topic. She spends time talking about the field trip to Explore next week. [It is not until we visit Explore and the students write in their journals that I realize the importance of this classroom event. These findings will be discussed further in the analysis and interpretation section.] John had arranged with Ginny to have the class go to Explore for the Society of Foresters' hike and talk. John thought it would be informative, and the students would get an opportunity to see what Explore is about. John asks Ginny to tell the class what they will be doing on their trip to Explore next week. Ginny says the foresters will be there, and they will be talking about the role that forests play in wildlife and the role of forestry over time. She explains some of the activities students will do is estimate the heights of trees using Biltmore sticks. They will also do increment borings to determine the age of the tree and what the weather was during the tree's life.

Ginny tells the students if there is time, she would like for them to visit the Blue Ridge Settlement. Ginny says this is a "selling job" because originally the park was supposed to have been similar to Busch Garden and King's Dominion. This has changed and now Explore is envisioned as "a place to trace the environmental component and man's effect on that environment." She tells us that at the settlement there is currently the Hoffhauger house and the Wrey barn. Another barn, built in 1828, is coming from Salem and an old school house that was constructed in 1861 from Franklin County. Through this field trip, Ginny says she hopes the students will learn about forestry and the mission of Explore Park.

Mara's Presentation
October 15, 1993

Mara will give a presentation about her work on the landfill. It is her first day to meet the students, and she is nervous because she has had little previous experience with high school students. She also knows I will be video taping. We will be working at the Governor's School, and six students from Ed's class at Patrick Henry High School will join us. These are students who have expressed an interest in doing independent activities on the landfill for their science fair projects.

John introduces "Ms. Sabre" to the students and tells them she is a graduate student from Virginia Tech and has been working with plants on the landfill. He says that she will share with us what she has done and will help us with recommendations on things we're going to be doing in the classroom.

Mara requests that the students call her "Mara." She launches immediately into telling the students about the hydroseed mixture that is normally sprayed onto the landfill when they revegetate it. She explains unless she recommends an alternative to the Roanoke Valley Resource Authority, this standard mixture is what they will use on the 265 acres of the landfill once it is closed. After giving this brief description of the problem, Mara engages the students in a collaborative, creative activity.

Designing a Landfill

Mara explains she would like for the students to work together as a table. Each group has a large piece of paper and several magic markers. They are to decide among themselves what they envision happening to a landfill once it closes. The students are to use the markers to illustrate their design. Mara begins with this activity because she wants students to think about the overall possibilities for use on a closed landfill. She also wants to allow them full range of their creativity. Students will share their designs when they finish. Mara asks how long do they need to do this? Five minutes? John says, "Why don't we make it ten minutes to brainstorm?" He clarifies directions. "You want to make a beautiful landfill. So what are you going to do with that? That's the general idea, right?" I remind them of the pictures they saw of closed landfills in other parts of the United States. Mara tells the students they can draw a picture, write a poem or a song to illustrate their design.

I have been maneuvering around the room with the camcorder and tape recorder trying to decide the best way to gather my data. To be as inconspicuous as possible, I video tape from the back of the room. When tables are working collaboratively, I decide to use a small tape recorder at the table to record the students' conversations. I choose to place the tape recorder at the first table. I ask if I can put it there to get the discussion that goes on while they decide what to do. "Yeaaaah, sure!" says Divya. "Yeaaah, all right!" says Kusum. I tell them they can pretend it's not there. "Okay. [Laughter.] "We'll just cut it off," says Kusum as she laughs. I have chosen the *Soil Compaction: Grasses* table because the girls have been very friendly to me in the short time I've been here, and they are very out-going.

The girls begin by trying to decide what they want to put on their paper. "Do you want to draw a mound?" asks Kusum. They are not sure. They try to remember what they saw in the pictures on restored landfills I showed on Monday. Kusum remembers a greenhouse. They wonder if they are to include vegetation as part of their design? Kavita calls Mara over to the table to verify directions. Kusum asks whether they are to decide types of vegetation, or use of the landfill. Mara tells them that they can do either one first. The girls decide to "go ahead and draw a mound."

Kavita asks if they want to title it? By giving it a title, they say it will give direction to what they draw. They give several suggestions. "There is trash under here." "Out of Sight, Out of Mind." "The Underground Trash." They finally choose "The Hidden

Trash." They continue drawing and decide to put grass on top of their mound. Kavita asks if they are going to also add a forest, swamp or marsh. "Swamp," says Divya. The discussion returns to the greenhouse and whether they want to include it. "We could just **build**," suggests Kusum. Mara tells the class they have five minutes left.

They try to integrate vegetation and buildings. Divya reminds them the vegetation can't have very deep roots. The girls suggest planting wheat, corn, or turnips. Kavita and Divya admit they don't know much about agriculture and vegetation. Kusum finally turns to John and asks if corn has deep roots. He replies, "No." Kusum asks John, "How can we [draw some type of vegetation] when a lot of us don't know a lot about vegetation?" [Laughter.] John suggests they might like to have a little forest in one area.

The girls like the forest idea and decide to draw a park. They draw swings, benches, and children. They include bushes, flowers and pathways. Kusum and Kavita continue to discuss where the pathway should go. Suddenly Divya makes a new suggestion.

> *Divya*: What else do you want? Like do you want tombstones and stuff like that?
>
> [Kusum can't believe Diva has thought of something so unique.]
>
> *Kusum*: A graveyard! Noooo!
>
> *Kavita*: Perfect! I can't believe any of this!

The girls become very excited with everyone talking at once. Kusum exclaims, "Nobody would have thought of that at all!" They stop working, get another sheet of paper, and begin again. They quickly draw a mound. Divya tells them to not make it too high. They then try to decide what is under there. Trash? Dirt? Clay? Soil? Kusum says it is soil. Kavita says it is clay. They decide to go with clay and trash. They put grass on top.

As they begin to visualize what they want, Kusum begins to draw tombstones. They have a lively conversation about the names to put on them and the year. Mara reminds them they have approximately two minutes. Kavita asks Divya why she is putting RIP on one. "Rest in peace," Divya replies. Kavita reminds them they need to put "little flowers" on the tombstones. They have difficulty in deciding what dates to put on the tombstones. The conversation shifts to what they think happened to each person.

The girls laugh and talk so much that Bob, at the *Soil Compaction: Rooting Depth* table, leans over and interferes with their work. "Bob! Bob! Stop!" says Kusum. Kavita decides it would be good to put Bob's name on one of the tombstones. She also asks if they should add "bats" to the picture. Divya says, "No." Kusum decides it would be great to add buzzards. Bob likes the picture. The girls have been laughing and talking rapidly since they switched ideas for their landfill. Suddenly Divya says, "That's soooo ugly." "Who cares?" asks Kusum. "This is like a last minute decision."

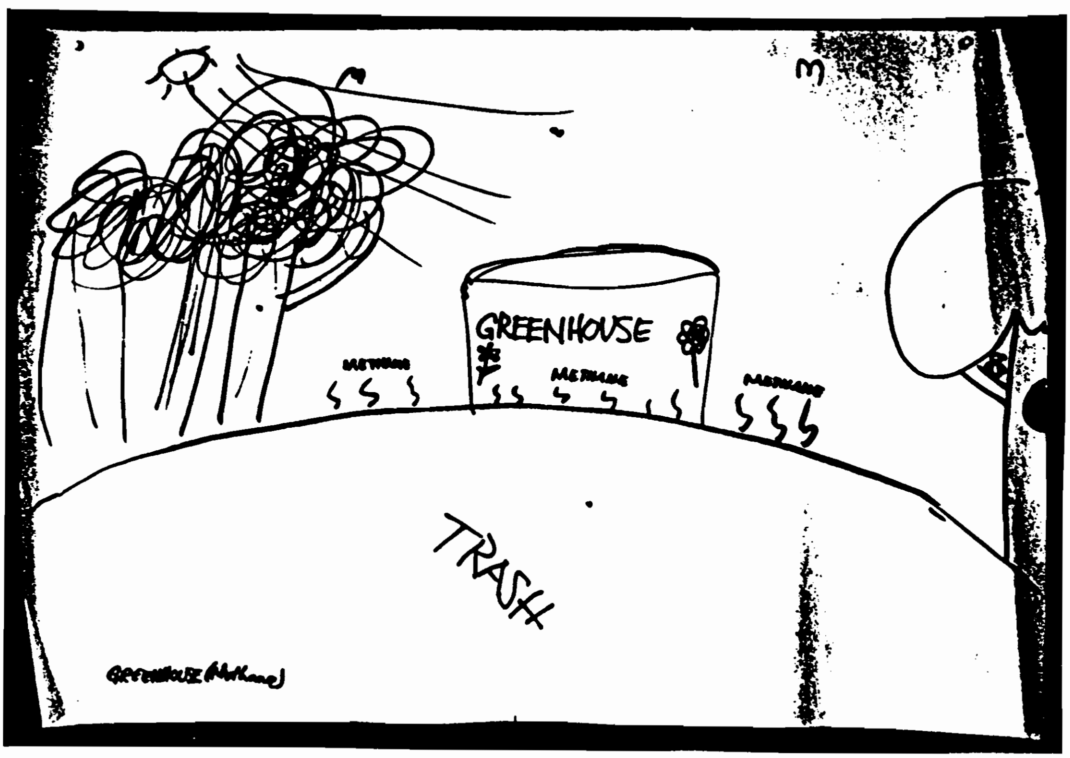
Bob has a magic marker and he is beginning to mark on their paper. The girls get upset with him and tell him to stop! Bob's first argument is that they are not giving him any flowers [on his tombstone]. They continue to work and try to get him to go back to his table. Bob keeps repeating, "It's not like it's for a grade or something like that." The girls, knowing they have little time left to work, appear to be getting flustered with Bob. They put some dates on the tombstones that are in the 1800's. Divya comments "I don't think the landfill was even there, then." They decide to change them to the 1900's and finish up by drawing a pathway.

Sharing Designs

Mara tells them they need to come together as a class so they can share their table's design. At this point, John facilitates the discussion with each table. He calls on each table to stand and describe what they have drawn.

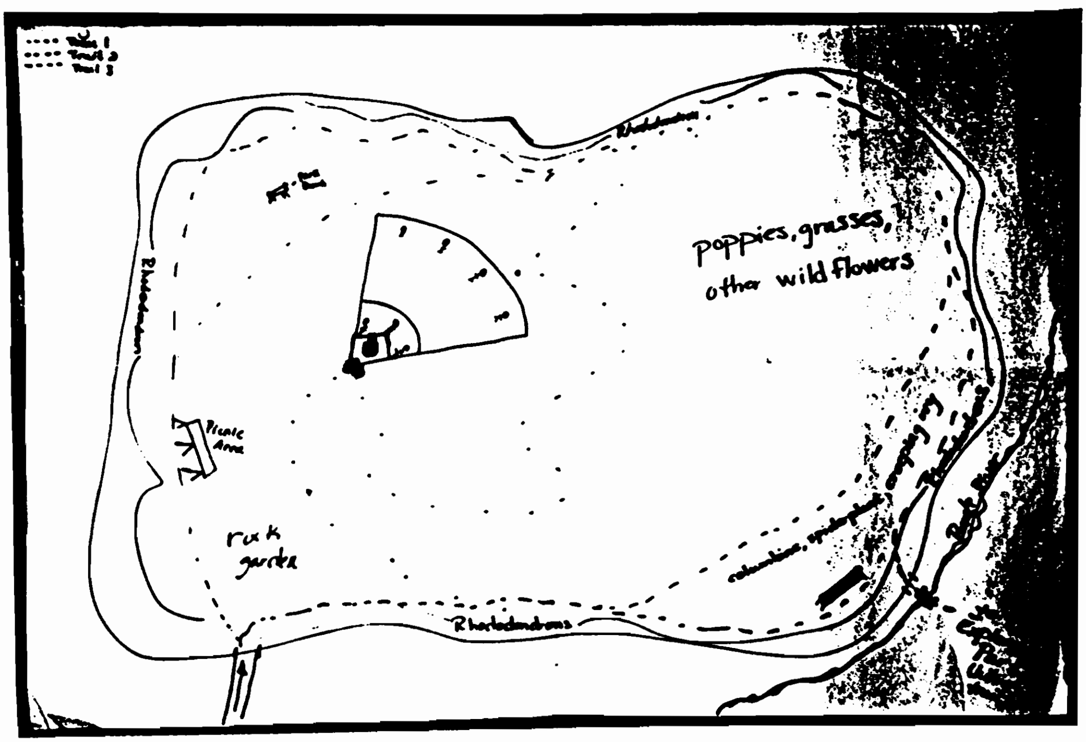
Soil compaction: Grasses table. Divya explains their first picture. Kusum has her back to the class, but laughs as Divya talks. They have drawn a mound with a swing set and children playing on top with trash below. "The first one [picture] is just a park on top of the trash," says Divya. "And the second [picture] is like...a graveyard." Kusum laughs. "It's like dead people wouldn't really mind," continues Divya. Kusum laughs again. One of the students makes a comment about "Zipping off on down to see the dead people." John asks no questions and says "Thank you" when they finish. [They tore up their drawing at the end of class.] Bob, the spokesperson for the next table stands to share their drawing.

<u>*Soil compaction: Rooting depth* table</u>. "We decided to make a methane generated greenhouse since there is so much excess methane in the landfills," explains Bob. (See Figure 11.) He says since there is so much methane coming up from the trash they could use it to heat the greenhouse. Bob says, "They did something like this in San Francisco." As he sits down, John points to the next table.



<u>Figure 11</u>. *Soil Compaction: Rooting Depth* Landfill Design

<u>*Hydroponics* table</u>. The *Hydroponics* table decides to make a giant park. Karen points to the different paths around the park (see Figure 12). There is a baseball field, picnic areas and park benches. They have a large meadow area with poppies, grasses, and wildflowers. Planted beds of Columbine, Spider Plants, and Creeping Ivy are at one end of the meadow. An edge of Rhododendron encircles the entire park. Karen says they also designed a path leading from the recreational area to Explore Park so there is access between the two. David says he wants to put in a golf course, but the girls won't let him. The class laughs, and Karen sits down.



<u>Figure 12</u>. *Hydroponics* Landfill Design

Slope study table. Karla says that they went the creative route. They did their picture in segments, like a comic strip (see Figure 13). The first segment is a play land or amusement park. Karla suggests it be called "Landfill Play land." The second segment is a picture of flowers and trees. Karla says there is always the option of returning the landfill to nature. Segments three says, "Education." Karla says there could be field trips so people could see how a landfill is operated, it's uses and the waste disposal system. The fourth segment has a drawing of a cow with six legs and three tails. Syann says she wonders about the effects on animals after she heard Ginny talk about the deformed turtles found at Explore park. In segment six, there is a sculpture park. Syann also came up with an idea for a Christmas Farm. The girls say the money from the amusement park and the Christmas Farm will help support everything else. [The picture of the cow was torn out before the paper was turned in.]

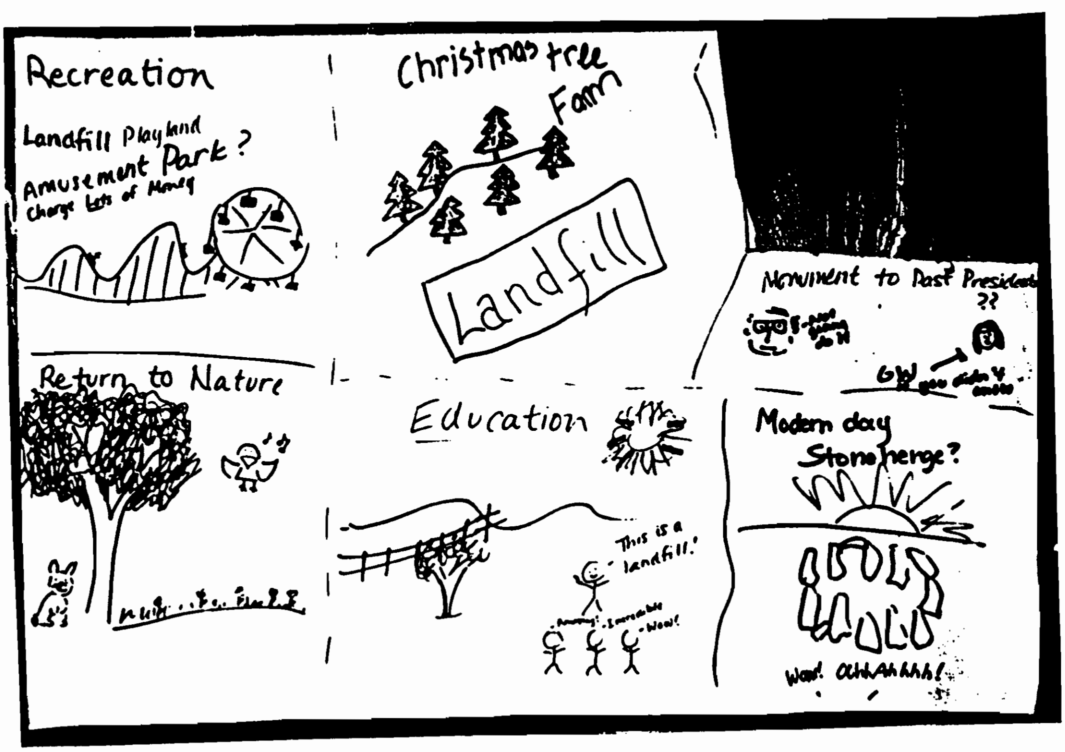


Figure 13. *Slope Study* Landfill Design

John asks them what would be a major problem with building an amusement park? Karla answers quickly, "It's very unsteady because of all the trash." "But," she continues, "they're building the parkway on it, I've discovered." John turns to Mara and asks her if the parkway is being built over the undisturbed section of the landfill. Mara answers, "Yes." John explains to the class that the parkway will be on the edge of the active site. He then calls on the next table to present.

Grass and wildflower aggression table. This table has colorful pictures around the edge of their paper. At the top is the title *A Recipe for One Beautiful Landfill* (see Figure 14). Karol shares their ideas, which sound like a poem.

Figure 14. *Grass and Wildflower Aggression* Landfill Design

"Put in one big smiling sun and three hundred miles of happy bright flowers with six hundred playing children in: sandboxes, swing sets, big wheels and bicycles. Lots of birds and animals, big trees to sit in, and vegetables and fruit to eat." They say that they envision a giant park where people can go, relax and enjoy themselves. John thanks them and asks the last table to present.

Temperature effects on plants table. The class laughs when Jon stands and holds up his table's picture. (See Figure 15). There are drawings over the entire paper. It is very difficult to distinguish anything. "There's my house," says Jon. [The class laughs again.] "And we've got some trees." "There's a cow, I see it," responds a girl. John asks them if they have a point in what they are doing. Jason says, "Uhhh, yeah. We've got some trees down here, some grass here." John tries to help them focus by asking questions.

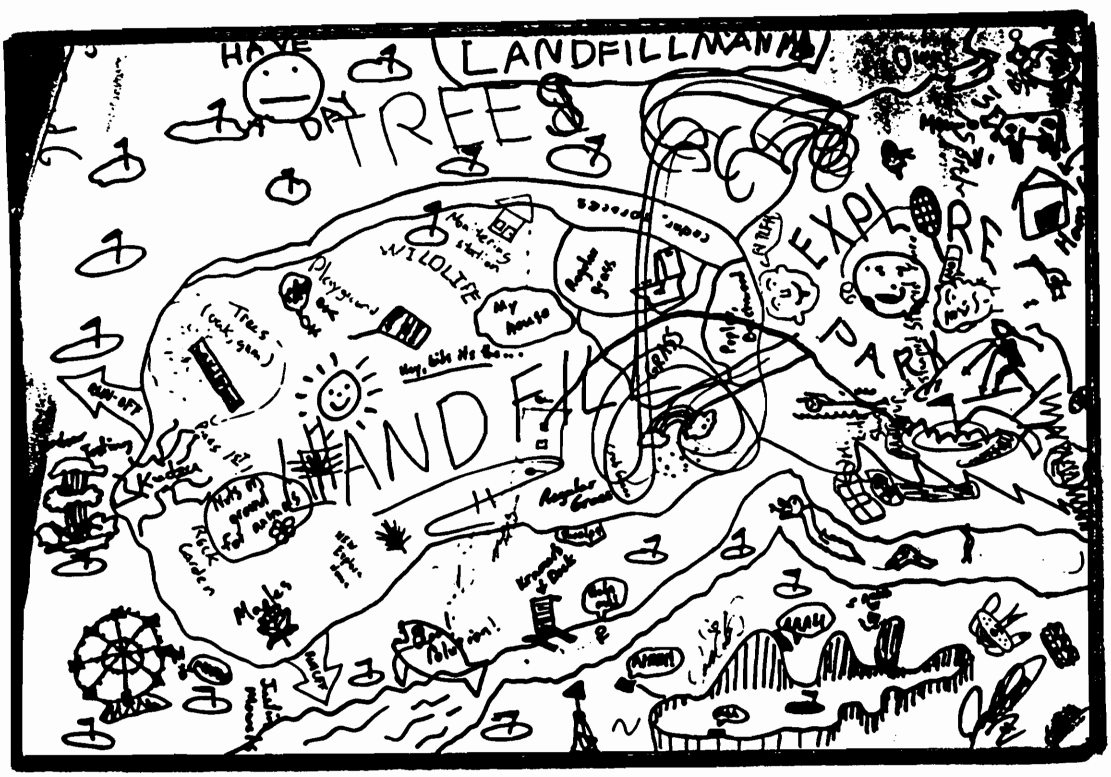


Figure 15. *Temperature Effects on Plants* Landfill Design

"So you have a mixture of different ecosystems there? How do you envision people coming in and using it...or wouldn't it be?" Bill, the more serious member of the group, makes a statement. "I think if people **really** knew what it [the playground on the landfill] was, I don't think they would want to come in," he says. John tries to salvage something from the group. He comments, "At least from a distance it would be aesthetic to look at." John calls on the students from Patrick Henry.

Karri is their spokesperson and says that they decided to fill in the landfill and "have lots of animals on top." John tries to get Karri to expand. "So you're just going to turn it back and keep people out and let animals take over?" "Yeah," she answers. John continues, "What kind of vegetation do you need for the kinds of animals you have? You need woods or grasslands?" "Yeah," says Karri, "we had woods, marshes, and lakes." John finishes, "So you put in different habitats for the different animals. Great!" he says.

John steps back, and Mara continues with her presentation. Mara explains when she first visualized what to do with the landfill, she thought of a meadow. She shows her drawing and explains that she has only two years in which to work because that is how long her project is funded. [She is in her second year.] During that time she hopes to try to establish fifteen different native species on the landfill. Her question is, "Will the plants grow, or won't they?"

Problems on the Landfill

Mara says her first concern when beginning to work on the landfill, was what type of plants to get. Should they be native or exotic? Native plants, she tells the students, are plants that developed on the continent of America or came in so long ago that they are said to be native. She explains that these plants have adapted well to the soil, climate and ecosystem. "However," she cautions, "it is important they don't out compete other native plants." Mara goes on to explain that exotic plants are plants that we have introduced to America. "An example is the kudzu vine," she says. Kudzu was introduced in the 1930's with the idea of using it in coal mining areas to help stop erosion. It was brought from the

Orient, and it was cheap. "Unfortunately," Mara shares, "the kudzu vine kills other plants because of it's tremendous growth. It can grow at a rate of over one foot a year and shade other plants so that eventually it kills everything."

Mara says her second problem was to locate a source for her seeds. Once she decided the plants she wanted to try on the landfill, she looked through seed catalogues. Many of the seed companies do not carry native wildflower seeds. This limited what she could use.

A third problem Mara had was with regulations. Last year the landfill operators told her the capping layer would be two feet of heavily compacted sandy clay. The landfill manager said she could plant anything as long as the roots did not penetrate that clay cap. Trees were definitely out because of their rooting depths. She felt a meadow would be fine because she would be using grasses. However, she discovered that many grasses have roots as deep as six feet! So, she needed plants that give good cover for erosion control and whose roots stop at six inches.

Mara tells the students she chose fifteen different types of native species. She says that the standard landfill mixture uses seven types to revegetate, and some of them are exotic. It was important to do test sites to compare the seeds. She picked plots that faced north, south, east, and west. She chose different slopes to plant them. Mara says that the viability of the seeds on slopes is important because 60% of the 265 acres are at a 25° slope. She is pleased because the preliminary results have shown that ten of her fifteen species have survived, while only two of the seven standard landfill mixture have survived. Mara says her mixture also has a high habitat diversity. Bees, butterflies, and insects like to visit her plants.

As of now, the Landfill Authority Board is going to cover all acreage with two feet of capping clay. This means they will cover the test sites Mara has been working on. Her annuals came up this year, but she will not be with the project long enough to see the perennials.

Mara now moves to the second part of the activity. "Our question to you is, with what you have as far as your pictures are concerned, and with all the information I've given you...think of what kind of activities you would like to do to see whether your ideas would be feasible ones on the landfill."

John delineates the task. "You've designed something as a utopia thing. Now go back and look at what you've designed and look at what are the advantages or disadvantages to constructing it and maintaining it on that particular landfill." This makes the students look critically at their design and decide whether or not it will work. I go back to the table and turn the tape recorder on.

Soil Compaction: Grasses dialogue. Divya, Kusum and Kavita are already deep into conversation. They are talking about the amount of money it will take to revegetate their landfill after it has become a graveyard. Divya tells them if they need more money, they'll just ask for it, but that it won't take as much money as it would if it weren't a graveyard. Kusum tries to explain:

> Right. Anyway. The people who are concerned about the money don't have to worry about spending the money because the people who are putting the bodies in have to be the ones spending the money to...don't you have to pay [to be buried in a cemetery]?

They decide they do not need trees, only grass. "Just make sure it doesn't have long roots," reminds Kavita. Kavita also says there will be revenue coming in because "it's not going to be like a park where people come but they don't pay anything." Divya is confused. She is not sure whether they are doing the park or the graveyard. Kusum says they are doing the graveyard. She gives as her reason:

I think the graveyard is a good idea. Because it's not hurting anybody but its not, you know, making anybody feel great because the person is dead, you know. They can't feel any emotions. I mean...

Kusum and Kavita decide even if they have "methane and stuff," it is not going to hurt the people that are buried there. Conversation turns to the problem of erosion. They do not feel the grass will keep erosion from happening. Divya says she thinks most of their expenditures will go to adding soil to the top of the landfill so it would be deep enough. This makes Kavita think about the amount of dirt they will need to bury someone.

Kavita says, "They have to go down more than **two** feet! More, I bet. Even though the coffin may not be that big, height wise... they still make you, they don't want..." Divya interrupts with a question about "support." She is not sure they will have enough dirt to support the weight of a coffin, a body, and a tombstone. Kavita says not to worry because the bodies will "erode." "Well, is that good or bad?" asks Divya. Kusum thinks it will be good because there is no interaction and nature won't be disturbed.

Ruth, from the *Soil Compaction: Rooting Depth* table, asks the girls whether there will be any erosion going on. Kusum responds, "Yeah. Do ya'll have a lot? [Ruth nods yes.] Yes! Way to go, Ruth. You're thinking!" Bob has also moved near the girls' table. They feel he is interfering. Kavita says to him, "You're not getting any ideas from us, Buddy!" Kusum tells him to get back to his table. Divya says the amazing thing about their design is "no one is going to get hurt." Kavita is beginning to wonder whether a graveyard is such a good idea. Divya echoes Kavita's feelings. However, each time Kavita starts to talk, Kusum finishes Kavita's sentence saying why they **should** do a graveyard. Kavita comments again about the large amount of soil they will be adding. Bob is still listening. He interjects, "But you can't do that! It's going to cost a lot of money!" Divya retorts, "But it's not like a Michael Jordan type of family that would..." "That's **good**!" says Kusum. "A cemetery for the homeless!"

The girls argue with Bob whether or not they can do this. Kusum thinks the landfill would be a good place for homeless people because they don't have any family. Divya wants to know how will they be able to distinguish between someone who is homeless and someone who is not. Bob again says he thinks this is a "dumb idea." Kusum says, "I know. Thanks, Bob. We're just thinking. We're brainstorming! This is what you do. You express your ideas." Divya has now decided Bob may be right. She says that what they are doing is "stupid" because they are going to need so much extra soil, which will require more money.

Sharing Advantages and Disadvantages

John calls for the class to come together and share. When he calls for the *Soil Compaction: Grasses* table, Kavita again is the spokesperson. She says her table decided the advantage to having a graveyard in the landfill is that they will not be spending money on building greenhouses or sculptures. Their money will go toward buying extra dirt to cap the landfill. They expect to get this money from the revenues they receive from the sale of the burial plots. The other advantage is their graveyard will not be hurting anyone. The only disadvantage they see is their need for additional dirt beyond the required two feet.

Each table shows their design again and gives several advantages and disadvantages. Some answers show thought. Bill, from the *Temperature Effects on Plants* table, continues to be adamant about the fact that you can't disguise a landfill. He would not want to play on one, and he thinks once anyone knew what was under the ground, they wouldn't want to be there either!

The students begin to see the problems they might have with their idealistic designs. John explains that the steps they are going through are similar to what one must do when faced with studies in scientific research, engineering, or medicine. He tells them if they go into these fields, they will sit down and write their big ideas down before they start a project. They will then begin to focus on what they're going to do, given whatever constraints they might be facing. John says this is the same thing that has happened in Mara's study; it has been necessary for her to narrow and focus because of restrictions and restraints. The final research project will probably be a small piece of the original conception. John states, "This is the way research is done."

Project Constraints

John again makes the analogy between what students will have to do when faced with a project involving scientific research and what we have been doing this morning. He explains that the focus narrows each time as more constraints are imposed on the project. John gives the students two constraints which they will be working while doing the landfill studies. The constraints are:

1. We'll be working with plants.
2. We'll be growing plants indoors under fluorescent lights in small environments.

There will also be significant variables. John asks the students to help list the variables they have talked about this morning. The students list:

1. Root depth
2. Erosion
3. Slope angle
4. Money available for use
5. Soil type
6. Soil compaction
7. Sunlight
8. Water

9. Methane emissions

10. Interspecies competition

11. Native or non-native species

John shares with the students the activity we will do at our next class. Each table is going to be responsible for designing and conducting an experiment using plants. Monday, Mara will tell the class about her experimental plants and the Virginia Department of Transportation (VDOT) plants and their characteristics. Students will be responsible for going through the seed catalogues and deciding what species they want to try. They can choose seeds based on the restrictions and requirements the species will encounter on the landfill. Once the students have designed their experiments, they need to list the plants, containers, and the type of dirt they want to use.

There are about three minutes until the bell rings. John tells the students we've had a busy and productive morning. Everyone relaxes with casual conversation. Mara and I will return on Monday, and students will begin to design their experiments.

Species Choices for Experiments
October 18, 1993

Mara's Lesson

Today is Mara's second day of teaching in the classroom. In our collaborative planning, John, Mara, and I decided the students need to have specific information about plants that are currently being used to revegetate landfills. They also need to know what plants Mara is using in her experimental mixture.

Mara begins the class by writing the definition of restoration on the board. She writes:

Restoration is the deliberate return to:

1. Conditions that reflect the ecosystems surrounding the disturbed area.
2. Conditions that pre-date the disturbance (such as landfills that used to be forests).
3. Conditions that will provide some of the ecosystem services that were lost during the disturbance.

She talks briefly about each point. Mara mentions "ecosystem services" and says she will talk about it later. She mentions that Dr. Cairns will also discuss it when he visits. She explains there are other terms some people use instead of "restoration." These are "reclamation, rehabilitation, and mitigation." Mara says environmental engineers, environmental chemists, regulators, and legislators often use these terms. "There are tiny, distinct, semantical differences between each one," she says, "but that's not to be worried about for this project." Mara stops and asks the class if they have questions or need clarification about anything. No one speaks, so she continues.

Mara asks the class, "Why are plants a part of an ecosystem?" Jason answers, "They are part of the basic food chain. They produce food and all that stuff." Mara writes:

Why are plants a part of an ecosystem?

(1) food

(2) photosynthesis

She asks if there is anything else. No one responds. Mara continues, "Something that's essential for landfill work or any work that involves a disturbed area is that plants hold soil through an extensive rooting system." She writes on the board:

(3) plants hold soil

Mara asks, "How do plants hold soil?" She quickly answers her question, "Roots are one, what's another?" She waits for several seconds, but no one speaks. She smiles and says, "I know its Monday." She pretends she is a tree as she positions her hands above her head with her palms out. "The rain comes down. Where does the rain come first, the soil or the leaves?" Several students answer, "The leaves." Mara continues, "I know it sounds funny, but if you have a huge tree and the rain comes down, the rain is buffered. The force of the water coming down is buffered by the leaves first. By the time it gets to the soil, the potential energy in that rainwater has been greatly reduced." She writes again on the board:

(4) buffer against the force of rain

Mara continues, "Plants are not just part of an ecosystem. They also have their own ecology." She tells the students she is going to talk about the individual plant ecology for each species she is using on her plots. "There are certain criteria and variables I have to consider, and all of us have to consider as far as landfill restoration goes. Plants, to exist in a landfill environment, will have to satisfy certain criteria that are both ecological and regulatory." Mara explains that the regulatory requirements are somebody's idea of what should and should not be on the landfill. "And they aren't even ecological!" she says.

"What are the ecological requirements of plants?" she asks. A girl answers, "Water." Someone else names "Carbon dioxide," and another says, "Sunlight." Mara writes:

Plant ecology

1. water

2. Carbon dioxide

3. sunlight

She pauses for a moment. When no one else speaks, John adds, "Minerals and nutrients." Mara writes that and includes with it, "Soil."

Mara tells the students we will call these words "variables." She acknowledges "While all plants need these factors to survive, different plants have different degrees of requirements of each one." She gives the example of house geraniums and says they need more water than goldenrod or cactus because of their development and evolution based on different habitats. Mara gives another example of differing plant needs with sunlight. She says that prairie grasses need much sunlight, whereas ferns do better in heavily shaded areas.

Mara begins to explain how these four variables may affect the students' research. Some of the variables may be beyond their control. She says, "Because of the room and where you are working, you are going to have constraints when you grow your plants. Some of these variables are going to be automatically attached to that." She comments that a constraint they will have is that everything will be growing under florescent lights. John interjects that the light stands also have places for two incandescent bulbs so the students will be able to use either in their experiments.

Mara tells the students they will have to consider the kind and amount of light they want for their experiment. "You know your plant needs light. But what you've chosen, is it the correct kind, intensity and amount?" She says people have spent many years studying the photo period of plants. "I will go over each plant and its lighting need." Mara then asks the students, based on their field trip experience, what kind of light do they think a plant on the landfill will need? "What did the landfill look like when you were out there?

Did it have trees and a lot of shading?" she asks. A student responds, "It was in the open." Mara says because of the lack of trees on the landfill, the plants are going to have to tolerate full sun. She reminds them that in the summertime that might mean 12-13 hours of sun each day.

Mara talks next about minerals and nutrients. "All plants need the same nutrients, but they need them in different amounts," she says. Mara tells about plants that fix nitrogen directly from the air or soil. She asks John if the students have studied mycorrhizae. He responds that they have talked about nitrogen fixing bacteria. Mara explains that "90% of the plants on this earth have a symbiotic relationship with some form of mycorrhizae that either grow around the roots or penetrate into the root system. Some mycorrhizae help plants fix nitrogen, and then there is some nitrogen fixing bacteria that form nodules on the plants." She continues, "So the question would be, would you want plants on the landfill to need a lot of nitrogen, or would you want some to have the ability to fix nitrogen? Maybe you want a mix of both."

Another suggestion Mara makes to the students is to investigate "slope" and "aspect." However, she comments that it might be difficult to simulate this in the lab. She explains that the slope of the hill is going to decide how fast the water runs off it and how much water percolates into the ground. All the plants in her experimental mixture can tolerate very droughty conditions. Mara reminds the students that there are some horizontal parts of the landfill, but the majority of the landfill slopes. Mara explains "aspect" as the direction the slope in relation to the sun. "If a plant is facing north, and you are in the northern hemisphere, the sun is going to have a different impact on a plant than one that is facing the south." She says this is equally true with plants facing east or west. She acknowledges these are not variables easily simulated in the lab, but they are ones she must consider when choosing the plants to go on the landfill. She adds that because of the size of the classroom, space is another constraint the students will have to work with.

Mara finishes giving the background on plants and the variables students might want to consider when designing their experiments. She tells them they will need pencil and paper because she is going to give them a list of the standard plants used on the landfill, along with her experimental wildflowers and grasses (see Table 1). Mara says that for now, she will give them the common name as it may help students to recognize some species. Once they have chosen the plants for their experiments, she will give them the scientific names.

Mara continues to talk about the restrictions of vegetation on the landfills. She says the goal of revegetating a landfill is to provide erosion control. Plants need a good root system to hold the soil and a large above ground biomass to buffer against a steady rainfall. Mara says, "Another criterion for me for this restoration project is biodiversity." She goes on to explain that in this region we have many habitats with a large variety of plants. It is important to her that the plants survive and persist over time without the need to be reseeded by people. Mara reminds the students that what you do in your garden is very different from what you can do on 300 acres. Landfill operators can't take the time or afford the money on something that requires close maintenance. Mara continues talking about restrictions.

Methane and carbon dioxide emissions are additional problems in landfills. Mara reviews what happens biochemically in a landfill. She talks about the anaerobic bacteria that "munch" on putrescible wastes and produce ethanol, which is reduced to methane and carbon dioxide. "Roots need oxygen. When methane and carbon dioxide are coming out, they are beating out the oxygen.... If you have methane beating out the oxygen, then carbon dioxide is going to be coming into the roots. Carbon dioxide in significant levels is always lethal to all root systems." However, she says that some plants can tolerate higher levels of carbon dioxide than can others.

Table 1. Standard and Experimental Plants for Landfill

name	annual/ perennial	native	water needs	sun	nutrients	comments
WILDFLOWERS						
cornflower	A	Naturalized	Droughty	Full	Min.	
lance-leaved coreopsis	P	Native	D	F	Min.	
plains coreopsis	A	Native	D	F	Min	
pale purple coneflower	P	Native	D	F	Unknown	Ability to fix Nitrogen
dame's rocket	P	Naturalized	D	F		
perennial lupine	P	Native	D	F	Min	Aerial N fixer
evening primrose	P	Native	D	F	Unknown	
black-eyed Susan	A/bi A	Native to Va	D	F	Min	
catchfly	A	Naturalized	D	F	Min	
goldenrod	P	Native	D	F	Min	
GRASSES*						
big blue-stem		Mid-west	D	F	Min	
little blue-stem		Mid-west	D	F	Min	
switchgrass		Mid-west	D	F	Min	

* Can get to grow in greenhouse, but not on landfill.

name	annual/ perennial	native	water needs	sun	nutrients	comments
STANDARD MIXTURE						
crown vetch	P	Hybrid	D	F	Min	Fixes N 2yrs to est.
lespedeza	P	Introduced	D	F		Est. 1st yr legume
annual rye	A		D	F	Min	Needs N
abruzzi rye	P		D	F	Min	Needs N
Potomac orchard gr.	P		D	F	Min	Needs N
*Kentucky Fescue-31	P	Hybrid	D	F	Min	Needs N

* Kentucky Fescue 31 is the most aggressive of the grasses. Later it is taken over by Lespedeza, which is taken over by crownvetch.

Mara says that erosion control is the most important consideration to landfill engineers when looking at vegetation cover. However, there is nothing in the state solid waste management guidelines that say what plants to use. The rooting depth of plants used on landfills concern both engineering firms and landscape architect firms that close landfills. Mara states that besides the erosion capability of the plants, these firms add rooting depth as a criterion as though it were a regulation. It is important that the rooting depth of any plant be less than the closing cap so that there is no chance of the roots penetrating it. "That is not based on plant physiology other than what they've observed on areas where soil compaction is insufficient to keep the plant roots from penetrating [the cap]." Mara has not found studies that talk about specific rooting depths. Instead she says biomass interests ecologists more than rooting depths. However, rooting depths interest engineers who close the landfills. She explains that what you have are "true" regulations and "pseudo" regulations. Mara shares her frustration as she finishes her talk. She says to the students,

> No one has done any studies on my plants to see what their tolerance level of carbon dioxide is. No one has done any studies to see which ones control erosion. No one has done anything with rooting depth. No one knows how they are affected by methane. There are some plants they will not allow me to put on, but then they can't come back and tell me what's better. So what I'm hoping you can do, at least in some studies, is to start up with what **you** think would be good. And then watch.

John tells the students they will have the remainder of the class to begin designing their experiments. He says once they have come to a consensus on what they want to do, they need to talk to Mara and get her "blessing." Mara says she has brought catalogues of wildflowers so the students can look at pictures of the different species she has named.

She also tells them if they have any questions, she will come to their table and help. I ask the *Soil Compaction: Rooting Depth Group* and the *Hydroponics Group* if I may place a tape recorder at their tables because I am wanting to listen to their conversation as they discuss how to design this experiment. I tell them I am trying to better understand how students learn in a group. Several of them say, "Yeah, okay," and no one objects. The students begin talking about their assignment.

Dialogue

Soil compaction: rooting depth table. Since this is the first day the tape recorder is at this table, it is somewhat of an oddity for the students. Bob begins by saying, "Uhhhh...hello? Is it on?" Mark answers, "Sure, man." Ruth states their assignment. "So, we're supposed to pick plants that we think should go on the landfill? Is that right?" Corrine asks, "That's all we're doing?" Bob says he thinks they should just use all the plants. There is a long pause and no one speaks. Bob [referring to the tape recorder] begins, "We're not going to say anything, so you can stop the tape from recording." He laughs and asks the group, "Okay, so what plants do we want to pick? I didn't get half the stuff she said." Mark is not sure why Mara gave them the list of plants. He asks:

> *Mark*: Okay. I have a question. If they already know what plants are being used, why do we have to take these for our experiment?
>
> *Ruth*: Maybe because the ones on there now aren't doing the job.
>
> *Mark*: Could it be if they know...
>
> *Bob*: Yeah, but they **are** [doing the job] because they put them on all the landfills, so they must be doing okay. Suits me. Why does there even need to be a project?

No one answers his question. Corrine was absent Friday so she asks what happened while she was out. Ruth says she has notes, and Bob tells her, "She [Mara] talked," and we did "that greenhouse thing." Ruth explains they had to come up with what they would put on a landfill. "What do we need to do now?" asks Bob. He thinks it will be best to test each species individually. "Let's just do one [species] so we can test how good it is," he suggests. Mark wants to test the species together. Corrine agrees and wants to know if they are going to use wildflowers, grasses, or a mix. Ruth suggests they use grasses and wildflowers. Bob asks again, "But what are we going to do? What are we going to be testing?" Ruth says, "We're going to be testing...." Bob finishes Ruth's sentence.

Bob: ...we pick one.

Ruth: Do you want to test one grass and one weed?

Bob: What are we going to test about them?

Ruth: Or two weeds?

Bob: **Weed?**

Ruth: Wildflowers. [Bob laughs.]

John stops by the table and asks how they are doing and whether they need any help. Bob tells him they are not getting very far. John suggests they could pick several species and look at them individually or as a mixture. He says they could look at the variables of light, water, temperature or fertilizer. John continues by offering the possibility of using different types of soils such as clay, sand, or landfill soil. Because of the effect the bulldozers have on the landfill soil, John suggests they might want to look at rooting depth using the variables of "smashed" soil versus loose soil.

John leaves to help another table, and Corrine asks whether they want to do something about rooting depth using the different types of soil. Ruth agrees and suggests they use loose and compacted soils to compare rooting depth. Bob wants to use only a few plants. Corrine asks, "What plants do you want?" Mark says he likes bachelor's button. Corrine asks if they want to use two wildflowers and two grasses. Bob and Ruth both say, “Yeah.” Ruth also suggests using black-eyed Susan. Corrine asks, “So we’re going to use cornflower?” “We are?” asks Bob and then says he guesses so. He asks what are crown vetch and lespedeza. Ruth tells him they are grasses. Bob wants to add Kentucky fescue-31. He comments that it will be a good choice because its used by people on their yards. Corrine agrees and adds to their list, abruzzi rye grass. Corrine sums up the list, “So we’re going to use cornflower, bachelor’s button, black-eyed Susan, Kentucky fescue-31, and abruzzi rye grass, right?” Bob says, “Correct.” Mark asks, “Any specific reasons you want to use these?” Corrine says they just picked them by random.

I tell the class that they will have access to soil from the landfill for use in their experiments. Mara and I will go to the landfill and get the soil for them if they want to use it in their comparisons. The group talks about whether they want to use the landfill soil. Ruth wants to know if they are going to use different types of clay. Corrine says, “Let’s do the compacted and...” “We can use the landfill soil,” finishes Ruth. Mark doesn’t want to use landfill soil. He says, “Excuse me. How is that going to help in this experiment? Just because we use this soil...and soil is soil. I mean, it’s still....” Corrine protests, “But it’s the compaction of it, too. Because if you compact it too much, it’s not going to grow and the seeds aren’t going to get down in there and the roots aren’t gonna....” Mark interrupts. He says they can compact just regular soil. Bob says it is necessary to have the landfill soil because that’s what they’re dealing with. “It just makes the experiment closer to...home.” Ruth says the landfill soil is different because it has “trash and junk and all that stuff.” Mark continues to disagree because he says the soil they will be using will not have trash in it. Ruth protests, “But there is [sic] going to be gases coming off.” Mark says, “Yeah, but soon there won’t be any more.” Bob agrees with Mark that there will be no gasses in the soil by the time it gets to the school. Mark says, “I know, when we start doing our project.” Corrine speaks up, “It would make **me** feel better to use the landfill soil. Okay?”

Bob now agrees with Mark that the soil at the landfill and the soil that Mara and I bring to the classroom will not be the same because the trash and gasses will not be in it. Bob says that they will not be able to predict what will happen in the landfill from the experiments they do in the classroom. Mark asks, "What's the point in having this...?" Bob interrupts, "There is **no** point in having it!" Ruth starts to say, "The point is...," but Bob interrupts again with "I'm not sure." Mark continues:

> *Mark*: Would you like to reiterate that question again to the point of this project? The validity of it. Why we are...
>
> *Bob*: Uhhh. I think to help these....
>
> *Mark*: College people who **don't** know what they're doing...[Bob laughs.] So they need the help of **students** who have no idea what to do, either. So it's pointless. Course we're joking. We're being facetious just because we know this tape is recording every word we say. [Bob laughs.]
>
> *Bob*: Uhhhh. Yeah right, Mark! [He laughs.]
>
> [Mark does not want to acknowledge on tape it was he who made the statement.]
>
> *Mark*: Mark? [They all laugh.]
>
> *Mark*: Well, it was playing, man...what could I say? [Bob laughs and joins in the game.]
>
> *Bob*: Uhhhh. I'm Corrine. [They all laugh.]

Everyone at the table enjoys the lightness of the conversation, but Corrine now brings them back to task. She says, "Okay, ya'll." Ruth asks, "So, are we going to put on individual seeds, or all together?" Bob suggests they should do them separate and then put them all together as one.

Corrine asks if they are using compacted landfill soil. This brings the conversation back to making a decision about the soil. Bob and Corrine have difficulty in communicating what kind of soil they want to use.

Corrine: So we're going to use the landfill compacted...?

Bob: But it won't be compacted until it gets here.

Corrine: Well, we can compact it and then regular...?

Bob: No, use the same landfill soil and if it wasn't compacted...

Corrine: But it's gonna be.

Bob: But it won't be compacted when we get it.

Corrine: But at the landfill, it **is**!

Bob: I know, but I'm saying...we're testing if it's not compacted soil what will happen.

Corrine: We're testing all of them?

Bob: Riiiight!

Corrine: [We'll be testing] if it's compacted, if it's not, and if it's kinda in between?

Bob: I know. But I'm saying. Why don't...we have to use the same soil the whole time because that has to be a constant.

Corrine: Yeah?

Bob: Right.

The students decide they are going to use landfill compacted soil and "non-compacted" soil. Ruth calls it "sifted soil." Mark teases, "You have to sift the soil before you can take out the wrinkles." He then brings up the question of whether they are going to try to imitate the slope of the landfill. "No," says Corrine. "We're just doing one test. We're not doing fifty." Ruth asks for clarification, "And then just a regular compaction?"

Mark wants to know what is "regular" compaction? Bob answers, "Natural!" At that, both boys laugh as Mark says, "Natural compaction."

John speaks up and tells the class that tomorrow when they come in, each group should be ready to tell what they think their design is going to be. The class will help each table refine their design. The tape recorder is turned off and back on.

Corrine says they have decided to do three compactions, sifted soil, loose soil and regular soil. "Right?" she asks. She tells them that means they will need fifteen different containers. "Right?" she asks again. Bob doesn't understand why it will take so many containers. He reminds them they only have a small space in which to put their plants. Mark says, "We have three different variables...five different plants." "Oh, that's right," says Bob. He questions the validity of the experiment. The lack of repetitions concern him.

> *Bob*: You know what? We'll only be doing one trial for each of these. Actually, these are not going to mean anything at all.
>
> *Mark*: Okay. Then why don't we just quit now. All right? Forget about the whole thing.
>
> *Bob*: Suits me.

Corrine is either unaware of Bob and Mark's conversation, or she chooses to ignore it. She says, as she is writing, "Then each plant will be...." Bob and Mark continue to talk about their experiment. Bob says, "So, it only has...in other words, our project is very shallow."

The conversation shifts to discussing the students from Patrick Henry who joined the class Friday when Mara gave her first talk and the students designed the vegetation for a closed landfill. The tape recorder is turned off and back on for the second time.

When the tape recorder starts again, Corrine is asking, "What about the water? Are we going to put the same amount of water in each...? Mark interrupts and says, "I think we should. Because then we'd be testing too many things, and we don't want to kill ourselves." Bob says they call that a "constant." Corrine says, "Same amount of water, same amount of light."

Once Corrine mentions "light," that brings up another question. Mark asks, "Are we going to use incandescent light, or are we going to use florescent light? Corrine and Bob agree that they should use incandescent. Mark says that they may have a problem because there may be more people wanting incandescent lighting than there is space available. Bob wants to know if it really makes any difference. Mark answers, "Yeah, because there is not going to be florescent light out on the landfill." Corrine agrees. Bob states, "There is not going to be incandescent, either. It's going to be sunlight." "What?" asks Mark. "It's going to be **sunlight**," responds Bob. Mark wants to know if that means that incandescent light is closer to sunlight than florescent light. Both Corrine and Bob say it is. Corrine then asks about the slope. She wants to know if they should have the same slope. Bob responds, "Yes. The same slope, the same amount of nutrients. Actually, that's in the soil type, so it doesn't really matter."

It is time to stop because it is the end of class. I quickly give the students Mara's and my e-mail addresses in case they have questions. They can use the computer in the classroom to ask questions on days we are not in Roanoke. I had placed the second tape recorder at the *Hydroponics* table. It is also their first day to have it on.

Hydroponics table. David speaks loudly into the tape recorder, "Is it on?" They all laugh. Karen is setting the group in motion by asking which seeds they want to use. She suggests coneflower because it has broad leaves that will help with erosion problems. Karen and Judy talk more about the plant, and then Karen comments that maybe they should decide their variables and controls before deciding what type of plants to use. The group looks at the environmental chamber, and Karen shares that the coneflower is a large plant and might not work well there. Judy asks if it gets to be about 3 or 4 feet. Karen says it is more like two or three feet. David teases, "About as tall as you are." Karen laughs. Judy says, "David!" "She knows I'm just kidding!" he responds. "Okay," says Karen, "what variables do we want?" "I used to be 3 foot tall myself," continues David.

Judy says she doesn't think they should work with slope because it is too hard. She adds that it will be **real** hard. Her comment is not taken seriously, and the group begins to talk about how to construct a slope. Judy suggests using a triangular shaped tray. David suggests angling the tray. Karen says, "Well, you could [angle it], if you had a long tray...you could set it like that. But the dirt would probably fall out." She says the plants will grow straight up to the light, not up to the sides of the pan. Karen asks, "How would you prop it up and keep it propped up? David responds, "Put a book under it." "A book!" cries Karen, "but that's not the type of slope we're looking at! We're looking at a slope like this. [She shows the angle with her hands, and the group discusses how to figure out the slope.]

Judy: 25 degrees

Karen: 25 percent

Judy: A quarter, so what's that? Like....It'd be a....

David: Five or six

Karen: Like over 1.4 something....

Judy: I'm trying to think where the degrees is[sic]....

David: At prime of X.

Judy: Like...

Karen: ... four five would be forty-five degrees.

Judy: No, that's a half.

Karen: A half has 5 degrees.

Judy: Oh, a half pi. A fourth would be.

Karen: Would be like say, right there.

Judy: It would be like, I'm trying to think. It would be like.....forty-five, whatever that is, wouldn't it? Am I thinking right or not?

Karen: Four. Let's see. Half. One half pi is 90 degrees. A fourth pi is 45 degrees. I don't know.

Judy: Let's see. Okay, 90 degrees is here.

[David says something and the girls laugh.]

Judy: This is here. So like, 45 degrees is like what?

Karen: 45 would be 50%, wouldn't it?

David: ...of 90

Karen: Probably.

Judy: Is that right? Am I thinking right?

Karen: Okay.

Judy: Okay. So I'm saying about 20-25...

David: 25 degrees is an eighth.

Karen: About 22 degrees

David: Almost.

Karen: About 22 degrees.

Judy: Yeah. Something like that.

Karen: About right.

Judy: 22.5 [She laughs.] Okay, but we don't want to work with point five.

Now that the table has figured out their slope angle, Karen asks David and Judy if they want sunlight as one of their variables. Judy says she likes David's idea of testing root depth or testing how methane and carbon dioxide affect it. Karen agrees and adds that Mara had said there had been no testing of the actual affects of the landfill on those plants. Judy suggests they have two controls and two variables. She continues, "It'd be like we have the plain control and the plain new species...just regular conditions that have been tested thus far."

Mara stops by the table and asks the students how they are doing. Karen says they are wondering if they could test root depth and the effects of methane and carbon dioxide on rooting system. Mara sits down and asks them a series of questions. "If I understand it then, you have two problems that are important to you: how far the plants go down in the soil, and methane." She wants to know how many species of plants they want to work with. Karen says that one or two, with three being the maximum. Mara says their constants will be sunlight and water. Karen adds, "The type of soil." Mara asks what kinds of soil do they want to use. Karen suggests they work with potting mixture. Mara questions whether that is the only kind of soil they want to use, pointing out that different kinds of soil may give different results. Karen acknowledges that the landfill soil is more compact, but she doesn't understand how they will compact it in the classroom, "unless you really pack it down in a pan or wherever we plant it." David reminds them that the capping layer will be different from the rest of the landfill soil. Karen wants to know if they can get actual landfill soil. Mara tells them it is available. Karen says, "We could pack it down in the pan...of course it still won't be quite as packed down as it will be...[on the landfill]. Mara begins to explain that soil is composed of three parts: sandy, silt, and clay. She is going to show them how to do a "bulk density" study, but needs a piece of paper.

Mara leaves the table to get some paper, and David says, "I smell salmon eggs." "What?" asks Karen. Judy says, "Is it 'salmon' or 'samon?'" David says again, "Salmon eggs." Judy laughs. David continues, "Well, I was sitting here while ago, and I smelled something like.... You know when you go trout fishing? I'm like, what's making me want to go trout fishing? And then I realized that I was smelling something like...salmon eggs." The girls laugh. They evidently know what is making the smell.

Mara returns to the table. She asks them if they are wanting to look at rooting depths of three plants in a compacted soil. Karen responds, "Uh-huh." Mara asks again if they are wanting to use landfill soil. Karen responds again, "Uh-huh," and adds, "The problem is, how would we measure, and how long will we be growing the plants?" Mara looks at their class schedule. She sees that their analysis draft is due December 3. Mara decides if she orders seeds this week they could arrive by Monday. If students plant them within the next week [the last week of October], then the seeds will have approximately five weeks to grow. Karen does not think that is much time to look at rooting depths. Mara says "It's not much to go on, but with very compacted soil, there may not be very many plants that survive, anyway." She tells them the first six weeks are very crucial for germination and survival. "No one has done studies on germination and survival of plants in heavily compacted soil," comments Mara. This type of study looks at the "establishment" of plants. Mara tells them to think about what they want to do with rooting depth.

Mara begins to talk about the second problem, methane. She asks if they have had chemistry. The students tell her that they had it last year. Mara talks about the chemical reaction of anaerobic decomposition. Mara admits she has had a difficult time putting a design together that would sample methane because there is not much in the literature. However, she says measuring carbon dioxide has been fairly successful. If they are interested in measuring carbon dioxide, she suggests that it could be done in a hydroponic environment. She asks the students if they have worked with hydroponics before. They say they have not. Mara explains, "Okay. 'Hydroponic' just means that plant studies are done with water rather than with soil." John interrupts and announces that when they come in tomorrow, each table is to tell what their experimental design is going to be. The class will help refine each table's design.

Mara quickly tells the table that she will give them her "blessing" today. She continues to talk about the hydroponic setup. She explains that the contents of the water is manipulated by putting something in it that forms carbon dioxide. Alkaseltzer would be one example. However, she explains, one of the problems in using Alkaseltzer is determining how much carbon dioxide it gives off. Mara suggests using several tanks that have varying amounts of Alkaseltzer, or use one tank in which the students vary the time they add the Alkaseltzer over a period of five or six weeks.

Karen wants to know if they can use a regular air pump, like those in fish aquariums. Mara says whatever design they wish to use is okay. "The only thing that you would need to do is...." "Measure the amount," interjects Karen. "Well," says Mara, "either measure the amount, but more importantly, compare it against what would be just a normal plant growth situation in hydroponics solution." She tells them they will need a control. The students will have to decide what their criterion for a "control" will be. If they add nutrients to the water in the control, they will need to add it also to their experimental tanks. She suggests they think more about it. David says, "I would like to do the methane." "Yeah," says Karen. David adds, " CO_2." Judy says, "CO_2, yeah. I think that would be really neat." Karen says she could bring the air pump and air stones because they have aquariums at her house and have extra equipment. Mara says she will get the plants and cups for the hydroponics. She wants the students to give her a list of plants they want to use and what equipment they think they will need. Mara says she and John will be responsible for getting the equipment once the students have made their list. She also asks them, "Do you want to do many different doses of amounts of Alkaseltzer, or do you want to use one tank and just dose it with the same amount, or dose it with increasing amounts? Sometimes these little bacteria work more and sometimes they work less. It might get a little harried if the plants died so quickly you didn't have a chance to see them." Mara and the students have to stop because it is time for class to be over. She puts her e-mail address on the board so students can ask her questions on days she is not in class.

Experimental design

The next day, the students present their experimental designs at the beginning of class. Most of the tables have an idea of what they want to do. In some instances John asks questions or makes comments. Below is an outline of each table's experimental design with comments or questions John asks the students to think about.

Soil compaction: grasses table.

Investigation: To test the effect of compaction on grasses

Seeds: 50 seeds each of annual rye, Kentucky fescue-31, Potomac orchard grass

Equipment: six 2-liter soda bottles

Design: Control is potting soil

Loosely compacted landfill soil

Highly compacted landfill soil

Method: For loosely compacted soil, weigh soil and put in container

For highly compacted soil, we will drop a 600ml glass beaker 3 times every time 231g of soil

John suggests that light affects roots, so they may wish to wrap their containers in foil.

Soil compaction: rooting depth table.

Investigation: To test the effect of soil compaction on rooting depths

Seeds: 45 seeds each of coneflower, black-eyed Susan, Kentucky fescue-31, and abruzzi rye grass

Equipment: eight 2-liter bottles and two 3-liter bottles

Design: Control is potting soil

Loosely compacted landfill soil

Highly compacted landfill soil

Method: For loosely compacted soil, weigh soil and put in container

For highly compacted soil, drop a beaker 10 times into the container of soil every time 500g of soil is put in. Sprinkle seeds and put 10 Tbs. of soil on top.

Hydroponics table.

Investigation: To test the effect of CO_2 on roots using a hydroponic solution

Seeds: lance-leaved coreopsis, brassica, cornflower

Equipment: Three 20 gallon aquarium tanks

Aerator pump and hose

Black Plexiglas lid for tanks (9 holes drilled in top)

27 optical lens containers

Sodium bicarbonate

Distilled, Deionized (DD) water

Design: Control tank with DD water and plants. Experimental tank with DD water, plants, and an aerator. Experimental tank with DD water, plants, aerator, and a solution of sodium bicarbonate.

Method: Plant one tray each of 24 pots to germinate, 4 seeds per pot. After a week, put plants in hydroponic solution. There will be one control tank, one tank with aeration, and one tank with aeration and sodium bicarbonate. Nine pots will hang in each tank, 3 seedlings per pot. Only the roots will be in the solution.

Slope study table.

Investigation: To test the effect of slope on the germination and viability of seeds

Seeds: 82 seeds each of cornflower, plains coreopsis, black-eyed Susan

Equipment: six 1-gallon square plastic containers

Design: Controls are compacted soil in containers on flat surface

All soil compacted

Three containers set at a 25^{o} slope

Method: Place 3/4" of gravel and 3" of compacted landfill soil in each container. Each species has one "flat" container and "sloped" container. Water containers with 200 ml every two days.

John asks them if they will water from the top or the whole thing. They answer that they are going to try to imitate the actual conditions at the landfill as accurately as possible. They will water the whole thing. [In final report, they state they watered the sloped containers at the top.] They are not sure whether they will plant each species separately and have three trials for each, or mix the species and see how they interact.

Grass & wildflower aggression table.

Investigation: To measure the aggression of grass and wildflowers

Seeds: birdsfoot trefoil, purple coneflower, plains coreopsis

Equipment: Four 1-gallon plastic containers

Design: Control is three containers of one species each

Three containers of mixture of species

Loosely compacted landfill

Method: Plant 60 seeds of each species in a container as a control. Plant 45 seeds of each of the three species in the mixture container.

John suggests they might like to measure density and biomass.

Temperature effects on plants table.

Investigation: To test the effect of sun and nutrients on germination rates

Seeds: Not decided

Equipment: 2-liter soda bottles

Design: Normal dirt with some potting soil

Landfill soil

John suggests they may want to add fertilizer and do some chemical testing of the soil for nitrogen, calcium. He says this they can do this along with measuring plant height.

*This group had difficulty coming to a consensus and getting started. They completely changed their design from their original design. Their final design was:

Investigation: To test the effect of temperature on three species

Seeds: 20 seeds each of birdsfoot trefoil, purple coneflower, lance-leaved coreopsis

Equipment: Eighteen 2-liter soda bottles

Design: Control is potting soil

Loosely compacted landfill soil

Temperatures are $2^{o}C$, $23^{o}C$, and $26^{o}C$

Method: Put six containers (3 landfill and 3 potting soil) of each species at Virginia Tech in a cold chamber. Put six containers (3 landfill and 3 potting soil) of each species in the room at RVGS. Put six containers (3 landfill and 3 potting soil) of each species into the environmental chamber at RVGS. The temperature in the environmental chamber will be $26^{o}C$. Water plants every day of class.

Issues and Values
October 19, 1993

Part of an STS study is realizing there are different stakeholders with different positions. These different positions influence one's beliefs and values. To help facilitate these understandings, I did a lesson on values and issues using information from A Science-Technology-Society case study: Municipal solid waste (Ramsey, Hungerford & Volk, 1989).

Lesson

We have been working on the unit for two weeks. Students enter the room, the buzzer rings, and they sit at their tables. I tell the class we will be doing a lesson on issues and values. I explain when dealing with a social issue, it is important to be able to identify the different stakeholders and recognize the beliefs and values these stakeholders have. I give the students a handout that defines terms we will use in the lesson (see Appendix C for a copy of terms and definitions). We begin to talk about environmental problems and how they arise. We acknowledge that living and non-living things decrease when conditions change in response to these problems. I ask the students what environmental things can decrease when such problems arise. They name threatened *plants* and *animals* along with *non-living things* such as air, water, and soil. I inquire as to what types of events bring about this change. They list clear cutting, dams, and over-hunting, which are man-made events. We also list natural events that lead to problems: floods, fires, earthquakes, and droughts.

I explain that a problem becomes an issue when there are two or more people who disagree about the problem and it's solution. I define these people as "players" or "stakeholders." The players may be individuals, groups, or organizations. I tell the class that each player usually has an idea how to solve the problem. Players may voice their ideas at meetings or through the media. This idea is the player's position. Beliefs and values influence one's position. I define "belief" as something someone believes to be true, whether it is or not. Beliefs also relate to values. People value those things they think important and worthy. I continue to say that values might involve money, status, beauty, or religion.

To understand this better, I tell a story about the decreasing population of the black rhinos which are being hunted by poachers (Ramsey, Hungerford & Volk, 1989). The issue is whether or not we should protect the black rhino. There are two players: the wildlife experts and the poachers. The wildlife expert's position is that the hunting of black rhinos should stop. The poacher's position is that hunting should be continued. Why does each player take his position? The wildlife experts believe the black rhino is endangered and want to protect it. I explain that this is an ecological value because the experts are wanting to maintain a natural system. The poachers want to kill the rhino for its horn. Some cultures consider it to have healing powers and use it as a medicine. I explain that this is a cultural value because it pertains to the continuation of a belief and custom. There is an additional economic value that comes when the horn is sold. To visualize this better, I show the students a chart (see Figure 16).

I talk again about values and how we value those things we give worth. I hand out a sheet of "Value Descriptors" (see Appendix C). I do not feel it necessary, given the academic status of the students, to read and discuss each descriptor. I also give the students worksheets that have examples of value statements (see Appendix C). They work in pairs to match the twelve statements with a value descriptor. We work about ten minutes on this activity and then review it, putting the answers on an overhead. Everyone agrees on the answers. The next stop is to take this "new knowledge" and apply it.

Issue Components	The Rhino Example
The Event	Hunting black rhinos
The Environmental Problem	The rhino population is declining and endangered.
The Environmental Issue	Should black rhinos be hunted or protected?
The Players	Wildlife experts Poachers
The Players' Positions	Experts: Black rhinos should not be hunted and killed. Poachers: Black rhinos should be hunted and killed.

Figure 16. Issue Components

Local Issues

We are ready to use this new knowledge to identify values and issues in local issues. John gave the students recent newspaper articles concerning garbage issues around the Roanoke Valley region. For homework, he had asked them to read the articles and be familiar with them when we met today. Each table has read different articles. I tell the class we are going to do the same activity with the newspaper articles as we did with the black rhino issue. Each table will decide:

(1) the issue in their article

(2) the players and their positions

(3) the players' beliefs

(4) the values that support those beliefs

(5) possible solutions to the issue

Students work first with a chart and then transfer their data to a large sheet of newsprint. When we finish, each group will share their information with the rest of the class. Each table gets a copy of the chart to help organize their data. (See Appendix C for a copy of the chart). There is much talking. I ask permission to set a tape recorder at the *Soil Compaction: Rooting Depth* table and the *Hydroponics* table so I can have detailed records of their conversation as they work through this activity. Both tables give permission. I place the tape recorders on the tables and walk around to answer questions and help.

In this lesson, I focus on the *Soil Compaction: Rooting Depth* table and the *Hydroponics* table. I will give a short synopsis of the articles for these two groups and share some of the dialogue from these tables. I will then share articles from the other tables and the presentations from the entire class.

Soil compaction: Rooting depth table - article. "Giles to pay dearly to send trash out of county" (Kittredge, 1993). This article tells about Giles County trying to decide what to do with its trash once its landfill closes on October 9. They now have a short-term contract to have their garbage collected and hauled to another landfill. Giles County's cost for garbage collection last year was $300,000. The new contract is over $1 million. Not all the towns in Giles County will be part of this new contract. Narrows, Pearisburg and Glen Lynn have decided to reject the county's plans. These towns feel the county made the decision without asking for their opinion. Narrows will continue to send their garbage to West Virginia.

The article says this will be the first time for many residents to pay for garbage pickup. It explains that part of the difficulty in locating a landfill in Giles County is the terrain. "The area is riddled with cracked, cavernous limestone, which can funnel landfill effluent into ground-water supplies." Because of objections to the removal of the large green boxes located along the roads for garbage disposal, some of the boxes will remain for a while. However, the county will charge residents for curbside service, even if they continue taking their trash to the boxes. The county says the boxes pose a problem because people from other counties are using them, and they are receptacles for motor oil and car batteries that the landfill no longer accepts. Giles county has also hired clerks and purchased computers to handle the billing for the new trash service.

Soil compaction: Rooting depth table - dialogue. The tape recorder begins with Ruth and Corrine discussing who are the players and what are their positions. Corrine asks, "Basically, do the people and the board of supervisors have different positions?" "No," answers Ruth, "the board of supervisors, they have one [position], and then the people have one idea and then..." Bob interrupts, "Really? I read this stuff but I didn't quite catch it. Well, I fell asleep once reading it." Corrine continues to read the article. It talks about a meeting where the people of Giles county are angry at the county supervisors. The county supervisors say that it's the fault of the people in Washington who make the laws. Ruth asks, "So, we've got the Giles County people, the general refuse service..." Bob doesn't think the refuse service is one of the players. He says, "They're just trying to do a job. So we have..." "Two players, right?" asks Corrine. They discuss what the other towns in Giles County are going to do. Bob says he thinks it's the people against the board of supervisors.

Corrine says the article also mentions the EPA. They continue to discuss who are the players. Is it the people, the leaders of the towns, the EPA, or the board of supervisors? Mark questions the role of the scientists. Corrine asks, "Scientists?" Mark says even though the article didn't mention them, he wonders about the "scientific people and their views." Corrine finally suggests, "Why don't we put just *generalpeople* that send their trash to whatever landfill it is, and then *the government* that is involved, whatever, from Montgomery, like the county supervisors or whatever." The group accepts this idea and places the players into two categories: general public and government officials.

The talk at the table shifts as Bob and Corrine talk about her ordering meat "rare" and getting it "well-done." Ruth brings the group back to task when she says, "Okay. So let's look for positions." Corrine responds, "Its that they don't want a landfill in their own backyard, but they don't want to spend the money to have the trash sent off." Bob is writing their thoughts down. Corrine excuses herself from the table. She remembers she left her books in the bathroom. Mark, who has said little up to this point speaks loudly into the tape recorder, "That was Corrine. She's doing the weed stuff in the bathroom." They laugh. The students continue to try to decide what the players' positions are.

> *Ruth*: (Writing on the paper). "Don't want to pay costs of transporting their trash...." "Transporting their trash," is that what we want to say?
>
> *Mark*: Wouldn't it be under "beliefs?"
>
> *Ruth*: This is under "issues."
>
> *Mark*: The general public, their position is...
>
> *Ruth*: They don't want the landfill in their backyard.
>
> *Mark*: They don't want the landfill in their backyard, but they don't want to pay the costs, extra costs for hauling and the tipping fees.
>
> *Ruth*: But they don't want to pay the costs....
>
> *Mark*: It would be "**and** they don't want to pay them." They don't want it near them. They don't want to pay them.

Bob settles the issue when he says, "Right. And the government...what's the government's position?" The group tries to decide the position of the government officials. There is more discussion about which option is cheaper, to transport the trash to West Virginia, or to open up a new landfill in the area. Bob says, "It is cheaper to do that [transport trash to West Virginia] in the short run, but in the long run, it's cheaper to go with a new landfill, I think. It doesn't say that, but that's what I think. Because, like Roanoke spent a lot of money on the new landfill..." Mark adds, "$42 million."

Corrine has rejoined the group, and she reads part of the article aloud. The boys cut up as they sniff and cough. The tape recorder is turned off and back on. Mark says something. "That's right, Mark," says Bob as he laughs. Ruth brings the group back to task, "So, what is their [government's] position on it?" Bob says he doesn't know and asks Corrine. Corrine is not sure. Ruth is drawing the line on the large sheet of paper to section it off. The boys say to her:

Mark: The line isn't straight.

Bob: That's correct, it's not.

Mark: You didn't have a ruler.

Corrine: It's straight. It's not crooked.

[A ruler is hit on the table. They laugh.]

Bob: Are you going to draw a line here, or just not?

Ruth: No, I'm not.

Bob: Awww. Better than that.

[Ruth tries to bring the group back to task.]

Ruth: The issue is.... [The boys laugh.]

Mark: See, what did I tell you.

Bob: Red, just red. [Referring to the magic marker Ruth is using to do the chart.]

Ruth: It's pretty!

Bob: It's **red**!

Ruth: It's red.

[The ruler is beat on the table in rhythm and swishing noises are made into the recorder.]

Bob: That's not parallel, either.

Corrine tries to get the group back on task as she simply says, "The issue." Ruth answers, "What is the...keep it in or put it out?" Bob picks up the thought and continues, "Haul garbage out of the county or keep it in the county with the new landfill. You can word that however...." Corrine says one of the players is the general public. Bob comments, "This [magic marker] is making me high. The red one is much better, I think. I think it's the red one." No one responds. Corrine asks, "Can I put 'government officials?'" Ruth answers, "Yeah." Bob says, "That looks terrible." Corrine ignores him and says, "Okay, the position of the general public is that they don't want the landfill in their backyard, and they don't want to pay costs of hauling and tipping." Bob laughs, "Hauling and tipping fees. That sounds really good." Corrine asks about the government. Both Mark and Bob agree that "Something has to be done now." Bob says that there is no time to fight over things now because the deadline for closing the landfill is near so "everyone is going to have to pay their money and stop crying about it."

Corrine continues to write. Ruth comments that Corrine made another mistake. Bob says they are going to have to start over. He also states another problem is that Giles County can't find a place to put the landfill, so the people are going to have to pay to have their trash hauled away. Mark interjects that he's watching "Highway of Agony" tonight and doesn't know if he can handle that. No one responds to his comment. Corrine asks, "Do you think county or in area?" Bob says, "County." Mark says, "Area." Bob changes and says, "Area."

Mark abruptly shifts the conversation and the whole table becomes involved. [Everyone seems to know who they are talking about.] Mark asks, "Where did you take him?" Corrine responds, "Downtown." "To Childress?" asks Mark. "Yeah," says Corrine. The students continue to socialize. Ruth says her driver education teacher came in Monday and told "turtle stories." Corrine then looks at Mark writing on the paper and tells him it looks like "chicken scratch." Ruth agrees. Corrine goes back and verifies Ruth's story, "That's what he did. He came in one day and told us turtle stories." Bob, taking up for Mark says, "Awwww, excuse me." Mark looks at the chart and comments, "It's neat, it's aesthetically pleasing with the mention of the blue and the red...." Bob, referring to Mark's contribution to the chart says, "And it's even got the 'Mark Dobbs' line down the middle." Mark agrees and says that line is known as the "Mark Dobbs" line. They do a play on words as Corrine acknowledges its "patriotic and political." Bob adds, "It gets down to the issues!"

Corrine brings the group back to task with "This *political* would be your value." Bob agrees and adds that another value is definitely *economical* and *aesthetic*. The group continues talking as they try to sort what they think the rest of the values are. Much of their conversation is one-word sentences. However, everyone seems to know what is meant. The dialogue goes:

Mark: Political!

Ruth: Political?

Bob: Yeah.

Corrine: Yeah. Noooo. I wasn't...

Mark: Aesthetics.

There is an incidence where Bob misunderstands what Ruth means with her one-word sentence. She says, "This isn't all of the question now. I was just saying 'economical?'" Bob tells her that she may think she is "saying" something, but when she raises her voice at the end of a word, it means she is "questioning." The conversation continues:

Mark: Would it be social?

Bob: Egocentric.

Ruth: Aesthetic?

Bob: And egocentric.

Mark: Shouldn't you have dashes there?

Ruth: No...egocentric.

They continue to discuss which values to put on their chart. The students cannot come to agreement on whether the government being concerned about the "will of the people" is *social* or *ethnocentric*, so they decide to not put it at all. Mark turns around and talks briefly with the *Soil Compaction: Grasses* table. Ruth realizes that they did not leave room for "solutions" on their paper. Corrine turns to the next table and asks Karen, "Do ya'll have the beliefs the same thing as the position?" Karen tells her, "No" and gives an example of the difference between a belief and a position. Mark, Corrine and Bob give several beliefs the general public has about landfills. Mark appears to be making fun of the collaborative process of the group.

Mark : I'm so glad I'm in this group.

Ruth: So you can sit back and...[Bob laughs.]

Mark: Noooo.

Bob: So he can juuust....

Mark: Supervise! Because, if I don't like it...don't have to use it.

[Ruth continues to write on the paper.]

Mark: Of course, all my ideas are great, like this line.

Corrine: [Teasing.] The dashes need help, Mark. You can be more creative than that.

Mark: I see you're using dashes here. **Don't** change it.

Bob: Uhhhhh...

Corrine: Okay?

Mark: See, they [Corrine and Ruth] won't like that either. They're just like, "What's the day?" [They are not "with it."]

Corrine: Okay.

Bob: She's going to put lines.... [He laughs.]

Corrine gets the group back on task as she asks approval for what she has written and reads from the chart. She has written one of the beliefs by the general public. Corrine says, "Okay? Okay. Landfills aren't sanitary, pleasing to the eye, pleasing in odor!"

Bob begins to say something about landfills when Mark interrupts, "This is a new quarter," referring to his money. No one responds. Ruth adds that the general public doesn't see the necessity in paying to have their trash dumped. Mark engages the group in "sidetalk" as he asks when they think they should get the results from the PSAT they took yesterday. This conversation interests everyone. The group discusses what portion of the test was hard and how they think they did. Just as quickly as the conversation shifted away from landfills, it shifts back. Mark says, "They need to have a way to dispose of the trash...would also have...." Ruth begins talking before he finishes, "The government believes that the EPA guidelines could be up, but the EPA won't allow it." Bob adds, "They also think the public should compromise and...."

John interrupts as he asks the students how much time they need for consultation on Thursday. It is decided each table will give their presentation at the start of class and consultation time will be at the end of the class.

<u>*Hydroponics* table - article</u>. "Trashing a neighborhood? Posh Salem subdivision fighting landfill" (Poole, 1993). The article states that residents of a neighborhood in Salem

are upset because the Mowles Spring Park landfill is going to be expanded right up to their backdoors. The 283 acre landfill, which now has a mile buffer of woods and topography, is expected to open its second site within 100 feet of the residents' property lines. This is not a neighborhood that needs renovating. The city values some of the homes for tax purposes at approximately $246,000. Many physicians live in this subdivision. The article states that residents fear pollution, smell, noise, and a decrease in their property values. They are suggesting the city move the landfill back on the park property 500 feet and build a earthen berm. Residents are also questioning why the city plans to open this site near the perimeter of the park and then after twenty years, open another site closer to the center of the park.

The city officials say they cannot release information about the site of the landfill because some of the information is not available, and the lawsuit hinders release of what they do have. A council member said to one of the residents, "You rich people don't want this landfill and are going to make everyone else pay for it."

The article also states that Salem City has contracted with Chambers Development Co. to haul their trash to a private landfill near Richmond, Virginia, for the next five years. The city is hoping that by the time the contract is up, they will have ventured into a new process that grinds up household garbage and turns it into market-grade compost. This would negate the need for further sites in Mowles Spring Park. In the meantime, the city has applied to the state for a permit to begin building so the site would be ready for use in five years.

<u>*Hydroponics* table - dialogue</u>. Conversation at the table begins by students talking about the tape recorder and their grades. David says that he is going to get a "B" now. Judy laughs and says that it'll be a 92 [which is just under an A], and he can sue her. He says it'll be a 89.6. Karen starts the group on their task. "Okay, let's start talking science here, guys." David teases, "Chemistry." Karen begins again, "Okay. The issue is

placement of the landfill near...." David finishes the thought, "A bunch of people's houses." Karen picks it up again, "Near a...." "New landfill near Salem," completes Judy. With the issue stated, they move to identifying the players and their positions. Judy identifies the Salem City council as a player and says their position is to obtain a permit for the landfill. David thinks it should go under "beliefs." Judy and Karen disagree. Karen is trying to remember the name of the street [Bent Ridge Lane] in the subdivision that is nearest the landfill. David teasingly calls it "Bitch" Ridge Lane. The name becomes a point of laughter several times as they try to remember it correctly. Judy say, "Bent Lane Ridge, no, Bent Ridge Lane. I can never get...." David teases her, "Lane Bridge Ridge." They all laugh. David says, "Just get the bridge for me." Karen brings the group back to task as she asks, "Okay. Now, what's their position?"

The group works smoothly through the players and their beliefs. There is an equal amount of talking by each person. Individual dialogue is lengthier and more sentences are complete than at the *Soil Compaction: Rooting Depth* table. Karen and Judy often asks direct questions to keep the momentum of the group moving toward completion. When the group discussion shifts away from the task, either Karen or Judy usually ask a question which focuses everyone again. A sample of their dialogue is:

> *Karen*: What about the values?
>
> *Judy*: Well, we'll go back to that. I mean, like one of their beliefs is...isn't it kinda like that they think that this is the best place for it? That the least amount of people will be affected by it?
>
> *Karen*: And the best possible solution?
>
> *Judy*: Or that they don't see it. I mean, they said that they were going to put up pine trees, and they don't see it as being detrimental to the community...believe that the best solution for all the people for everybody. Okay, so....

Karen: We've got like the residents.... Okay. Now, what's their position?

Judy: No landfill! No landfill! All right. They want to prevent the city or the county from obtaining the permit. That's what their position is.

Karen: Don't want landfill near their house.

Judy: They believe it will depreciate the value of their property.

[David makes sounds into the recorder.]

Judy: Okay. Anything else we want?

David: Something about they don't want the smell...they don't want to hear the bulldozers, smell the garbage, and watch their property values plummet!

Karen: They believe that it will be too close to them. The new landfill will be too close.

David helps to keep the conversation light. He makes jokes about the topic and involves whatever Judy and Karen are talking about. When they try to decide what the values are, David says he likes the one about "the spitter." This is a reference to the man in the article that says the landfill will be so close "you could spit over there." When the girls try to decide whether the values are *egocentric* or *social*, Judy says, "Let's see, looking out for the welfare of your children." David interjects, "Mutant kids." This refers to his belief that landfill toxins may cause genetic mutations to organisms that live on or around the landfill. When the group tries to come up with a solution, David offers, "You know what they [the residents] ought to do? The residents ought to sell their property to the board members and let the board members...." Everyone laughs because they know what he is going to say next.

The group finishes their chart before John calls the class back to order. The conversation ends when Judy says, "I think that's gonna do it. Ya'll might think differently." She laughs. No one disagrees. Class time is over, and John tells the class each table will present their findings to the group when we meet again on Thursday morning.

Group Reports

Thursday classes begin at 8:15 and finish at 11:00. [Monday, Tuesday, and Friday classes start at 9:30.] This is an "extended" class and gives us an additional hour to work. John and I decided the best way to share information was for each table to stand and present their chart. This procedure allowed us to expose the students to more articles than the one they read. John was the facilitator for this lesson. He called on each table and asked questions when they finished. I will give a summary of each table's article [the *Soil Compaction: Rooting Depth* table and the *Hydroponics* table have already been given], along with a picture of their chart, and any comments they made that give insight to their feelings about the article.

Soil compaction: Grasses table - article. "Garbage in, compost out: Salem studies green option" (Poole, 1993). The article states that Salem is looking at a compost process that Minnesota uses to get rid of its garbage. It explains that Wright County, Minnesota, takes in slightly less garbage than Salem takes in now. Officials of Wright County say that environmentally, it's good; but financially, it's questionable. Tipping fees at the composting facility is $89 a ton. Part of the high cost is that haulers bring in only 110 tons a day, and the plant was designed to break even at 127 tons a day. Not all localities use the composting facility. Many localities ship out-of-state where tipping fees are less.

The compost produced in Wright County feels and smells like peat moss. It takes approximately six months for the garbage to become compost. When the trucks bring the trash in, inspectors search for "rejects," like water heaters, tires, old baseball bats, or copper tubing. The composting company sends these rejects to the landfill. They put the remaining garbage on a conveyor belt where they remove recyclables and look again for rejects. The garbage then passes through shredders, screens and magnets. The ferrous metals are drawn out. [This is important so the compost will not have heavy metals in them.]

A problem with the compost is that lab tests show it has elevated levels of zinc and PCBs. Because of this, the compost is only used for landfill cover and restricted agricultural purposes. The county gives the compost away, but there are few takers. To make the compost, they add water and oxygen and do periodic turning. A second shredding is also done to remove any remaining glass, plastic or other inorganic material. The compost then cures for approximately six months.

The commissioner's chairman thinks they would have done better if they had gone with a less elaborate plant. He thinks had they gone with a waste processing station instead of a composting plant they would be better financially and still have a place for their garbage.

The article contends that these things do not intimidate the City of Salem. Salem might enjoy having the first composting plant in Virginia. The city is known for doing things differently. Salem did their own thing in the 1970's and 1980's when they decided to rid their trash through a waste-to-steam incinerator when everyone else was burning it. The city council says that composting will keep things out of the landfill and will also show that Salem "can do things as well--if not better--than anyone else." The Salem City Manager feels they can learn what "you shouldn't do" from other people and continue from there.

<u>*Soil compaction: Grasses* table - presentation.</u> Kavita is the spokesperson for her table. (See Figure 17 for the chart.) She says their issue is whether or not to turn garbage into compost. She says Salem is leaning toward doing the composting. She thinks "that it would probably be a good idea because it is probably safer than using landfills and takes up less space. There is a health risk that is also in a landfill with leachate." John asks her

whether they will have to build a special facility and will it include all the garbage. She tells him it would not include everything, only paper, wood and food. Kavita says the article mentions that metals do get into the compost because of batteries that are in the trash. The inspectors do not see these, so they are not pulled out. The heavy metals from this cause a problem because of leaching. John asks her what will Salem City do with the compost after this. Kavita says they will put it on the land as they do in Minnesota.

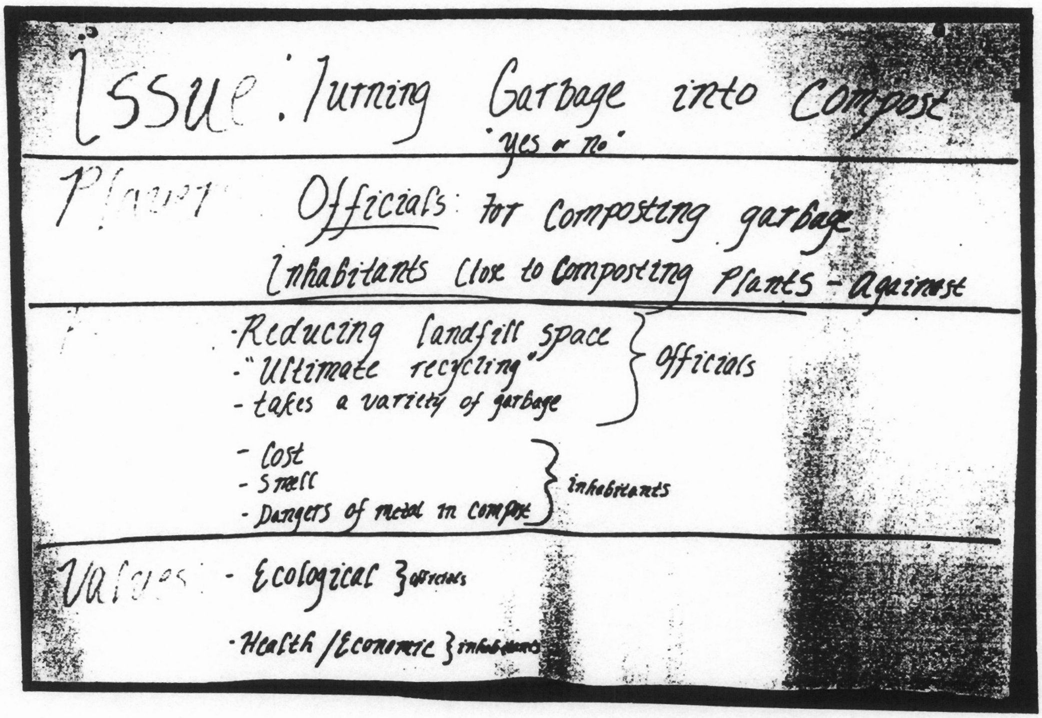
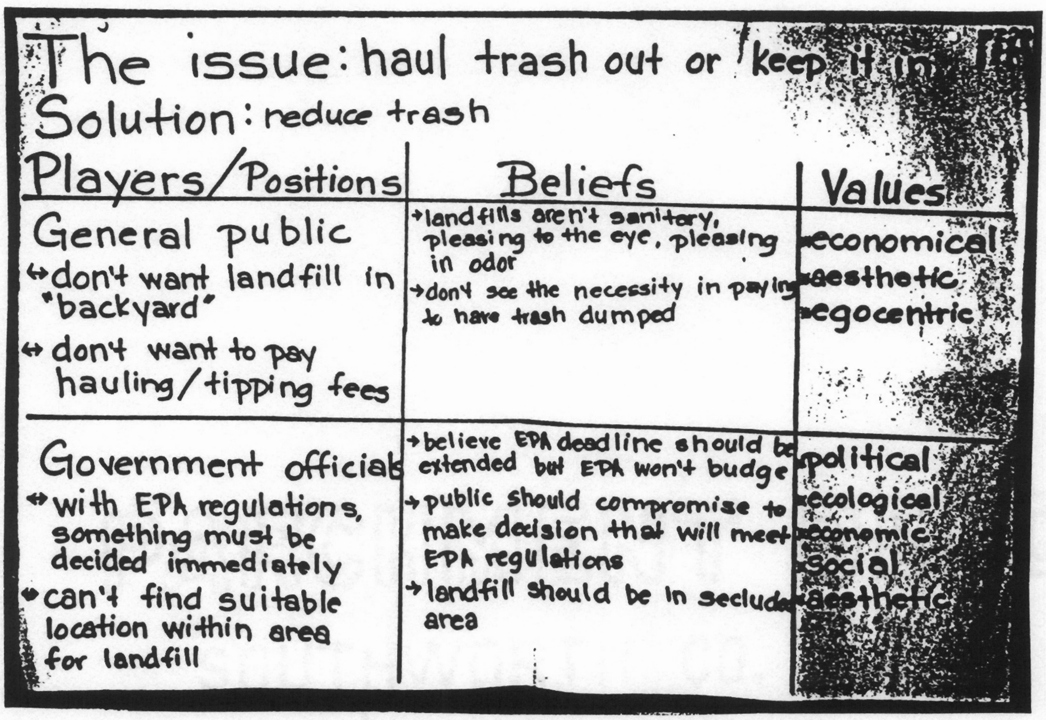


Figure 17. *Soil Compaction: Grasses* Issues Presentation

John asks the class if anyone is familiar with the "sludge issue" with sewage treatment plants. No one is. He tells how the sewage treatment plants produce a compost at the end of their process. It is available for residents to put on their gardens. John says that a group from Virginia Tech tried to develop a process of getting compost and sludge from sewage treatment plants to increase crop yields in southwest Virginia. He says, "This created an uproar because the residents there said they didn't want the end of other people's sewage treatment plants." Their major concern was contamination with metals. "That shows you in small communities like Salem," says John, "people are going to have to get creative with what they do with their trash." He continues by asking the next table to present.

<u>*Soil compaction: Rooting depth* table - presentation</u>. This table says the issue in their article is to haul the trash out, or keep it in Giles County. (See Figure 18.) Mark is the spokesperson. Mark says that the belief of the general public is that landfills are really dirty, are not aesthetically pleasing, and they smell. He disagrees.


The issue: haul trash out or keep it in

Solution: reduce trash

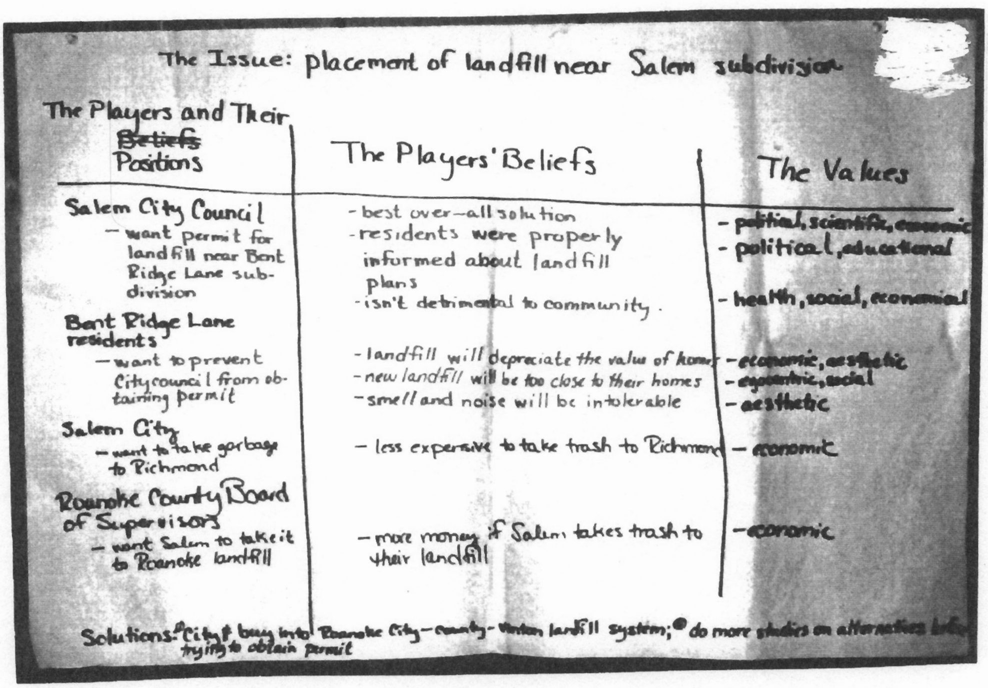
Players/Positions	Beliefs	Values
General public ↔ don't want landfill in "backyard" ↔ don't want to pay hauling/tipping fees	→ landfills aren't sanitary, pleasing to the eye, pleasing in odor → don't see the necessity in paying to have trash dumped	economical aesthetic egocentric
Government officials ↔ with EPA regulations, something must be decided immediately ↔ can't find suitable location within area for landfill	→ believe EPA deadline should be extended but EPA won't budge → public should compromise to make decision that will meet EPA regulations → landfill should be in secluded area	political ecological economic social aesthetic

<u>Figure 18</u>. *Soil Compaction: Rooting Depth* Issues Presentation

"My trip to the landfill proved that it didn't smell that bad and wasn't that bad looking. But, of course, that is the general public's opinion about it." This table gives their solution to the problem of hauling trash out or building their own landfill. Mark states, "Everybody needs to reduce their trash so it won't be so much of a problem in trying to find a place and trying to know what to do with it." John asks which way the group thinks the county is leaning, shipping the trash out or building a new landfill within the county. Bob says he thinks Giles County will go for shipping it out because they are having difficulty finding a suitable place for a landfill within the county. This table finishes, and John points to the next table.

Hydroponics table - presentation. Karen is the spokesperson for the *Hydroponics* table. (See Figure 19). She says the issue of their article is that Salem is thinking about putting a new landfill near the Bent Ridge Lane subdivision. "There are a lot of rich people who live there, and they don't want a landfill anywhere near there." According to Karen, part of the issue is that the doctors feel the Salem City Council gave them the wrong information. The council says they did not. They say they told the residents when they were going to build and where they were going to build. This table also read a second article that gave some of the problems the Salem City Council faces concerning their trash. It seems another alternative to the landfill near Bent Ridge Lane would be to haul their trash to Richmond. This would be $10 a ton cheaper than becoming a member of the RVRA and cooperating with the opening of the new landfill. This table's solution was that Salem City Council should do more studies on alternatives to the landfill in Salem before they continue to try to get the permit. Karen says if Salem would buy into the new landfill, that will solve their problems with the Bent Ridge Lane residents.

John wants to know if "people who have a higher assessed value on their houses or bigger houses have a bigger right to argue whether to have a landfill near them than someone with a smaller house." Judy quickly answers, "No, they just have better means to do it." Karen says that the issue is more public because the people with the bigger houses are wealthier and have more pull. John asks the group how they feel about Salem choosing not to cooperate with the RVRA. "Do they have an obligation to buy into a regional cooperative effort, or can they just go their own way?" he asks. Karen thinks Salem has an obligation to buy in. She says if the trash stays nearby, you realize how much you are producing and "it is more important to you to come up with alternatives because it is in your backyard. If it is off in somebody else's [backyard], they don't feel like it's their property." This table finishes, and the students at the *Slope Study* table are ready to present.



<u>Figure 19</u>. *Hydroponics* Issues Presentation

<u>*Slope study* table - article</u>. The title of their article is "A profit problem; Recyclers find there's not a lot of gold in garbage" (Kelly, 1993). The article states that a private

company in Roanoke that processes used items and sells them to the mills has quit accepting No. 2 colored plastic for recycling. They assert that there is no longer a profit in recycling No. 2 colored plastics. The article states that even if a company must pay to have someone take their recyclables, it is often cheaper than paying to put them in a landfill. Prices paid for recyclables fluctuate with supply and demand. The more people recycle, the less they get paid for their trash. The price for cardboard has gone from $80 in 1990 to $40 in 1993. "Recycling doesn't necessarily save money. What recycling does is save space in the landfill," says the article. Cities that sponsor recycling programs realize that making a profit is not their motive. It is their need to keep the additional trash out of the landfill and meet state mandates. Citizens are going to be more aware of the costs of landfilling and recycling with the new tipping fees. "Trash collection traditionally has been discussed as a service to citizens, not as an expense for them," says Handy Dump. Companies are looking for ways to cut down on their trash collection expenses by recycling. Some companies save their Styrofoam "peanuts" and give them to other companies who use them for packaging. Some wood-related industries also use their wastes to make their own energy. Sears and Kroger have issued guidelines for packaging they will accept at their stores which has forced changes in the shipping methods from their suppliers.

Slope study table - presentation. Syann is the spokesperson for her table. She says their issue is "Recycling when there isn't a profit." (See Figure 20.) The players in their article are the recycling company, who wants to make a profit; the small businesses who want to recycle, but need the support of a recycling company; and the environmental groups who feel everyone should recycle, even if there is no profit.

Syann does not think the recycling companies are environmentally friendly because they are in the recycling business only to make a profit. Their table's solution is for the government to give economic incentives to area businesses or recycling companies to recycle non-profitable items. John tells the class about towns in the Northeast that have huge stockpiles of papers and other recyclables that no one wants to buy. He explains if we are going to recycle, we must have a market for it. John calls on the next table to present.

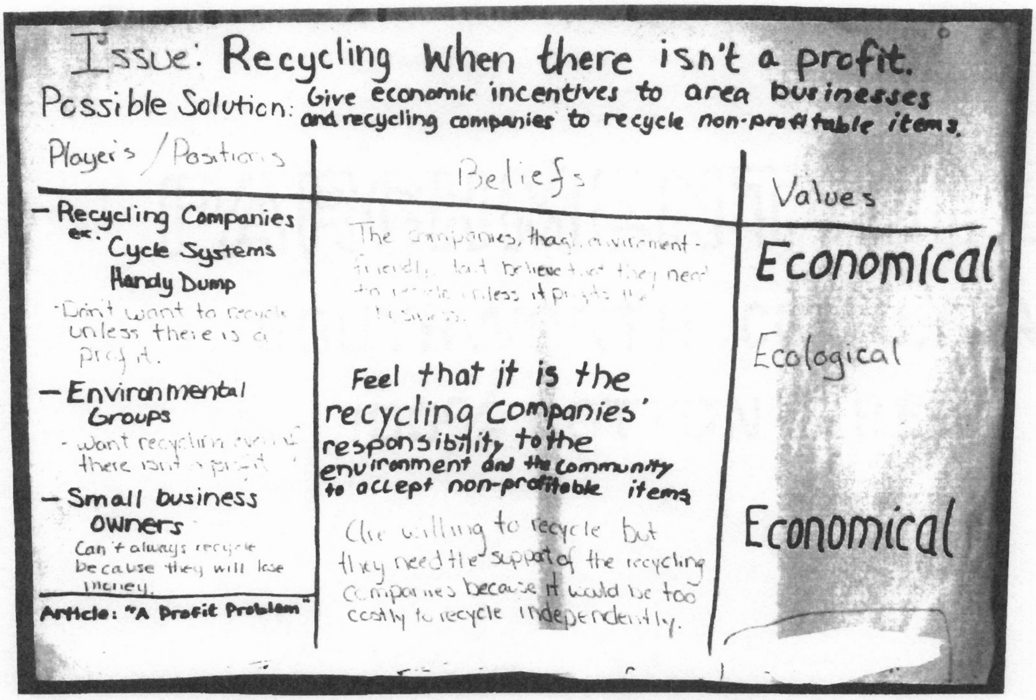


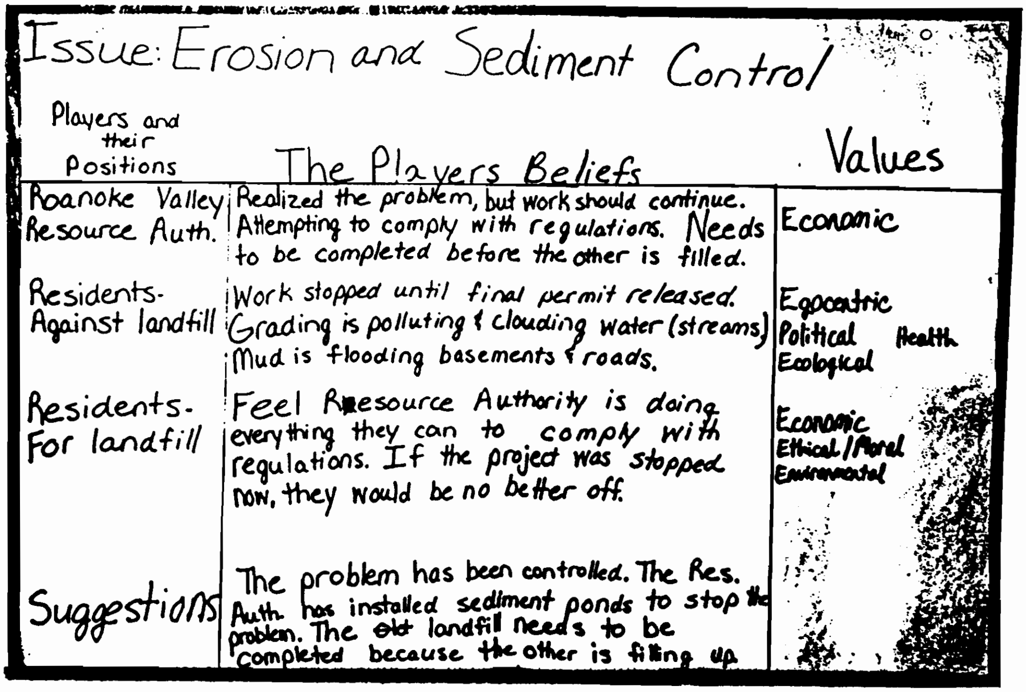
Figure 20. *Slope Study* Issues Presentation

Grass and wildflower aggression table - article. This table's article is "Halt to landfill work requested" (Turner, 1993). Several residents of Montgomery County want the state to halt construction on the new landfill until the state issues a final permit. They say that the RVRA is "violating state regulations by grading and preparing the Smith Gap site." The residents contend that the grading is polluting the underground water and small streams off Bradshaw Road near the landfill. According to the article, there is a two-phase permit, the first deals with the site location, and the second with the "design and technical issues." RVRA has continued construction in order to meet the October 9 deadlines, even though the state has not issued the second permit.

However, not everyone agrees because not all residents want construction stopped. "I feel Roanoke County is doing its part to see that it is done right. It would be a shame to put this project on hold," says one landowner on Bradshaw Road. Barry Wright, from the Department of Environmental Quality (DEQ), says the state will review everything. The fact that construction has already begun will not sway DEQ because they understand localities having to go ahead when they are in a bind to build a landfill.

John also included in this packet several articles telling about the mud some of the Bradshaw Road residents were finding in their basements. The article quotes the director of the Roanoke Valley Resource Authority (RVRA) as saying, "Certainly the mud's coming up there from the landfill area." One article has a picture of a car that has slid off Bradshaw Road and into a ravine because of the mud.

Grass and wildflower aggression table - presentation. Ann is the spokesperson for her table. (See Figure 21.) Their issue is the need for erosion and sediment control at the new landfill at Smith Mountain Gap. Ann says, "We feel basically the problem has been controlled. The Resource Authority has installed sediment ponds to stop the problem, and the landfill needs to be completed because the other [one] is filling up very fast. Otherwise, we won't have any place to put our trash." John asks her to summarize what happened on Bradshaw Road this summer. Ann tells the class that one lady had mud in her basement and the Resource Authority paid to have it cleaned up. John reminds them, "When we were out there you saw that open bare area with all that dirt. When it rains, the water is going to run down all of that and turn it to mud.



Issue: Erosion and Sediment Control

Players and their Positions	The Players Beliefs	Values
Roanoke Valley Resource Auth.	Realized the problem, but work should continue. Attempting to comply with regulations. Needs to be completed before the other is filled.	Economic
Residents- Against landfill	Work stopped until final permit released. Grading is polluting & clouding water (streams) Mud is flooding basements & roads.	Egocentric Political Health Ecological
Residents- For landfill	Feel Resource Authority is doing everything they can to comply with regulations. If the project was stopped now, they would be no better off.	Economic Ethical/Moral Environmental
Suggestions	The problem has been controlled. The Res. Auth. has installed sediment ponds to stop the problem. The ~~old~~ landfill needs to be completed because the other is filling up	

Figure 21. *Grass and Wildflower Aggression* Issues Presentation

If the Resource Authority didn't have their sediment ponds in place, or in the proper place, then the road and houses are going to get all that mud." This table is finished and John points to the last table.

Temperature effects on plants table - article. Their article is "Is out-of-state trash big bucks or big problems?" (Coccaro, 1993). The article states that several huge landfills are to open in southwest Virginia. The rural areas are selling something they have plenty of, space, to urban areas that need a place to put their trash. It says, "Only California and Missouri plow more waste into landfills per capita than Virginia, industry statistics show." Those against the landfills say that Virginia is "mortgaging its future by creating a legacy that could prove costly in decades to come." State laws do not limit the amount of trash we can import into Virginia. Most of the out-of-state trash comes from Washington, D. C., New York City, New Jersey and Pennsylvania. The only commodity banned for import into Virginia's landfills is hazardous materials.

This article states that Central and Southwest Virginia are good locations for landfills because of their accessibility by interstate and rail. The terrain is also composed of clay soil. The poorer the county, the more apt they are to come looking for landfill dollars, or "trash for cash." Those against the landfills call it "environmental racism." They say that low-income and minority communities are powerless if they don't want a landfill in their area.

Landfill operators say they are not exploiting the residents. They point to the fact that they set aside money to close landfills or correct pollution problems if something happens within thirty years. Opponents argue that thirty years is not long enough. They also say that private operators do not have the same level of concern as do the people who live there.

The article reports that everyone agrees with the need for the new EPA regulations. What everybody doesn't realize is the amount of money it will take to operate the new landfills. Because of this increased cost, large landfills are more economical to operate. When commercial operators are willing to buy the land, build the landfill, share a small percentage of the landfill proceeds and take care of the host county's trash free, it is difficult for rural county supervisors to turn down such an offer.

Temperature effects on plants table - presentation. Bill is the spokesperson for this table. He says their issue is whether out-of-state trash be allowed into Virginia landfills. (See Figure 22.) Bill says that the rural county supervisors like the idea of having new landfills built. However, rural county residents do not like the idea, and state legislators are split on the issue. Bill states that some state legislators think the rural counties are being discriminated against because they are rural and have a high minority population. "Others are saying that some of the politicians have been bought off by the landfill operators." Bill said their table had difficulty coming up with a solution.

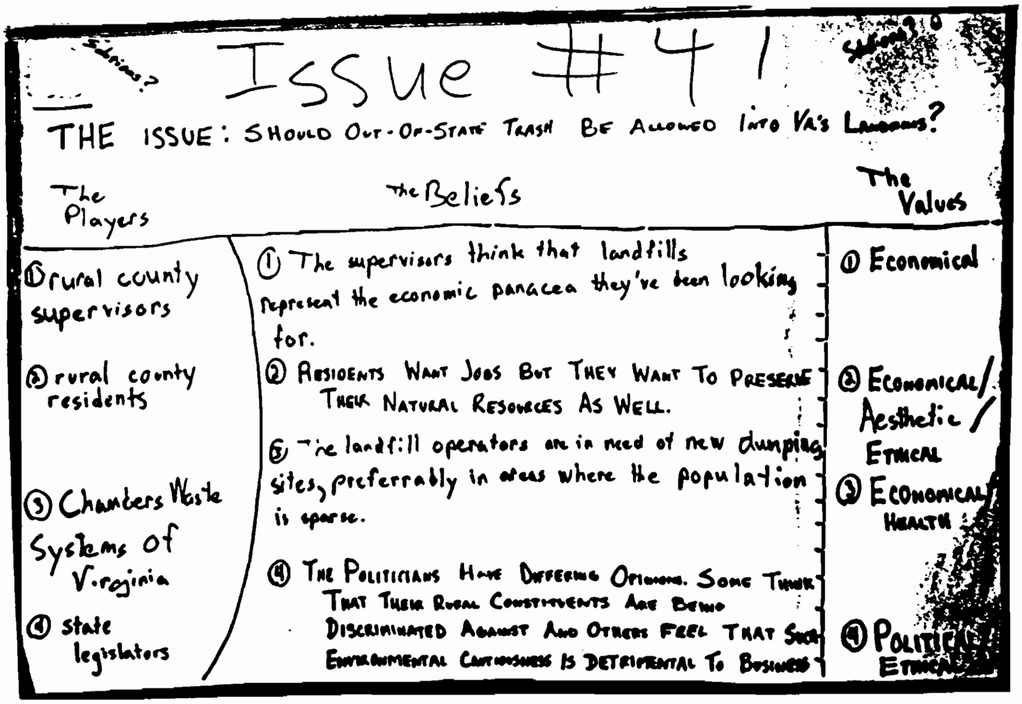


Figure 22. *Temperature Effects on Plants* Issues Presentation

"We just didn't know," admitted Bill. "If the county residents vote down the landfill, the landfill operator is just going to go somewhere else, so it doesn't really matter to them." John tells the class that Franklin County landfill has a tipping fee of $20 a ton and the new Roanoke landfill is going to be $55 a ton. John explains that because of Franklin County's low price, they have been willing to be the recipient of much trash from around the state. "If you want the money, then you take the trash," he says.

John asks the class if there are questions on any of the articles we have read. No one says anything. John tells the students he thinks they have a good understanding of the players and issues. He says that by understanding these articles, they will understand the landfill issues.

Setting up Experiments

November 1, 1993

The students are busy when I arrive at school. John has the tables covered with newspaper. There is one table for sieving soil and another for cutting containers. Everyone seems to be doing something. Mara cannot come today so she will be "on-line" on the computer at Tech while we are "on-line" here. [We were going to do interactive talking on the computers through Virginia Pen, but I couldn't get Mara logged on this morning.] We will log on at 10:00 a.m. from the Governor's School with our questions. (See Appendix A for copies of e-mail messages.)

The students have been working on sieving the landfill soil in their spare time this week. However, they have not gotten much done. Mara told them it was important to try to have the dirt of uniform size. It is obvious John, Mara, and I underestimated the amount of time it will take to prepare the soil. We have most of the containers cut, but we need to sieve more soil. None of the groups planted seeds today. John realizes this activity is going to extend into another day, and he is becoming concerned with the amount of time it's taking. I did not use the tape recorders today because everyone was moving about the room; no one was in any set place. The floor has turned to a dusty orange color from the landfill soil.

November 2, 1993

The class is busy working again this morning. The students are focused and working in their groups. I set my tape recorder at the *Soil Compaction: Grasses* table. When most of the activity shifts to the workroom where students are using the electric balances, I move the tape recorder in there. The *Soil Compaction: Rooting Depth* table is also working in the workroom.

The workroom. Divya and Kusum are in the workroom trying to decide how much soil to put on the balance. Mark, Corrine, and Judy are also weighing their soil. Bob is in the classroom. Mara has told the students if they are testing compacted soils, they should weigh small amounts of landfill dirt, put it in their container, and then compact it. By doing this several times, their compaction will be more uniform than if they put the dirt in at once and then compact it.

Divya spills something. Kusum says, "Oh, my God, you've got to be kidding me!" This upsets Divya. She says, "What do we do now?" "Hold on," says Kusum, "we'll just scoop that up." Mark sees the mess and says, "You guys are soooo messy. I mean...my God." Kavita tries to reassure Divya. She says, "Don't worry." They clean everything up and continue working. It is fairly quiet in the workroom as everyone is weighing and measuring. Mark weighs his soil and says, "Perfection!"

Divya and Kusum finish weighing part of their soil. Kavita comes into the workroom. Divya and Kavita, who are sisters, get into an argument about who is going to do the weighing next. Kavita has been in the classroom cutting bottles.

Kavita: I think I want to do this [weigh soil].

Divya: No, I am.

Kavita: No, I am. I haven't done anything.

Divya: You have.

Kavita: No, I haven't.

Divya: Well, I started this, okay?

[No one else speaks, and Divya finishes what she started.]

Corrine and Judy are putting gravel into the bottom of the bottles for drainage. Judy laughs. Mark says, "Shut up, people!" Judy says, "We're not laughing at you." He responds, "I know, I was just kidding. Can't I be facetious?" Judy giggles. Mark goodheartedly says, "**Now** you're laughing at me." Judy asks if anybody is writing down the weights. Mark answers, "Corrine is."

Bob walks in. He has been in the classroom cutting the tops off bottles and removing the bottoms. He has come to see what the rest of the group is doing. Bob evidently has a difference of opinion with what Mara told them to do when measuring and compacting the landfill dirt. Bob argues they should have the same volume of landfill soil in both containers and then compact the soil in the "compacted container." Mara has told the students doing compaction studies they should have the same *weight* in both compacted and uncompacted containers. He says:

Bob: I **still** think that it's the same volume, only different compaction. How does that go?

[I walk in and the discussion stops. Bob leaves, and the students continue working. I walk out, and Bob comes back in.]

Bob: Is there anything that I can do to help ya'll?

[Divya moves to get around Mark.]

Divya: Excuse me, Mark. Thank you.

Bob: I was saying, ya'll. I still, I KNOW...

[He bumps into Divya.]

Divya: Bob! Thanks a lot!

Bob: I'm sorry. I don't care what Miss Mara thinks! This has to be the same volume...

Corrine: Good-bye.

Bob: ...or it's different compaction.

Corrine: Good-bye.

Bob: This is my experiment, too. Okay?....Okay?

Corrine: Yeah.

Bob: It's my grade.

Ruth: What are you saying, Bob?

Bob: I don't care what **anybody** says,

Mark: What are you saying?

Bob: Unless these are the same...unless this is the same volume that this mass....

[Bob knocks into Divya again. She is very aggravated this time.]

Divya: Bob! Gosh! Thank you, Bob! Thank you soooo much!

Bob: It's not the same compaction. So we have to measure this and measure the same volume.

[Corrine and Judy talk about what they are doing and continue working.]

Bob: Does anybody listen to me? Does anybody care?

Divya: You've **really** got to move because it's going to keep on spilling.

Corrine: So you're saying that we need to do something about this?

Bob: We have to make sure this is the same volume or it's not the same compaction, it's just the same amount of volume.

Corrine: Well, they're the same kind of bottles.

Bob: I know, but this is filled up higher.

Corrine: But they are the same weight!

Bob: That doesn't matter, because it's a different method.

Corrine: Let's just put it in there.

Bob: It's not going to matter as much for the uncompacted as for the compacted. But once we get to the compacted, it's going to be kinda full. So, if we are going to do it for the compacted, we need to do it for the uncompacted.

Mark: They [Corrine and Ruth] just ignore us.

Bob: I know. [The girls laugh.] All I am saying is that we need to make sure this is the same height.

Corrine: Okay.

[Bob leaves and goes back into the classroom.]

Most of the activity in the workroom has finished. The *Soil Compaction: Grasses* group has moved back to the classroom. They have weighed and compacted their landfill soil. John has told the students to saturate the soil before planting their seeds. The girls are watering their soil and measuring the amount of water they have poured in. It concerns them that some of the water is leaking out. Divya asks Corrine how are they watering theirs, are they "spraying it around a little?" Corrine answers, "Yeah." John comes to Divya's table and looks at their containers. Kusum tells John that it is a lot harder for the water to get in. He says that it will take a while for the water to soak down. Kusum wants to know if it is okay for them to put different amounts of water in different containers. John tells them it will be fine; the idea is to get them soaked.

Divya, Kusum and Kavita continue to put water into the container. They are watching to see if the soil is becoming saturated. "Where is it going?" asks Kavita. "Look at this side. It looks like, dry," says Kusum. "The other side is worse than that," says Divya. It frustrates the girls that they are putting water in, it is running out the bottom, and isn't saturating the soil. They have put 900 ml of water in one container and 400 ml of water in another. "Do you think this one is okay?" asks Kavita. "I don't know," responds Divya. "Should we put [water in] one more time, do you think?" asks Kavita again. "I don't **know**," says Kusum. "I don't know what we're waiting for, I guess it could say, 'I'm full!'" says Kavita. They laugh. They continue trying to decide what to do.

Mark walks to the table where Divya, Kusum and Kavita are working. He asks, "How much water did you guys put in?" "It's been different. We put 900 ml [in one] and 400 ml [in another]," says Kusum. "We don't know how much to **put**!" says Kavita. "I think we should put [it in] one more time," says Kusum. She turns and talks to Mark again, "We don't know. This one seemed to soak it up and that one has dry places. This is as much...." Mark says, "All right," and he leaves to go back to his table. Kusum is concerned that it is going to take "forever" to soak the compacted soil. They are afraid that they will not get the soil soaked in time to plant their seeds today. I walk by the table and hear the girls talking about how much water they are using. I tell them now they know why Mara called the landfill soil "droughty." John hears us and says, "Yes, because it dries out so badly."

Mark returns to the *Soil Compaction: Grasses* table. He sees the pan that the 2-liter bottles are sitting in is full of water. He asks, "How come you've got water all in the bottom?" "Because it's all leaking through," answers Kavita. Mark notes, "We put gravel in the bottom of ours. Are we suppose to use straight water from the tap?" he asks. "Yeah, to water [the soil]," says Kavita. They scoop the water from the pan and pour it back into the containers as they try to saturate the soil. Kusum says they "could sit here all day and do this."

Kavita asks Divya and Kusum if they saw the 'Spanish dance.' They say they did. "The costumes were very colorful," says Kavita. "It was pretty nice," respond Divya and Kusum. The discussion returns immediately to concern over the amount of water they are putting in the containers.

Mark returns to their table. He asks, "How much water did you put in the clay?" Divya answers, "Let's see, for this one, the loose one, we put 900 ml. In this one [the compact one], we put 400 ml." [Evidently the uncompacted soil absorbed more water than did the compacted soil.] Kusum says, "As much as you can until you get it saturated." "Okay," says Mark, "I think we should have put holes in the bottom." "You didn't?" asks Divya, "I thought you did." "We put gravel at the bottom," responds Mark. "I know it's [the water] gonna come back up," says Divya. Kavita asks, "How much gravel did ya'll put?" "Uhhh, about an inch and a half," answers Mark. He then says something and the girls laugh. Mark pretends Kavita said it. He says, "Kavita, you've got to watch your mouth." She laughs and says, "Okay."

Mark leaves and the girls continue to talk about the water in the containers. They continue to be surprised at how much water each container takes. Even though they see the water draining out the holes in bottom, they notice the soil on the sides of the container is still not becoming saturated. The girls continue to work even though other tables around them are beginning to finish and clean up.

The *Soil Compaction: Rooting Depth* table is finished so Bob walks to the table with Divya, Kusum, and Kavita. Kusum teases Bob about the orange colored water that continues to filter through the landfill soil. "Bob, you want some? Yum, yum, yum!" she says. "You want to drink it? Here!" offers Divya. They all laugh. Kavita asks Bob, "What are ya'll doing now?" "Nothing," responds Bob. "Well, we were doing those bottles, but we ran out of time," he says. Bob and Kusum talk about a test they have this week. Mark joins the group and there is light conversation between the boys and girls. The topic of driving comes up. Mark says that he is a good driver. Kavita teases him and tells him to look "forward, not backward." Mark says, "You girls don't understand, okay? They don't make cars for big guys." "For what?" asks Divya. "For big people, like myself," says Mark. "Why," asks Divya, "what's the problem?" "I'm in the car like this," says Mark. [He is extending his arms in front of him.] "All the way back?" asks Divya. "Yeah," responds Mark. "If I'm up too far, my knees are under the steering wheel." The topic changes, and they talk about some students who moved.

The girls talk as they continue to scoop up water from the pan and pour it back into the containers. They are very frustrated. Bob and Mark leave. Kusum wants to make sure they are writing everything down. Divya suggests they get a pipette to suck the water up rather than scooping it up with a cup. John brings a turkey baster to help. I join their table and explain what they are seeing in their containers is an example of what happens on the landfill; the water on the landfill doesn't percolate into the soil either. The bell rings, but the girls decide to stay after class and work until they are satisfied the soil is saturated.

Letter Writing Activity
November 4, 1993

I thought today would be a good time for students to integrate the information they have gathered from the various sources. John and I have talked in our planning about the students having the opportunity to write to the chairman of the board, Roanoke Valley Resource Authority (RVRA). These were not letters we expected to share with him, but to use the writing as an opportunity for the students to voice their opinions and ask questions in the classroom setting. In the letter, they were to share their positive or negative thoughts about anything they have seen or read that involved landfills. I also gave the students a one-page note that restated what my purpose in the classroom was and outlined their assignment for writing this letter. (See Appendix A for Notes from Bea Taylor.) The students had a week to write. The day they brought their letters to class, John decided to have them exchange their letters with someone in the room. The students pretended they were the chairman and wrote a response. I was not aware John was going to do this, but I was pleased he took the activity one step further. I will look first at the letters the students wrote to the chairman and then their responses. (See Appendix D for copies of letters.)

Student Letters

The students make many thoughtful comments and bring up new issues in their letters. Several common themes emerge. The first is the cost of the project. The students know the cost of constructing the new landfill is approximately $42 million. They have feelings both for and against the amount of money spent. Corrine's feelings are very strong. She writes, "...would it have been possible to create the same technologically advanced waste removal system with maybe a little less monetary means?" Corrine feels the transfer station is "much more elaborate" than our homes. She wonders if we should house our trash better than we house ourselves. Corrine sees education as a way to help cut down the need for such a large landfill. She states, "...if people knew exactly how many millions of their dollars are being spent on the construction of the landfill operation, they would make more of an effort to reduce the amount of wastes produced." Kavita also questions the amount of money spent. She asks whether we could spend our money better in other areas that are more needy or beneficial.

Several students believe the new landfill is going to be more cost effective than the old one. Divya does. She states that the use of rail cars is much more economical than the use of garbage trucks. She realizes we will save on gas, tires, time, and the number of vehicles on the road. Divya also believes a healthy environment should be important. She says, "...cost should not be a great factor when trying to keep the people and the environment healthy." Ann agrees with Divya. She thinks costs do concern the RVRA. By making the clay on site, Ann says that the RVRA is helping to keep down the cost of the new landfill.

Regardless of the cost, the construction of the landfill impresses the students. Jason writes that the new landfill will be very effective in controlling pollution, and Linda comments that the train will help limit the traffic on Bradshaw Road. However, Bob sees the size of the landfill creating another problem. He thinks it may send the wrong message to people about trash. He writes, "One concern I have is that the opening of a new landfill may encourage people to continue to produce large amount of waste." He thinks if there is someplace to put trash, people will not try to limit what they throw away. Ann and Corrine also ask several questions about the use of the geotextile liner. Because the geotextile liner is an open plastic grating, they are uncertain how it functions. Bob states that safety to the environment is important, and it pleases him that the liner is "much more substantial than I had imagined it would be."

Students also comment in their letters on the management of the landfill. There are three localities that will be dumping their trash in the new landfill: Roanoke County, Roanoke City, and the City of Vinton. Kavita questions whether they should admit new members. She wonders if more members might hinder the safety and smoothness of the operation. Linda wants to know what will be the qualifications or restrictions on new members.

The students also question the effect of the landfill on people who live near it. Karol says she has received "all the landfill propaganda," yet she wonders about the negative reactions. She wants to know about community reactions as the landfill is nearing completion. She is aware of the newspaper articles we read in the classroom that talked about the mud that came from the landfill. The paper said the mud was due to inadequate settling ponds on the landfill while construction is in progress. When it rains, the mud did not go into the ponds, but washed onto the road and into homes. Karol feels this is reason for many complaints from neighbors. Divya also wants to know if there have been any complaints. Kavita voices a "N.I.M.B.Y." attitude. She does **N**ot want the landfill "**I**n **M**y **B**ack **Y**ard." She writes she has read the pamphlets about safety and RVRA's policy to help prevent the reduction of property values, and they do not convince her. "Why shuld [sic] I take the risk of living near a landfill?" she asks. Kavita's opinion is not that unusual for resident who may be impacted by the location of a landfill.

The level of planning and construction of the new landfill is new to many of the students. Divya says, "There has been a major change in reorganizing the priorities important to us, and it seems that an efficient landfill is on the top of the list." Students comment that before this study they had not realized how complicated the operation of a landfill is. Karen says the sophistication of the procedures and materials currently in use at the new landfill are impressive. Ethel writes, "I realize landfills are always going to cause some environmental problems; however, they are a necessary evil, and I think you have done a good job of handling it."

Another topic many of the students address is recycling. Seven of the twenty students write about it. Their main concern is the large amount of recyclables they saw in the baling building at the Roanoke Regional landfill. There were plastics, cardboard, and papers going into the landfill. Russell told us on our landfill trip that operators look for hazardous wastes. He said they pull these out of the trash and do not put them into the landfill. Several of the students feel the landfill operators should pull out recyclables in the same way. Mark says that with all the publicity about recycling, it surprises him there are not more recycling programs initiated at the landfill site. Kavita agrees with Mark. She wonders why there are not any recycling areas. Bob questions whether governmental regulations and financial benefits for recycling will really help us become more preventive of waste. He thinks we will continue as we have and continue to throw things away.

Syann offers several suggestions to the recycling problem. She states that we should fine people who throw away recyclables according to the weight of those items. She sees this as motivation for people who recycle and a deterrent for those who don't. Syann does caution though, "We need to be careful not to make people think that it is not necessary for them to separate their recyclable goods because the city will do it anyway." She knows there are some people who would rather pay someone else to do it than do it themselves.

Monitoring of the landfill for possible leachate pollution of the ground water and streams also concerns the students. Even though they offer few suggestions for monitoring, they do have many questions. Since workers had not laid the leachate pipes in the new landfill when we visited, and we didn't have the opportunity to talk to someone who does the testing, this aspect of landfill monitoring is somewhat nebulous. Students ask what will RVRA do if water from the settling ponds runs over into the Roanoke River, or how many times will they analyze the water throughout the year. Several students want to know how the monitoring is done. The people who live on Bradshaw Road near the landfill concern Karol. She asks since the people there are reliant upon well water, how will RVRA handle the possible problem of leachate runoff that might contaminate their wells. She feels the cost of a cleanup would be "extensive" when combined with the pumping in of fresh water for consumption.

The students also address the issue of restoration. Karol asks what plans RVRA has for the Roanoke Regional Landfill once they close it? Many of the questions revolve around the rooting depth of plants. Syann says she believes it will be beneficial to increase the capping layer so they can use a more extensive variety of plants on the landfill. A deeper cap of soil allows the planting of trees and other vegetation with rooting depths greater than six inches. Syann especially wants the inclusion of trees on the landfill. She says, "They help prevent erosion, provide habitats for animals, attract people, and have their own natural beauty." Syann also calls for more plant testing. Kavita feels RVRA is being too "idealistic" about the closing of the landfill. She writes, "To think that there will be no ground water contamination, methane problems, or health hazards is too unrealistic." Kavita does not think the landfill will be able to grow and maintain grasses, flowers, and a meadow. Karol talks the problems the Roanoke Regional Landfill Authority has encountered because of "stricter standards, recovering and drainage" when closing the Roanoke Regional Landfill. She wonders whether they foresee problems of this type when the Smith Mountain Gap landfill closes. The students not only posed questions in their letters, they also stated their perceptions about what we were doing in the classroom.

The students shared how they felt about being a part of this study. "I am really excited about the new landfill program," says Syann. "Touring the old landfill made an impression on me," comments Bill. Ruth talks about the impact of the field trip. She says, "I had heard the facts and figures, but it didn't strike me until I saw what those facts and figures represented." The students hope their work in the study will be helpful. Karen writes, "I can only hope that we will be able to gather data and observations that the RVRA will find useful. Perhaps our experiences will serve some purpose in future experiments concerning landfill restoration." Students also see the importance of educating the public. Bill says he hopes the RVRA will make more of an effort in the future to disseminate information on waste management policy. Bob agrees saying, "Hopefully, the new landfill will provide the public with education, which is the key to success, and our waste situations will be resolved."

The Chairman's Simulated Responses

How do the students, as they pretend to be the chairman, answer their classmates' questions and concerns? (See Appendix D for copies of responses.) The students did not realize before the exchange of papers there would be a second component to the letter writing activity. They begin their answers thanking the writers for their concerns. Karol writes, "It is great to hear of your interest in the landfill and its procedures." Kusum says, "It is always my pleasure to read such letters from interested and caring students of your nature." The students then address the questions of the writers.

Corrine and Kavita have written about their concern over the cost of the new landfill project. Mark tells Kavita it is natural that the cost of the landfill be a concern. "However," he says, "it is going towards the best and cleanest methods of waste management." Divya, when responding to Corrine, says that answering her question about "creating a technologically advanced waste removal system with less monetary means" is difficult. She explains that materials are expensive, and they do try to get the best. Divya also says that she doesn't think money should be a factor when one is trying to protect the public and the environment. She offers the suggestion that if people think the waste management system is expensive, they might recycle, reduce, and reuse. Divya also defends the cost of the buildings by saying, "We feel that our landfill project needed to take on a whole different picture." She thinks the RVRA is trying to change the landfill's image so people will be willing to live and work near it without thinking of trash.

Several writers inquire about the purpose of the geotextile liner. The students have difficulty answering this question. Their responses are very honest. "I cannot answer your question because I am not that familiar with the function of the plastic liner and the cloth covered grated liner," answers Divya. However, most students offer to find answers for the writers, or give them a number to call to get additional information.

Divya, Karol, and Kavita also ask questions about the residents on Bradshaw Road. The responders promise Divya and Kavita they are doing everything they can to make sure the landfill pleases the residents of Smith Mountain Gap and the taxpayers. However, Jason is less accommodating. He tells Karol, "As long as pollution tests are maintained and other pollutions are kept under control, they're [the residents] not really concerned. I'm not really positive about the residents' views about the completion of the landfill, but most of them don't really have a choice on the matter."

Many of the students address concerns of the writers about the lack of recycling at the Roanoke Regional Landfill. The students give similar answers, even though they say it in different ways. They see the problem with sorting out recyclables as one of time and money. Kavita tells Mark, "It takes a great deal of time for a person to sort through trash searching for recyclable wastes." Ethel writes, "Because the trash could not be processed very quickly, removing recyclables would also be very inefficient." Kusum offers the suggestion that recycling needs to start in the homes. Bill says that he hopes the municipal recycling program will become more convenient in the future. In response to Bob's question whether governmental regulations really help us become more preventive of wastes, Bill simply says, "I hope you understand that they [government regulations] are necessary." Ethel responds to Syann's suggestion on fining people who throw away recyclables. She says, "Fining those who throw away recyclables is difficult because most household garbage comes to the transfer station in trucks. The owners of the garbage cannot be traced."

Many of the writers have questions about closing and monitoring procedures. Karol asks what is going to happen to the Roanoke Regional Landfill once it closes. Jason answers that he is not in charge of the use of the closed landfill. However, he tells Karol she can call his friend who has that information. Syann writes that she feels they need more topsoil when they cap the landfill so they can plant trees. Ethel tells her that additional topsoil will "pose problems in terms of time and money." She does say that Syann "makes a good point in that more research needs to be done concerning the plants used as landfill cover."

Students also have questions about leachate and water monitoring. Karol asks how the RVRA plans to handle the problem of runoff and leachate that might contaminate the water system. Jason begins by explaining to her the use of the clay liner and the plastic liner. He says there will also be drainage pipes to collect the leachate. The pipes will take the leachate to the sewage treatment plant. However, Jason is confident that the leachate problems at the new landfill do not concern him. He writes, "The technology is so advanced that every aspect of the problem has been solved." When Kusum asks the same question about contamination, Karen assures her they will take action to reduce the risk of contamination to the water "to the best of our ability."

The students finish answering their letters as cordially as they began. They tell the writer they hope they have been able to answer the questions and invite the writer to "feel free to inquire about other issues." Bob writes, "Hopefully, through education and planning, together, we can solve our landfill conflicts and produce less waste."

Beyond Landfills
December 3, 1993

Dr. John Cairns, Director of the Center for Environmental and Hazardous Materials Studies at Virginia Tech, spoke to the students at the Governor's School. He is Mara's advisor and principal investigator for the restoration of the Roanoke Regional Landfill project. As soon as the students arrived, Mara introduced him. Dr. Cairns thanked the students for the work they have done on the project and for their help in assisting Mara with seed experiments. He said part of his response in this talk will be to the letter writing activity the students did when they "wrote" to the chairman of the board of the Roanoke Valley Resource Authority (RVRA). "This [talk] is going to go way beyond landfills and restoration and will cover countries other than our own," said Dr. Cairns. The students sat quietly as Dr. Cairns stepped to the front of the classroom.

Ecosystem Services

Dr. Cairns begins by telling what natural ecosystems do for us. He begins by explaining that natural ecosystems maintain the proportion of gases in the atmosphere. The natural systems regulate that proportion so it is suitable for us. Without it, he warns, we could not survive. The exchange of gases with plants helps to maintain this balance. Dr. Cairns describes our atmosphere as "a very thin envelope." He tells the students the distance from the earth to the edge of this envelope is probably less than the distance they traveled from home to school this morning. Natural systems also purify the water for us. Water takes some of the wastes and degrades it. Then living material incorporates this waste, making it less dangerous for us. In addition, Dr. Cairns lists that natural systems provide genetic materials that are resistant to pests and produce medicinal substances. He states that taxol from the bark of the yew tree is a good example of this. He says that we are finding taxol useful in the treatment of some cancers. And, of course, natural ecosystems also provide recreation for us in the way of water sports, and outdoors activities. Dr. Cairns states that we call these provisions of the natural ecosystem "ecosystem services."

Dr. Cairns tells the students that today we'll look at the natural ecosystems of water and air. "Water wouldn't be fit to drink if something didn't happen to the waste we discharge into it," says Dr. Cairns. He explains that natural systems purify much of the waste. In the same way, organisms that grow on the earth help to maintain the gas balance in the atmosphere. He says that methane is a good example. Soil organisms take the methane out of the air and decompose it. After giving background on ecosystem services, Dr. Cairns begins to explain negative impacts on them.

Dr. Cairns tells the students two things are happening in their lifetimes that are very important. First, the population is growing very rapidly. He states that the equivalence of the population of the United States is being added to the world every two and one-half years. In addition, we are destroying ecosystems at a high rate. He asks, "How many ecosystem services per capita would you like to have?" No one responds. Dr. Cairns explains even if ecosystem services remain the same and we destroy no more, because our population continues to grow and the earth is finite, there will still be a drop in ecosystem services per capita. Dr. Cairns tries to explain the idea of limited ecosystem services by giving an example.

> Supposed you took a big lid and put it over the Roanoke Valley. Would there be enough ecosystem action to keep the air pure and the water pure? And what would happen if you doubled the population and the lid still stayed on? What would happen if you destroyed some of the ecosystems? [He pauses briefly and then answers his questions.] We can't destroy ecosystems, increase the population, and continue to have acceptable living conditions.

Dr. Cairns tells two stories to show that air currents tie the countries in each hemisphere together. He says the atmospheric pollution from the United States is so bad that pilots, when flying to Europe, can see a smoke plume riding the air currents all the way across the ocean. He also tells of the killing of 100,000 reindeer in Lapland because of their absorbing too much radiation from the Chernobyl nuclear explosion. Even though it is a long distance between Chernobyl and Lapland, the air currents carried enough pollution to affect the reindeer. Dr. Cairns also talks about the environmental and political problems he anticipates will confront the students shortly after their graduating from college. He expects these problems to come from China.

IPAT Equation

Dr. Cairns says the People's Republic of China wants to double its energy consumption per capita by the year 2000. He predicts this is possible because China has big coal reserves and nuclear capabilities, and will probably increase their energy consumption with coal. However, because China's coal is not as good as ours, he hypothesizes that there will probably be more pollution. Dr. Cairns also tells us that India wants to double its energy consumption, but he is doubtful whether they will make it because they are not in an industrial boom. He reminds the students that India and China have over half of the world's population.

Dr. Cairns walks to the board and writes in big letters:

$$I = P \times A \times T$$

He explains the equation saying that "I" stands for environmental *impact*, "P" is *population*, and "A" is the level of *affluence*. "T" stands for *technology*. Dr. Cairns tells us one way to measure affluence is the per capita level of energy consumption. The most developed countries have the highest per capita energy consumption, and America is the highest of all.

China. Dr. Cairns explains to the students a simple way to see the difference between American's culture and China's culture. "The Chinese get 100 calories in agriculture for every calorie of energy they invest in the system," he says. He defines their culture as an agricultural system based on manual labor. People buy food close to its source and in its natural state. China does not have landfills because they reuse their materials. "In contrast," he remarks, "our necessities are their luxuries, and in our system we use high technology. We get back one calorie for every 100 calories we invest." We process most of our food and then ship it to different parts of the United States. "Basically, we're eating oil. If we could ingest oil, it would be a much more efficient process. We would get 100 calories out of every 100 calories invested," he asserts. Dr. Cairns pauses to defend our technology. He states, "Just because its technology doesn't mean it's bad. It can be 'clean' technology. In clean technology, people use computers rather than writing and mailing letters. We will cut fewer trees for paper when people use computers for communicating." Dr. Cairns returns to his story about China.

He speaks of his friends in China. Dr. Cairns tells his friends, "Your problem is over population." However right now, Dr. Cairns interjects, America's environmental impact is greater than the People's Republic of China because we have a high affluence and higher technology. This is with America having a much lower population. Dr. Cairns shares with us what he sees as "the problem."

> Suppose we wrote to the People Republic of China and said, 'If you double your energy consumption by the year 2000, that is going to do terrible things to the air in the Northern Hemisphere, and that air will come over our country and will contribute to global warming. Things might get very bad if global warming gets as bad as some of the models say it's going to be. Maybe you shouldn't double your

energy consumption by the year 2000. It would be better for the planet if you didn't.'

Their answer would be, 'Come off it! When we double our energy consumption, we would only be using 7 1/2 percent of the energy per capita that **you** people use! Why shouldn't we use as much energy per capita as you guys? Everybody wants to be like an American, and therefore, if you can use that much energy, then why can't we use that much energy? If we control our contamination of the atmosphere, then **you** have to do something to reduce the contamination of the atmosphere, or we don't do anything.'

Dr. Cairns agrees that this is not an unreasonable position. If we say to them, "You have too many people," they can tell us that they have cut their population growth to zero. They would say to us that **we** keep using more technology and more energy. China asserts there should be more equity in the way people live around the world. Dr. Cairns says that China's feeling is that Americans should give up a few things so the rest of the world can come closer to America in energy consumption.

"How can we solve this?" he asks. Since the net effect of the IPAT equation is interrelated, we have to be willing to do something with the *affluence* and *technology* part of the equation, and China has to do something with the *population.* China would like to keep the same population and increase affluence and technology. This increase will probably have a negative impact on the environment. Dr. Cairns states that the results will probably be acid rain, global warming, atmospheric contamination, and loss of species.

Dr. Cairns asks the students, "What do you think about this? Do you think China has a right to increase their energy consumption to 7.5% of what we consume as individuals?" Karen answers him, "I think they have a valid argument. They don't have as much as we do. We're saying, 'We can have it, but you can't.'" Dr. Cairns agrees with her. He says he would never write them and say, "You can't have what we have."

Dr. Cairns continues to ask more questions about air pollution and global warming. He wants to know whether we should continue the way we are and see what happens to our environment, or should we do something. He admits he doesn't have the answers. He asks the students what part of the IPAT equation they think we should juggle. Do we cut down on the population? "Would you be willing to give up some of our affluence so the People's Republic of China could have more?" he asks.

Karla, who sits at the front of the room, answers, "Some people would, but a lot of people wouldn't." Dr. Cairns asks her, "Do you think you could persuade the people who now wouldn't, to do it if they knew more about the situation?" She pauses a minute before she answers, "Possibly...possibly." Karla's comment leads Dr. Cairns to ask the class if they have seen anything on "sustainable use of the planet"? No one responds. He continues to tell them that "sustainable use" means that we will do nothing today to impair the use of the environment for future generations; they should be able to have the same things we have. Dr. Cairns warns that global warming will impair some of those things.

Global warming. Dr. Cairns talks about the argument of global warming. He says that trapping heat by the earth has been a scientifically established fact for about 100 years. Dr. Cairns explains that it is difficult to validate the model because the earth is the only planet we have, and there is no control. The argument is between the empiricists who gather a limited amount of data in very few areas and the modelers who model for the entire planet.

Dr. Cairns says there is **never** going to be proof of global warming. People don't understand that science works by disproving theories. He explains that we continually challenge a series of models. Those we can't disprove, we accept as valid until we find something better. He asserts we are having to make social decisions with a high degree of uncertainty.

Energy distribution. Dr. Cairns tells about a proposed energy distribution program in Sweden. He thinks it is somewhat equitable and fair. In this plan, he explains, the government will give citizens an energy allotment. Each person will decide how to spend their allotment. Dr. Cairns gives what he calls a simplistic example, "You could have two cars, or 6-8 kids, or spend a vacation in the Canary Islands, or you could keep your house nice and warm. But, you couldn't do all the above." He asks the students what they think. "Do you think that is too much state interference? If you can afford to do all of those, why couldn't you do it?" Dr. Cairns also wonders if people knew what was happening, do the students think the people would accept it? Karen says that people will have to give up something.

Education. Dr. Cairns asks if education is the problem. Karla answers that she thinks a lack of education is part of it. He asks the students how would they feel if they were well educated, had read a lot about environmental issues, and tried to be good stewards but, their neighbor didn't take the time to read and was careless with his use of the environment. Would this bother them? "It would bother me, I tell you," Dr. Cairns honestly admits. However, he concedes he would still do what he thinks is environmentally correct. He wonders if there is any solution other than letting the government do it. Dr. Cairns comments that B. F. Skinner said that no human behavior will change unless there are consequences and people can see those consequences. Improving one's education is one way to be able to see the consequences, or they can just let the government decide what measures should or should not be taken.

Dr. Cairns reminds the students that they will decide these issues in their lifetime. He says we are beginning to see some of it with NAFTA [North American Foreign Trade Agreement]. One of the statements he heard was America shouldn't have a trade agreement with Mexico because Mexico is not as environmentally sensitive as we are. However, Dr. Cairns says the Mexicans say, "We have to get up to your level of affluence and then we will have [sensitivity]! You rich people can afford to be kind to the environment, but we're starving and we can't afford to be kind to the environment. But if you'll let us make more money, we'll have the same environmental ethics you do." Mexico is wanting to increase their *affluence* (A) and *technology* (T), but not decrease their *population* (P). Dr. Cairns postulates that this juggling of the equation will make things environmentally worse.

Dr. Cairns tries to help the students understand levels of affluence by telling a story about Malcolm Forbes. For his birthday, Forbes decided to fly a group of friends, one of which was Elizabeth Taylor, to Algiers to celebrate. However, in consumption of energy, Dr. Cairns says it was a very expensive birthday party. Dr. Cairns asks, "Should Malcolm Forbes be told he couldn't have his party there? Should it be held where he lives?" Dr. Cairns says Malcolm Forbes looks rich to us, but to the rest of the world, **we** are the ones who look rich. It is easier to see the problem when it is Malcolm Forbes, but not so easy when the problem is us.

Dr. Cairns does not think giving up energy consumption is necessarily going to mean a deterioration of the quality of life. However, he acknowledges there is not going to be a solution everybody likes. Dr. Cairns asks the students to think about a question. "What is the most you would put up with to get the people in other countries not to damage the world too much?" He wonders if we should give up something so someone else will give up something? Dr. Cairns finishes by telling the students the problem is theirs to solve, and that he has confidence in their ability to do so.

Student Reactions

What do the students think about Dr. Cairns' talk? Does he make an impact? I ask the students to write a one or two page reaction paper stating anything they want about the lecture. The papers were collected and given to Dr. Cairns so he could read them and respond (see Appendix D). Most of the student papers showed strong responses. Common themes run through the papers: the concern about China, comments on technology and energy, suggestions to the problem, and additional questions of their own.

Several students say the environmental issues with China are new to them. David says, "I have never been exposed to this topic before, and I feel my knowledge has been expanded in the ways the environment is being hurt." Judy says she has never heard of the problem with China before and is interested in learning more. Karla acknowledges, "Dr. Cairnes's [sic] lecture was another reminder to me of how very important it is to respect the fragile ecosystems that support mankind."

Most of the students have an opinion about the issue with China. Judy says she "felt guilty" after hearing about it. The students feel we do not have the right to tell China they cannot increase their affluence. Several students say individuals in China are already doing a lot to keep their consumption down. Jason agrees we should be the first to sacrifice something. Corrine feels it will not be "democratic" for the United States to tell China they cannot increase their population, level of affluence, and technology. She feels the best influence on China will be to cut back on our own environmental impact. Karla calls the United States as the "bad guy" in this situation. Some students have mixed feelings because they don't feel we can tell China to hold back on developing their energy consumption, and yet the outcome concerns them if China does develop it. Judy says, "I definitely don't want the consequences that would come from China's proposed doubled energy consumption." Doris voices the same feeling when she states, "They [China] do, however, need to consider the rest of the world and the impact that it will cause."

Because the issue with China deals with affluence, and we measure affluence by energy consumption, many of the students say something about energy in their responses. However, not all students are positive about a solution. Several of them feel we need to cut back before we could take the position of telling someone else to cut back. Ethel acknowledges, "This will be difficult because Americans are used to a very wasteful lifestyle." Ann writes that we should try to bring the amount of energy invested in agriculture closer to the amount of energy consumed. Syann agrees with the idea of a governmental allotment, at least until we can find alternative energy supplies. Corrine doesn't agree with Syann. She remarks, "Americans are addicted to energy." She does not believe there is a solution. Her concern is, "A major player is going to become invaded if any move is made." Mark declares that a global allocation of energy will be the best solution, even though it "doesn't seem very plausible." To him, what looks good on paper, when it comes to implementing it, "seems useless and...futile." Bill sums up the tone of the class by saying, "The problem will inevitably become a matter of politics and ideology."

How do students view the *technology* (T) part of the IPAT equation? Feelings about technology didn't fare much better than did energy. Divya feels we have become "addicted" to wealth and luxury. She feels it will be difficult to return to the basic needs because of the impact technology makes in our daily lives. Brian says he thinks technology "is hindering the overall well-being of humans and the earth, and if it declined we would be better off." In fact, he states that he believes the quality of life diminishes as the population, affluence, and technology increases. "I don't understand why everyone desires these things," he writes. David looks at technology in two ways: he wonders whether technology has so gone far we require more than our share of the earth's energy, or whether technology has *not* gone far enough and we need to develop it to the point we use less energy.

What suggestions do the students see to this problem? The one they repeat most often is that of cutting our own energy consumption. Students feel we cannot ask China, or any other country, to delay their energy development. Divya says as a "prominent, technologically advanced nation," it is our responsibility to set the standard by restricting our own energy consumption. Ruth and Judy think education may be the key to a solution. Ruth says, "Somehow, each individual needs to be informed and touched by the fact of our destruction to the point of change." Judy believes the government and media should work together to educate the people. She writes if the information is "readily available and easily understandable," then most Americans will be willing to work together for solutions.

Ethel believes in the power of the dollar. She says, "Americans need some additional motivation." She knows people respond better to short-term consequences. She suggests, "The government needs to either impose more regulations on energy consumption or provide more economic incentives to cut back."

Jon gives a different point of view. He is very adamant against government intervention. He says Dr. Cairns' ideas about government allotment are "nice ideas, but they are economically impossible." Jon writes that this type of government mediation "borders on socialism." The only time Jon believes it is right for the government to become involved is when human life is directly in danger, "Which in this case, I don't think it is." Jon also feels environmental involvement should be a "personal decision."

After listening to Dr. Cairns' talk and having time to reflect on it, the students have additional questions. Karol and Doris ask about global warming. "Do you think it will be as big a problem as environmental leaders believe?" asks Karol. Doris wants to know how much of the energy development in China will affect global warming? She also wonders whether acid rain, by killing the plants, will contribute to global warming? Syann refers to Dr. Cairns' statement that energy consumption is a primary factor in determining a country's affluence. She wants to know what the other factors are.

Ruth admits she does not have pleasant feelings towards technology. She is afraid "the future effects of 'clean technology' *now* may be as dreadful as what our ancestors began ignorantly years ago." She asks, "Is there *really* clean technology?" Karen also has a question about technology. She wonders how one decides what is *good* technology and what is *bad* technology? She wants to know how technology enters into the IPAT equation and does the "T" encompasses all technology? Syann sees the problem of an increasing population having a negative impact on the sustainable use of our planet. "Does this mean that if the population continues to grow, we eventually will totally destroy the environment?"

Bill's comment about Dr. Cairns' talk is probably a good synthesis of the students' feeling concerning the magnitude of the problem. He writes, "He [Dr. Cairns] seemed intent on impressing upon us both the urgency and the futility of finding a solution." Bill is also frustrated as he writes, "One would think that a person of his experience could at least offer some guidance or clues to an answer."

Dr. Cairn's Reaction

I took the reaction papers to Dr. Cairns at Virginia Tech. He read each one of them and responded by writing a letter to the class. (See Appendix D.) In his letter, he addresses Syann's question about how energy became a measure of affluence. He also tells her he seriously doubts man will destroy the environment. Dr. Cairns responds to Karen's question about technology. He says if we measure technological efficiency in convenience to the individual rather than efficiency in energy, we arrive at two different answers. He tells her that his generation was the first to become aware of global problems, and hers will be the first to face them.

Dr. Cairns asks Corrine if she thinks environmental literacy is increased on a global basis to the extent her class is experiencing it, can we work out a compromise so we will not have changes forced on us? Dr. Cairns tells Doris and Karol he can't answer their questions on either acid rain or global warming because those predictions are based on models and not empirical evidence. He says they might like to think about:

(1) Should we take whatever measures possible to prevent global warming?

(2) Are there things that would reduce the probability of global warming that would also be beneficial to society?

(3) What things would help reduce the probability of global warming that would be good for human society even if the predictive models are wrong?

Dr. Cairns says even though he has not responded individually to each letter, he did read them all. "I was also pleased by the fact that you questioned many of the issues raised--you should! I am constantly re-examining my own thoughts and expect everyone else to do the same." He continues to address issues about the importance of personal choice and how the gathering of information has improved, even though our ability to make social decisions has not changed. "Unfortunately, our abilities to solve scientific problems have surged far ahead of our ability to solve societal problems." He concludes by saying, "It was great fun meeting with your class, and I am delighted I provoked some interest and discussion!" Dr. Cairns closes by giving his support, but emphasizing that this is a problem for their generation. "I believe the solutions to these problems are primarily in your hands, although I intend to do my part."

Closing, Opening & Alternatives to a Landfill
Class Presentations - December 14, 1993

When planning this assignment, John and I named three topics we felt students needed to know to understand the issues surrounding the landfill. John indicated that the students were to investigate the scientific/environmental, social/political, and economic issues. They should address the issues specific to the city of Roanoke, the state of Virginia, or the United States. Students were to include qualitative and quantitative information. A computerized bibliography and literature search was to be done using the General Science Index and Reader's Guide, and at least one resource person was to be interviewed. (See Appendix for a copy of the assignment.) John told the students that two tables will research the same topic. They could choose to investigate (1) Closing, monitoring, and reclaiming a filled landfill; (2) Opening and monitoring a new landfill; or (3) Alternatives to landfills. Each table was to talk among themselves and choose their topic. They were to write it on a slip of paper, and give it to John. It was a "first come, first choice" selection. Interestingly enough, every table got their first choice.

Today, the students will give their group presentations. They have overheads and posters to use for visuals. All students will share in their table's presentation. They will also give John a typed report. For brevity, I will combine the information from both tables for the reader. John holds discussions and asks questions after each topic.

Alternatives to Landfills

The *Slope Study* table and the *Grass & Wildflower Aggression* table choose to write about *Alternatives to Landfills.* The *Slope Study* table address three alternatives: recycling, incineration, and composting. The *Grass & Wildflower Aggression* table list recycling, composting, and waste reduction as their alternatives.

Recycling. Karla begins talking about recycling. She says there are two types of recycling: primary or closed-loop recycling, and secondary or open-loop recycling. She says that primary recycling is when we recycle to produce new products of the same type. An example is recycled paper. Secondary recycling, she explains, is a conversion of products that we must find a use for. An example is mixed paper. "Primary recycling is more desirable because it reduces the amount of virgin material needed by 29%-90%. Secondary recycling only reduces it from 0%-25%."

Karla also talks about *resource recovery* as an important facet of recycling. "Resource recovery," she says, "is the salvaging and reselling of recyclables to solid waste industries for reuse." Karla explains there is a *high tech resource recovery*, which involves the separation and shredding of recyclable materials by machine. The *low tech resource recovery* involves the community collecting and sorting the recyclables. She says that the machinery used for the high tech resource recovery is very expensive and difficult to maintain. Karla lists two obstacles to recycling: (1) advertising encourages us to throw away, and (2) individuals and industries have little incentive to recycle. She sees solutions in (1) education, and (2) economic incentives to businesses and individuals.

Ethel also discusses recycling. She says there are two types of recycling programs: voluntary and mandatory. The literature she has read says that mandatory programs usually result in higher amounts of recyclables, but they can also result in public antagonism and illegal dumping. She also states that voluntary programs don't result in long term participation. Ethel suggests we can enhance interest to recycle through economic incentives. One of the problems in recycling paper, she says, is that the fibers are shorter and have less strength. She also notes that we do not recycle commercial glass containers and Styrofoam products in Roanoke. Doris offers some suggestions to make recycling more viable. She says that the government needs to become more active in regulations and in helping to create a market for recycled goods. Doris also says that we could feed left over food to the animals that are outside.

Incineration. Syann discusses incineration. She says that the players are the environmentalists and the businessmen. The environmentalists want tougher air pollution laws, and the businessmen want cheaper ways to control air pollution. Syann explains there are two ways to incinerate: *trash to energy*, and *mass burn*. "Trash energy," she says, "is where trash is burned to produce energy." Syann says they do not do this often. "Mass burn is when they just burn trash and fly ash and bottom ash has to be put in the landfill." One of the problems in mass burn is that they do not recycle out many of the toxic things. She explains that they are burned, thus increasing the toxicity of the bottom ash and fly ash.

Composting. Linda and Karol discuss composting. Linda says, "Composting is taking the biodegradable solid waste, mixing it with the soils and making it decompose by bacteria." She lists things we can compost: solid wastes from food processing plants and kitchens, grass clippings, manure, and sewer sludge. Linda says if we compost only household yard wastes, the solid wastes in the United States would drop by 20%. She explains that composting is positive because it (1) saves space in the landfills, (2) can be used as fertilizer, and (3) can be sold as a profit for the community. Karol also says that it (1) costs less than alternative solid waste combustionable systems, (2) is compatible with recycling, and (3) it has a low potential for environmental impact.

Karol tells that in Wisconsin, Illinois, Florida, and Minnesota there will soon be statewide bands prohibiting landfills from accepting leaves, brush, and grass clippings. She says Fairfield, Connecticut, hopes to reduce their annual collection of grass and yard clipping by 4,000 tons. They will use the grass and yard clippings for compost rather than putting them into the landfill. Karol states that food wastes make up 13% of all garbage in the United States. "Food waste composition," she says, "is used for swine feed, compost, or compost for institutional and commercial sources."

Waste reduction. Waste reduction and education are two more important things Linda and Ann see as alternatives to landfills. She says consumers need to learn to buy wisely and get out of the "throw away habit." Linda recommends that schools need to educate the children because they can make changes in the home, and the children will be the ones who will be trying to find solutions to the solid waste problem.

Ann also offers several suggestions for waste reduction. She thinks we need to reduce it at the source. "The government needs to financially encourage the manufacturers and industry to reduce packaging," she says. Ann also states that the government should ban the production of non-biodegradable packaging. However, she believes the responsibility should not lie only with the government. "The consumer also has the responsibility to choose reliable non-wastable products," she says. Ann talks about the program the Green Valley Council has with Kroger where employees inform the consumers of products that have less packaging, recycled products, and products that are recyclable.

John asks these two tables what they would give as economic incentives to encourage alternatives. They suggest tax breaks for industries. Karol also suggests deposits on glass bottles and aluminum cans. Ann says that in New York there is a tax on cans. "When you take them back," she says, "you get your money back." The class talks briefly about localities that are charging customers per bag of garbage they put out. John also comments that increased tipping fees are an incentive to not send as much to the landfill. He gives as an example where schools are having to pay per building for every bag that goes into the dumpster. John explains that the Roanoke City School system has given the schools an incentive by offering to pay them $4 for every bag of recyclables. The school system assumes if it is being recycled, it is not going into the dumpster.

John asks the students if they are aware of what is happening in Botetourt County involving incineration. Linda says Tarmac is burning tires. John says they were burning tires to produce energy for the plant. John also says Tarmac wanted to burn medical wastes. He says the community was really "stirred up" because of pollution concerns.

John also asks if the students know whether anybody locally is doing composting or talking about doing it. No one responds. John reminds the students that Salem's landfill is full. He explains that Salem decided not to participate in the Smith Mountain Gap landfill, so they are taking their trash to a landfill near Richmond. He says that Salem is talking about composting as a possible alternative.

We have had a good discussion with these first two groups. John realizes we will run out of time for the rest of the groups to present if we take this long with each topic. He decides to have the last four groups present before we ask questions.

Closing, Monitoring & Reclaiming a Landfill

The *Soil Compaction: Grasses* table and the *Temperature Effect* table chose the topic "Closing, Monitoring, and Reclaiming a Landfill." Kusum and Jon begin by defining a landfill. She says it is "an area where there has been a disposal of refuse." Kusum tells the class that when closing, "You should try to minimize the maintenance, additional maintenance and post-closure leachate, surface runoff, and waste and gas decomposition." She then gives specific regulations for closure procedure. She says that a barrier of 30-50 cm of clay, followed by 60 cm of fertile soil is put on top of the closed landfill. She says they call this the "mound system." They monitor solid, organic, and inorganic constituents. Jon talks in the vernacular when he defines a landfill.

> First, they dig a big hole in the ground and stuff like that. They line the bottom with clay and plastic and an asphalt membrane and it makes, like a liner, that a lot of stuff can't get through. They install these pipes that pump out leachate or some of

it, anyway. And then they put all the trash in. The rest of the landfill is all filled up. Then they cover it over with sand, gravel and topsoil. That's pretty much basically how landfills are constructed and the basic procedure.

Hydrolics. Kavita and Bill talk about hydraulics. Kavita says that hydraulics are a major consideration when closing a landfill. She explains hydraulics as "basically the ability of water to flow against a resistance." Hydraulics is important because it explains how ground water becomes contaminated from leachate in the landfill. Kavita says that Virginia requires at least three monitoring wells. She says "during closure and post-closure, these wells have to be monitored semi-annually. After post-closure, they are monitored annually."

Bill shows a poster of the layers of a landfill as he talks about leachate moving through the landfill. He says it can move along a *pressure gradient*, or a *concentration gradient*. "The pressure gradient," he says, "is not a problem." However, when leachate moves along a concentration gradient, it can break through the clay layers in the landfill. The newer landfills have special plastic layers that control this movement.

Gas. Kavita, Bill, and Jason each address the problems of gas. They acknowledge gas is another problem in closing. Kavita says that you will find methane, carbon dioxide, ammonia and hydrogen sulfide in a landfill. "To control the gas," she continues, "you build trenches, vents, and pipes to ventilate the gases." Bill explains when the methane moves up through the soil, it will discolor the soil and kill the plants. "Those are called 'hot spots'" comments Kavita. Bill states that methane is especially hard on trees. Jason notes that only 1% of the landfills in the United States collect methane gas. He acknowledges if we collect methane, we could produce electricity and also lower atmospheric emissions.

Reclamation. Jon and Kusum discuss some of the problems in reclamation of a landfill. Kusum talks about the vegetation that goes on the landfill during reclamation. She says we need to consider four factors when choosing the vegetation: (1) ability of the vegetation to prevent erosion, (2) rooting depth of the plants, (3) the effect of gas emissions on the plants, and (3) biodiversity.

Some of the suggestions Kusum has for a reclaimed landfill are: recreational purposes, parking lots, roadways, or buildings. She notes that recreational purposes are most feasible and buildings are least. Jon suggests their solution to a closed landfill was to look at the revegetation. He cites Brush Kills in New York where they took a landfill and "made it look natural." Jon says that many animal species have reappeared and that "it's doing real well, even though it's been a landfill." They finish, and John draws the class into discussion about the construction of landfills.

John asks the class what is the difference in the poster Bill showed of a cross section of a landfill and the Roanoke Regional Landfill. As John directs the questions, the students realize that the Roanoke Regional Landfill has no gas monitoring wells, no leachate collecting system, and no plastic liners. However, the Roanoke Regional Landfill does have holding ponds and a clay liner on the bottom. John also notes that the landfill operators are monitoring leachate, but not collecting it. Bill interjects that the Environmental Protection Agency (EPA) didn't require a synthetic liner until 1985. That brings John to ask another question. "What's the other major problem with the Roanoke Landfill without any synthetic liner on the bottom? What's the danger?" The students tell him, "The Roanoke River." The class understands the implication of the location of the landfill to the river.

<u>Opening & Monitoring a New Landfill</u>

The *Soil Compaction: Rooting Depth* table and the *Hydroponics* table chose "Opening and Monitoring a New Landfill." Corrine and Karen introduce the topic. Corrine gives some statistics on landfills. She says that in 1989 the Office of Technology Assessment Reports estimated that 80% of the existing landfills would be closed in 20 years. However, in 1990, EPA issued new guidelines and accelerated the number of landfills to close. Corrine says these guidelines also affect how a new landfill is opened. Karen adds that we must consider political, social, environmental, and economical aspects when opening a new landfill.

Political aspects. Bob and Karen talk about the political issues in having a landfill. Karen begins with governmental regulations. She says that the Solid Waste Disposal Act of October 1965 publicized the problem we are having with solid wastes. She states that the EPA regulations establish the criteria for determining the health and environmental impact of the solid waste disposal facilities. In 1980, Karen says that the EPA set regulations for identifying hazardous wastes. It was also in 1980, the Virginia Hazardous Waste Management Regulation provided for the control of hazardous waste. Karen notes that the EPA was involved with the problems of sediment control at Smith Mountain Gap landfill early last spring. This was when heavy rains and the lack of settling ponds caused water to wash mud into people's homes. The EPA inspected the construction, location, and number of ponds at the landfill. Karen says the RVRA has finished the ponds and have tried to redesign them to make them better.

Bob says he sees three players in the building of the new landfill: the Roanoke Valley Resource Authority (RVRA), the residents of the Smith Mountain Gap area, and the EPA. Bob says he thinks the RVRA wants to make money, but "they also want to build a landfill that is safe and that is not going to hurt the environment, and they want to show that they are a good company to be with." Bob believes that from the couple of months he has been studying landfills, that landfills are not that bad if taken care of properly and are of high quality. "Education makes the difference in how people view a landfill." he states. "Some of the people that are educated think that the landfill is okay," he reports. Bob also thinks everyone is working together to get things fixed "so we will have a good landfill."

Social aspects. David, Judy, and Karen share in talking about the social aspects of a landfill. David states that no one wants a landfill near them. He explains how the RVRA will guarantee homeowners' property value next to the landfill in case the homeowner tries to sell. David also relates how the RVRA has set up a drinking water protection plan to replace the homeowner's water if it becomes contaminated because of the landfill. Karen adds that the RVRA has involved the people who live near the landfill in the decision making process in some aspects of the landfill. Judy says she thinks the RVRA did a good job of conveying exactly what was going on. She comments, "Articles in the newspaper and meetings have helped to inform the public."

Environmental aspects. David continues to talk about the environmental aspects, and Mark joins him. The environmental issues, David explains, have to do with leachate pipes, clay and plastic liners, ground water monitoring wells, and gas collection pipes. He also says the landfill needs a large supply of soil for nightly cover. Mark notes there is controversy about how to best construct landfills to eliminate leachate. He says there is a group of scientists that want to destroy the lining barriers and use bacteria to rot the wastes. "These scientists state if we allow the garbage to decay rapidly, we will not have the problems we have now," reports Mark. Another group of scientists suggests to completely entomb the landfill so nothing can get into the landfill and decay. This way leachate cannot form and leak into the ground water.

Economic aspects. David states that the cost of the landfill is approximately $42 million. He explains that the sale of bonds has helped to pay for it. However, once the landfill becomes operational, the landfill operators will use funds from the tipping fees to operate the system and pay off the bonds. In contrast, to the cost of the new landfill, Ruth interjects that the cost of the Roanoke Regional Landfill was only $1 million. David notes that tipping fees have risen from $25 per ton to $55 per ton. David finishes and completes the presentations for the morning.

Conclusions

John finishes by asking the students to think about problems and solutions. He states that sometimes we get so caught up in the problems we can't come up with solutions. John does not think the students should leave this unit with either a totally negative or totally positive feeling about what they have studied.

It has been a morning of much talking and sharing. I look at the clock and realize we began at 9:30, and it is now 10:55. We have only five minutes until the buzzer rings. John says that this is very good. "Often when doing presentations," he says, "the students stand up, talk, and sit down in a matter of minutes. This group really had something to say." He sees the morning as being very productive.

Post Webbing Activity
December 16, 1993

This is **suppose** to be my last day in the class. However, Mara has looked at the plants and decided they have not grown enough for the students to collect their final data. John has talked to the students and they want to continue the experiments. We are going to have to make some major adjustments, though. The winter holidays are here, and when the students return, they go into Intercession for the month of January. [Intercession is when they investigate other interests instead of their regular classes. They will not have biology classes again until the beginning of February.] John has agreed to water the plants during the month, and we will take final measurements and collect data upon the students' return in February.

John and I decided since the students have done their reports on landfills and have heard all the guest speakers, we will do the final webbing activity today. I will compare this post-webbing activity with the pre-webbing activity done in October. [I discuss findings in the analysis section.] This vignette is the dialogue among the students at the *Soil Compaction: Rooting Depth* table and the *Hydroponics* table as they construct their new webs.

Instructions

I told the class we wanted to do another webbing map similar to the one they did at the beginning of the study. This map gives them an opportunity to compare what they knew before the study with what they know now. However, this time I asked them to add another dimension to their web. I wanted them to put verbs or verb phrases on the lines so we can follow how they constructed their connections. Once they finished their webs, the students were to answer the final questionnaire that John, Mara, and I had constructed. John also had another activity planned for the students once they completed their webs and questionnaires. Because of the other activity, only a portion of the morning was used for landfill activities. We did not have time for each table to share their map with the rest of the class. Tape recorders were placed at the two tables.

Soil Compaction: Rooting Depth Table Dialogue

This group has gotten their markers and paper. Mark and Bob are writing the names of everyone at the table. The conversation this morning is composed of short bursts of thoughts. David and Bob are trying to figure out how to spell Ruth's name. Once they decide, Bob starts the group on task. He asks what are they going to put on the paper. Corrine says she doesn't know. Bob suggests, "a lot of birds." Corrine sarcastically responds, "Yeah, right over us." Bob rephrases his original question, "What's in a landfill?" Ruth immediately defers to Corrine, and Corrine responds, "Monitoring." Ruth wants to know if that should be webbed from something else. Bob says they should put "political, social, and..." Ruth tells him they should get the basics down first. Corrine suggests *environment*. Bob agrees and begins writing.

Mark makes fun of Bob's writing. Mark says, "It's gonna be good!" Bob realizes he misspelled a word and says, "Actually, it should be an 'A,' shouldn't it? Verbs are an 'A.'" Corrine responds, "Gosh, Bob." Mark comments that Corrine should have the marker [because she can spell]. The group decides to get another piece of paper and starts over. Mark is concerned about the time and says, "We can't really afford to be that neat." Bob is still trying to get his ideas accepted by the group. He says again, "Social, political, and all that..." Mark laughs, "Har, har, har." "Wait! Wait!" calls Bob, "What are we going to put here... 'planting is...'" Corrine finishes his sentence, "Correct social aspects." "That's 'aspect,'" corrects Bob. They laugh over how to spell it. Mark accidentally hits the tape recorder. He says, "I'm seeing if she [Bea] can still hear us."

Bob speaks loudly into the recorder, "I'm learning how to spell *affects* today." They laugh again.

The group continues to decide what to put on the lines. Mark says, "I think somebody...affects social aspects." Corrine is writing *social*, and Mark continues to talk. "Would it be 'causes social' like gratification, or whatever? You know. People worried about it." Bob agrees with Mark and begins to say, "Yeah, I think..." Corrine finishes writing and before Bob finishes his sentence she says, "We've got down what we've got down." Bob laments, "It's too late now. It's non-erasable." Corrine agrees, "Already done." Someone turns the tape recorder off.

The recorder is turned back on, and the group continues to add words to their web. Corrine and Bob are working on one side of the table; Mark and Ruth on the other side. Corrine asks for another idea to web from the topic, landfill. Bob says, "economical, landfill, economics..." Ruth tells Bob, "We did this one without you." "What?" he asks. Mark acknowledges they already have it on paper. He says, "Anyway, we wrote. Non-erasable." Corrine misspells "economical," and Bob suggests she just write over it. The boys tease her. "Good write over," says Mark. Bob agrees, "Yeah. Very good write over." Bob continues to give ideas as Corrine writes them down. At one point he says, "I've got the hard job [coming up with ideas."]

I walk around the room stopping at each table to see what is happening. When I come to their table, I move the tape recorder closer to Ruth and tell them that Ruth's voice is so soft I can't always hear her. Bob speaks up, "But we can always hear Corrine Harper!" I defend her, "Corrine has some good thoughts, too." Corrine puts herself down, "But I've got that 'drum major' voice, and..." I quickly add, "There's nothing wrong with that!"

Bob brings the group back to task, "Okay. Environment. We've talked about monitoring. Like, we've got to think about our verbiage here." Ruth jokes, "What's our 'verbiage,' Bob?" They discuss how they want to put it on the chart. Corrine continues to do the writing. The rest of the table laughs at her lettering. Bob says, "She's going to screw it up. We had it all neat and stuff like that. Corrine had to come over and..." Ruth joins in the teasing and tells Corrine they had a color scheme. "Plus," says Bob, "we were going to have it all neat coming off in the right direction...but, that's okay." Corrine realizes they are teasing her about the way she is doing the chart. The group knows Corrine likes to be precise about her work. She replies, "I know ya'll on me." However, she continues to move the group on, "What's another [one]?" "Political," responds Ruth. Mark tells Corrine to "go on with [writing] it." Bob teases Mark when Mark says, "Here's my idea." Bob responds before Mark has a chance to say anything else, "That's a good idea, thank you." Bob laughs. Corrine is writing verbs or verb phrases on the lines between the bubbles. Bob pesters Corrine, "Just let Corrine do it, she'd just put 'is' for everything." Mark continues to suggest ideas to write.

Bob, Ruth and Mark discuss what to put on the paper as Corrine continues to write. Bob says of Corrine's drawing, "She failed 'circles.'" Ruth is still trying to think of a word to put on the paper. The boys try to help.

Ruth: I can't think of the word!

Bob: What? Leachate!

Mark: Methane! Leachate! Chemicals! Toxins! Bioreactant! My name is!

Ruth: Noooo. Because that's not the word I'm looking for.

Bob: [seriously] Well, is it environment?

Ruth: Yeah!

Mark starts to say something about his sister, but Ruth interrupts him. Bob continues to talk about their work. Corrine, who has said little up to this point asks, "What else are we going to put in that box? We need another...actually, two more to balance out our ellipse." Bob answers, "That's right." Ruth jokes, "Our beautiful ellipse!"

They continue to play with words. There is a pause in the conversation, and Mark quickly interjects his unfinished story,

> My sister last night started a report for school that is, like, due for Monday, no, Friday. And she's got all this stuff to do, and she finished part of it, like the first page or something. And the cat jumped on her back and then jumped on the typewriter and wrote all over it. And the thing is all ruined and she is, like in tears because she had to start all over. I wanted to laugh, but it would have been mean.

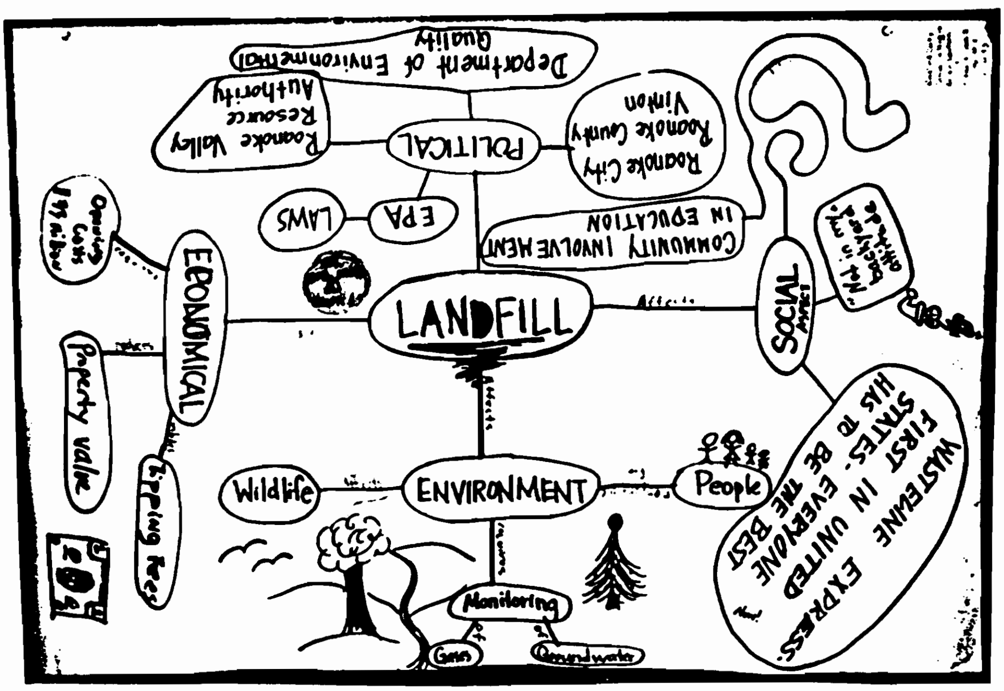
No one responds. Mark whispers into the tape recorder, "It was funny!" Corrine is still thinking about the web. She asks, "What's another one?" Mark answers her, "For what, political? Hmmmmm." He does heavy breathing into the tape recorder. Corrine reprimands him, "Come o-o-o-on, Mark!"

Bob is also writing now. He wants to know what descriptors the group wants to web off *economical.* Mark asks, "What's economical?" Mark, pretends he is Bob and says, "It costs a lot, Mark." Then, becoming serious again, Mark gives Bob the answer he is looking for. He says, "tipping fees." Bob ignores Mark and asks, "Well, should I just go ahead and put tipping fees?" Bob complains about the marker, and Mark says, "It smells *so* good!" Corrine says they need to find something else to put under *political* to "balance out this one." Bob admonishes her and says it doesn't have to be symmetrical. She tersely replies, "Yes it does!" Mark responds, "Well, let's find something." He says, "Let's see. You've got issues, values...critical values, I guess." [This statement makes Mark think of another story.]

"Speaking of values, that girl who [sic] I tutored last weekend, her mom said that she would fix a batch of brownies for me doing it, and I haven't gotten my brownies. And the girl got an A on her test. So..." Corrine interrupts, "I'm really sure that Mrs. Taylor really cares to know this." Mark is defensive, "Look, ya'll aren't talking about anything really important so I just fill it up with something." Ruth tells him to "speak up" [so he can be heard on the tape recorder.] He speaks loudly into the recorder, "Say what?" This makes Corrine laugh. "Quit it," she says. Corrine joins in Mark's conversation. "What did you tutor her in?" she asks. Mark tells her it was geometric proofs. The conversation returns to finishing the web. Corrine and Bob are continuing to do the writing on opposite sides of the paper. Ruth jokes with Corrine about her drawing, "What is that, Corrine? That is not symmetrical." [Corrine is writing everything so it can be read from one side.] Bob asks her why she is writing "upside down?" She tells him because it "goes that way." Bob says it doesn't matter if you write it upside down or not.

Mark reminds them that they have two hours to do the lab, the questionnaire and this [webbing activity]. Bob tells him not to worry because they haven't had consulting time, and they will have extra time to work then. [*Consulting time* is given during the week for the students to work on collaborative projects. John says it is necessary because the students come from various schools and do not have the opportunity to meet after school or on the weekends to work.] Mark replies, "We won't have time because we are doing this." The tone of his voice changes as he continues, "Not that there is anything wrong with this because we enjoy it, but..." The entire table laughs. Corrine tells him, "That was very sincere, Mark." The group returns to work until Mark says, "The membrane in my nose is melting." Bob responds, "Maybe we could look at it under the microscope. Get a toothpick and scrape it." Mark then turns his attention to the tape recorder. He comments on its different functions and says he wishes he could have it.

Bob and Corrine continue to write on the paper. Corrine tells Bob he has to write "Wasteline Express" in greeeen! [The large railway cars are bright green.] Bob looks at the chart and asks, "Corrine, what is that? What does that go to?" Before she answers, he says, "I don't understand when they had, like, the opening....When they drove the thing for the first time, the wasteline thing, and they said that all the seats were filled. I didn't know it had seats." No one tries to clarify Bob's misunderstanding that he is talking about the rail cars and at the opening the visitors rode in passenger cars. Mark begins another story about his sister. Mark tells the group that his sister was at the groundbreaking ceremonies for the landfill. Corrine returns to the conversation and answers Bob's previous question. Mark continues to talk. He tells what his sister saw and that part of her head was in a newspaper picture. Mark pauses and Corrine talks about the importance of every landfill being better than the one before it. When she finishes, Mark says patronizingly, "Good point, Corrine!" [See Figure 23 for the *Soil Compaction: Rooting Depth* table's web.] The table finished the webbing activity. Corrine picked up copies of the final questionnaire for everyone.



<u>Figure 23</u>. *Soil Compaction: Rooting Depth* Final Webbing Map

Final Questionnaire

I asked the students to respond informally to a final questionnaire. Some tables talked less than did others. Some students discussed what they thought the questions meant. [See Appendix F for a copy of the questions, and the chapter on Analysis for a discussion of the findings.] I told the students to complete the questionnaire individually; it was not collaborative work.

Soil compaction: Rooting depth table dialogue. The tape recorder continued to run at the *Soil Compaction: Rooting Depth* table. The group discussed several of the questions. Bob looked at the questionnaire and said,

> *Bob*: That's not a survey. That's a book. [Long pause.] What does 'collaborative' mean?
>
> *Corrine*: You wouldn't know what that means.
>
> *Bob*: Ha! Ha! Ha! I'm sorry, Corrine. I won't say that.
>
> *Mark*: Remember, you're on...listening tapes.
>
> *Bob*: I know.
>
> *Mark*: I never think about that. I just say what I think and then go, "Oop! Aaaah!"
>
> *Corrine*: When actually we should be able to be our natural selves. Right?
>
> *Bob*: Of course, I always am.
>
> *Corrine*: Huh?
>
> [They discuss whether they did a group project last year in science.]
>
> *Corrine*: I don't like groups.
>
> *Bob*: I can't imagine why. [He laughs.]
>
> *Ruth*: Thanks, Corrine!
>
> *Corrine*: I mean, I like ya'll. I just don't like working in groups. I just don't.
>
> *Bob*: Because no body else ever does anything?

Corrine: [Hesitantly.] Noooo.

Bob: Well, that's part of it, buuuut! [Corrine laughs.] That's not the only reason. [Corrine lists the different classes she has worked in groups. There is a pause in conversation. Mark makes unintelligible remarks.]

Ruth: Stop it, Mark.

Bob: What did you say?

Mark: [Whispers.] This is Ruth. That's why you can't hear me.

Ruth: Oh, my goodness!

[Bob shifts the conversation as he talks about John and his semester grade. Mark joins in the game.]

Bob: [Teasingly.] Dr. Kowalski is just the greatest teacher and is going to give me an 'A' on the exam and everything.

Mark: He better, or I'll find out where he lives. [They laugh.] I'll come over at Christmas with my baseball bat. Of course, I'm kidding and hopefully he's not going to hear this tape! If he is, I'm being facetious. Yeah, being facetious. That's what it is. I'm not being serious.

Bob is trying to figure out what they call those courses "with one big class." Ruth suggests, "Integrated." Finally they decide it is "interdisciplinary." Mark says, "Sounds right to me." Corrine says, "Sounds good." Bob begins to talk about Coca-Cola putting nutrition facts on their cans now.

Bob: How can you have no calories? They take all the good stuff out.

Corrine: It's water.

Mark: You can't have water that looks like that.

Bob: They put...colored stuff in it.

Mark: Yeah, but you can't have just one calorie when you have sugar and carbonation. Oh, man. It's [Cokes] just messed up.

Bob: They don't have sugar in diet cokes.

Corrine: They're **trying** to make you **think** it's all in there.

Bob: It is!

Ruth: And then you'll lose weight.

Mark: But then you **taste** it. You taste it and it does taste like watered down regular coke. But watered down regular coke is still going to have calories in it.

Bob: I think we should do a group project on this!

Mark: We should! We'll change our project.

Bob: Forget this landfill stuff, let's do something on **coke**!

This table finished their concept map and final questionnaire. The tape recorder is turned off, and they proceed to the activity John planned for the remainder of the morning.

<u>*Hydroponics* Table Dialogue</u>

This table is already on task when the tape recorder is turned on. Karen and Judy are trying to decide what are alternatives to a landfill. They are looking for "connecting words or phrases." They each come up with a suggestion. Judy comments, "Good, Karen! I'm not thinking straight." Karen responds, "I'm lucky to be thinking at all." They decide *incineration* is one alternative. They can't decide how to spell it.

Karen: Incineration's...I, N..

David: C, I...wait a minute.

Karen: I, N, C...

Judy: C, I...

David: [Teasing.] M, C, I...

No one responds, so David changes the subject and asks about the packages that need to be in today to one of the teachers. [These are Christmas presents the students are collecting for needy families.] Judy evidently doesn't have hers at school. She says she put them under the tree and forgot them. Karen suggests Judy speak to the teacher about it. She directs the group back on task and asks, "What can we say about...?" Judy breaks in and continues to talk about the packages. David makes fun of the girls by saying, "Tah, tah, tah!" The girls laugh at him. Karen asks again, "What are we going to say? David hits the table with a marker each time he speaks, "R! R! R! R! R is!" There is a long silence as Karen continues to write.

David remarks, "These things [magic markers] stink." Karen ignores David's comments and asks, "What else goes with *restoration*?" Karen and Judy decide they need to add *closing* and *monitoring*. Karen asks, "What are some of the things they monitor at the landfill." Judy says, "Ground water!" David adds, "Leachate" and then he asks, "Do they monitor leachate?" Judy tells him that leachate is the same as ground water. She discusses the packages again. "We're supposed to put 'team #7' on them, right?" she asks. Judy says she doesn't even know her teacher's number. David teasingly says about the number, "Yeah. Put that down [on the paper]." Judy ignores him and says she put on her package, "From Santa Claus." David and Karen laugh at her. David suggests she put "From the Grinch." Judy, referring to the people they had asked to donate gifts responds, "To get money from some of them [sic] people, you'd have to be a Grinch."

Judy shifts the subject and asks David, "I thought you were going to run against me this morning." This elicits a lengthy conversation about running for office at the Governor's School. David says that he doesn't feel like running against her; he doesn't feel like running at all. David asks Karen if she would like to run for the position. She answers, "I guess." Judy says she was nominated and they voted, but she was the only one on the ballot. David says that he'll nominate Karen and they can vote again today. Karen answers, "Okay." David responds, "I'll nominate myself, but I don't want to be it, so I'll let ya'll win."

David, Karen and Judy discuss one of the students who had to resign because of health reasons. Karen abruptly asks, "*Restoration, vegetation.* How are we going to link *restoration* and *vegetation*?" David continues with the discussion of the elections. He says he wants to be president of "that little health career thing." Judy asks, "Who all's in there?" David gives her a list of people. Judy has been watching Karen write on the paper. She suddenly says, "Wait a minute. 'Is affected by' or 'can affect?'" Karen responds, "*Vegetation* is effected by." David blows into the tape recorder microphone several times, and also makes a rattling noise. David asks, "Did that scare you, Judy?" She tells him, "No." David continues, "That [rattling] sounds cool." He reads from the paper, "Traaash trains, rail cars." Karen looks at the paper and says they need to fill up the blank spot. David suggests she put "big hole...landfills are a big hole that have pipes and stuff." Karen wants to know how they are going to link the ideas. Judy suggests they put "create." David says, "Yeah, creation." He continues talking. Judy pointedly tells him to "Shut up." He laughs and says, "Wheeeee. Creeeeeate! I guess." Karen names several types of pollution: air, water, plant. She continues to write.

David notices what Jon, Jason, and Bill at the *Temperature Effects on Plants* table have written on their paper. He comments, "Look at theirs. They got..." [See Figure 24 for final web.] Karen responds, "They always do that." They laugh. [The boys have filled up the entire paper with words and lines.] David jokes, "Hey, Jon, you have to put 'big hole.'" Jon responds, "Big hole?" David, "Yeah." Jason answers David, "We already did," and he reads from their paper, "Big hole...in the ground."

Karen and Judy continue to discuss words to put on their web. Karen gives the word that goes in the circle and Judy supplies the phrase for the line. Judy laughs at Karen because Karen draws a long line connecting ideas. She says, "You took the long road." David picks up on it and says, "You took the long waaaay." Judy is annoyed and retorts, "You think you're soooo funny!" David looks at the drawing and says, "It looks terrible."

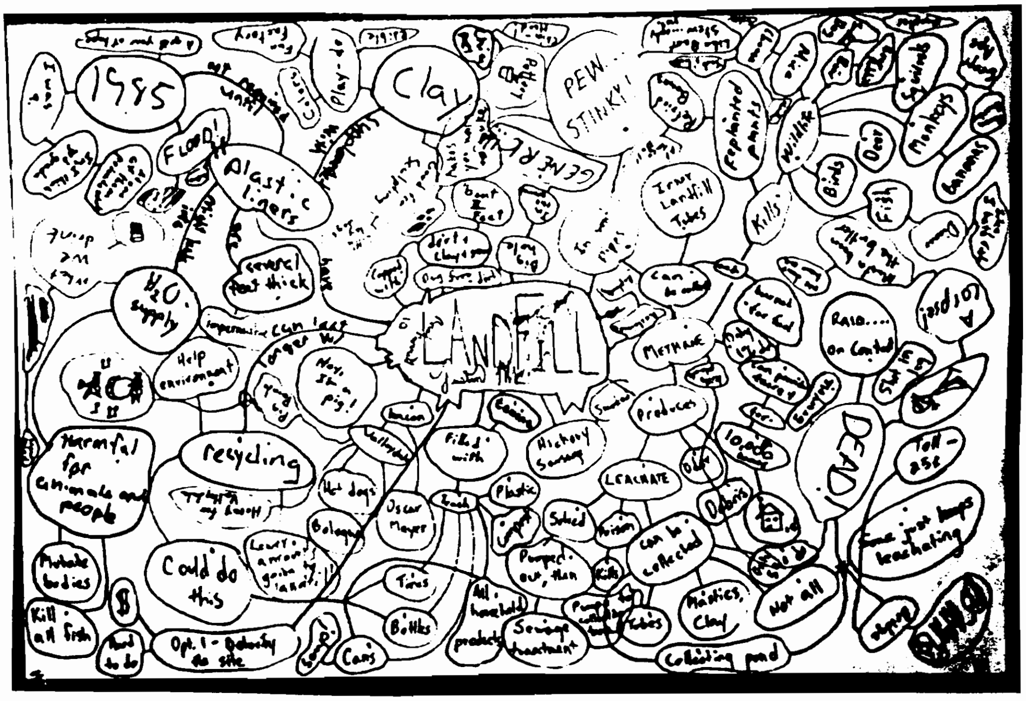


Figure 24. *Temperature Effects on Plants* Final Webbing Map

Judy says of David, "Poor thing, I feel sorry for him." Karen ignores the interaction and continues to write. She says, "Two types of..." David interrupts, "She was just telling me that I looked terrible." Karen defuses things when she says, "Awww, I thought you were telling about [another girl student]. Yes, she called me on the phone last night." Karen continues by mimicking what the girl said. [See Figure 25 for *Hydroponics* final web.]

The bantering between Judy and David seems to stop. There is a long silence before Karen asks, "What else would go right here? State regulations?" "Maybe local government?" Judy and Karen continue to talk as they finish the web. Finally Karen says, "Anything else we want to add?" Judy responds, "I can't think of anything. It's like, you thought of something else? David? [David aggravates Judy again.] Whaaat!" She pauses a moment and then adds, "David is a landfill." Karen decides they are finished and says, "Okay, get the survey."

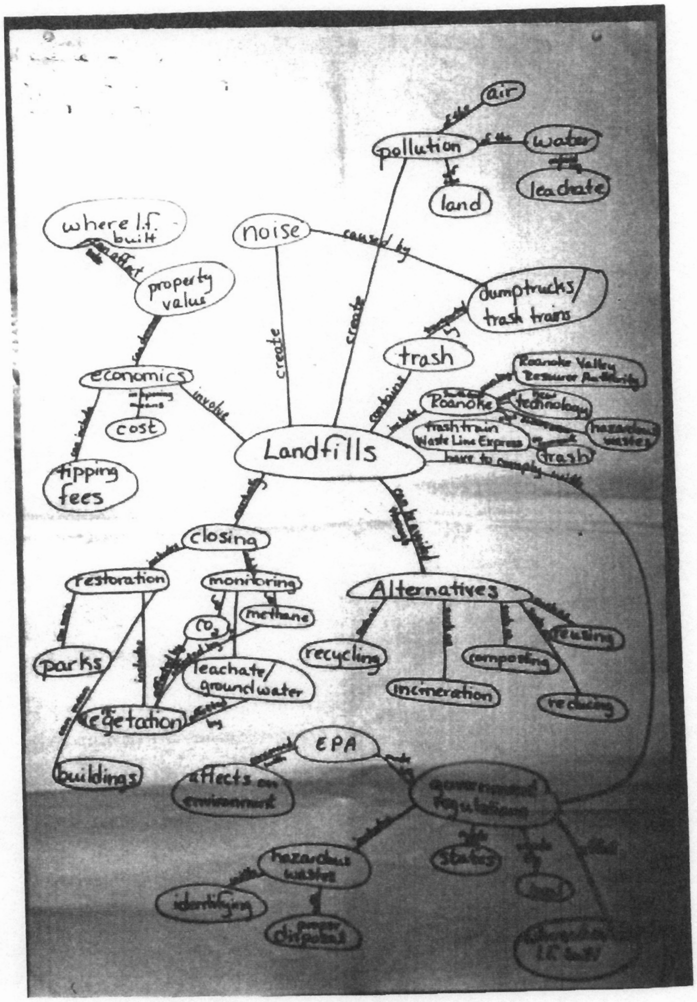


Figure 25. *Hydroponics* Final Webbing Map

Final Webbing Maps

Each table finishes their final webbing map and turns it in. It is interesting to see the words and pictures the students have put on their papers. The students at the *Soil Compaction: Grasses* table [see Figure 26] have chosen to not use pictures on their map.

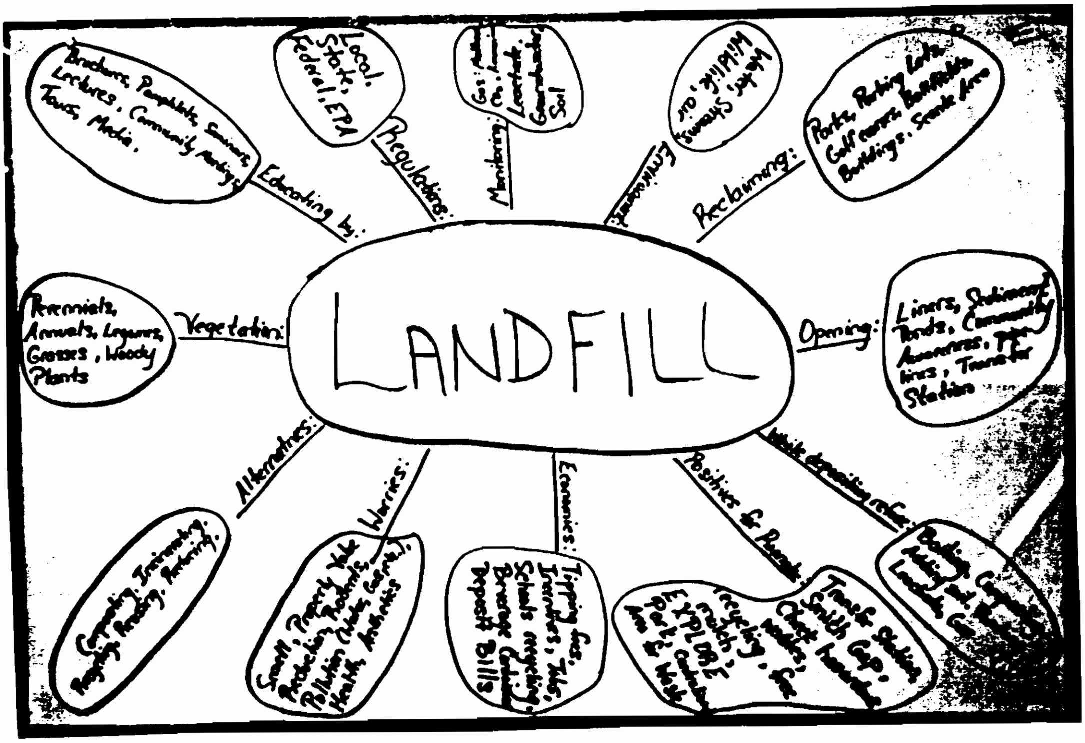


Figure 26. *Soil Compaction: Grasses* Final Webbing Map

The *Slope Study* table's picture has a cow emitting methane gas, a house that has exploded because of migrating methane gas, a trash tree [in the shape of a Christmas tree] and other signs of the season [see Figure 27].

The *Grass and Wildflower Aggression* table has pictures that seem to be more decoration than illustration of a concept. They have a smiling sun [with a bowtie], a person decorating a Christmas tree, and holly sprigs sprinkled throughout the paper. [See Figure 28.]

As each table finishes their concept map, they pick up their final questionnaires. Upon their completion, students bring them to me and begin to reorganize to do the activity John has planned for them this morning.

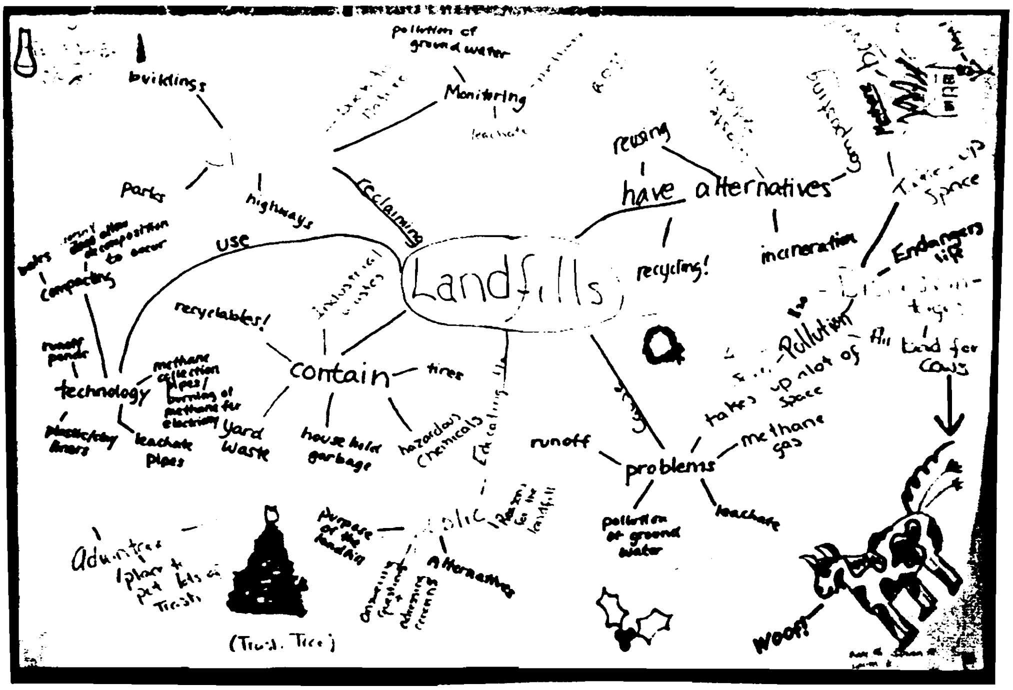


Figure 27. *Slope Study* Final Webbing Map

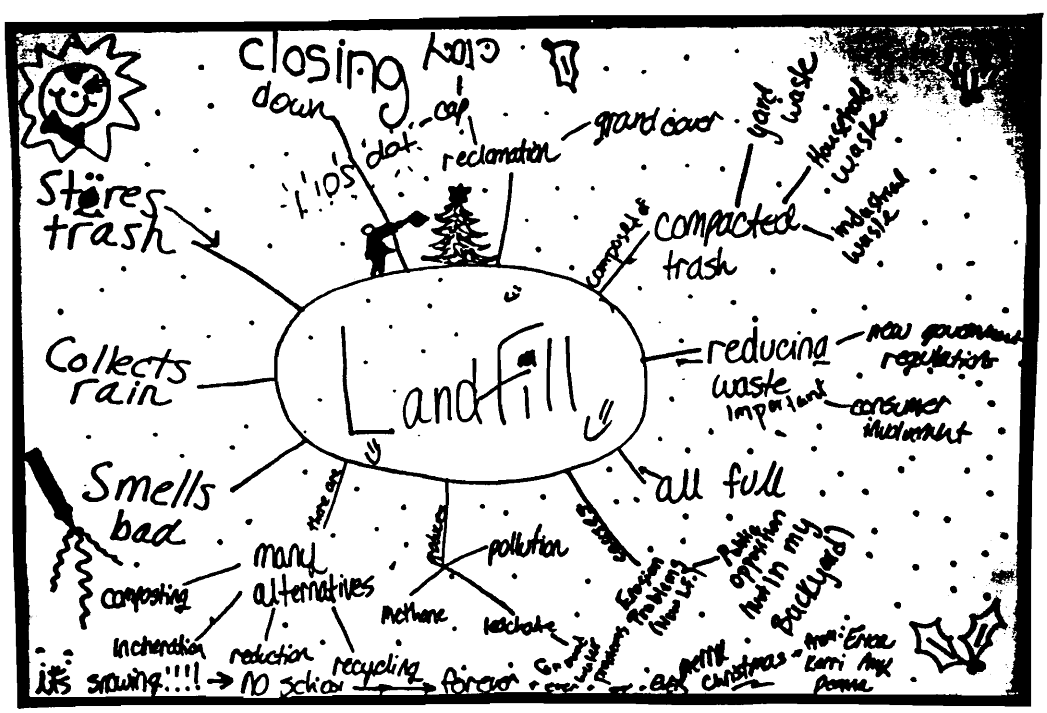


Figure 28. *Grass and Wildflower Aggression* Final Webbing Map

Project Sharing and Recommendations
March 31, 1994

Greetings

We are excited because this is the time for which we have been waiting...the opportunity to share our findings and recommendations for the revegetating of the Roanoke Regional Landfill! Mara will take copies of the students' papers and incorporate the information into her recommendations to the closing engineering firm. The students have made overheads and are ready to explain their experiments. John, Mara, and I have coffee, juice, and muffins for the students and our guests to enjoy during this informal time of sharing. We are meeting early [8:30 a.m.] to allow students time to finish during the class period and so our guests can attend other meetings.

John begins by thanking everyone for coming. "The students in this room have done a really remarkable effort," he says. John explains that the class was "told" they would be working on landfill issues. "As the teacher," he says, "I am really proud of everything they have done. They have persevered, they had a good sense of humor about things. When stuff has gone right, they were happy; when it's gone wrong, we just figured out what's gone wrong and fixed it. This group has been very mature, very disciplined, very scholarly." He also thanks Mara and I as the initiators of the project. John makes sure everyone has a copy of the syllabus which lists the participants, explains the activities, and gives a summation of each experiment (see Appendix G for syllabus). He then asks me to continue with the introductions.

Introduction of Guests

I tell our guests that they were invited to the class today because they bring a variety of experiences to our study (see Appendix G for letter of invitation). "Students want to share with you what they have been doing in conjunction with some aspect of the work you are doing in the field." I introduce each guest, beginning with the person seated nearest me.

There are (1) a member of the Board of Supervisors, and an advocate of Explore Park; (2) Dr. John Cairns, Director of the University Center for Environmental and Hazardous Materials Studies from Virginia Tech, who has been to the class to talk about issues other than landfills; (3) the Director of General Services in Roanoke County, and past Chairman of the Roanoke Valley Resource Authority (RVRA); (4) the current Chairman of the RVRA; (5) Dr. George Glasson, my advisor from Virginia Tech; (6) the Project Engineer for Explore; (7) Virginia Laubinger, Environmental Educational Programs' Coordinator for Explore Park, who has talked about landfills and the Roanoke Regional Landfill's impact on Explore; and (8) the Principal of the Roanoke Valley Governor's School for Science and Technology.

Schedule of Activities

Bob and Corrine begin the presentations by telling the activities we have done as part of this study. Bob explains the webbing activity. He says, "We put 'landfill' in the middle [of the paper] and then everything we could think of just kind of came out to the sides." Corrine tells about the trip to the "old" landfill, the transfer station, and the "new" landfill. She says that they learned about the old landfill, how trash was going to be delivered to the new landfill, and how the new landfill was going to be opened. Bob names Ginny Laubinger as one of our guest speakers. "She told us about Explore Park and what they do. She also told us how the landfill affects Explore Park because of their location being downstream from the landfill."

Corrine mentions the Smithsonian Magazine article about garbage they read and summarized (see Appendix E for a copy of the article). Bob continues to tell about the Issues and Values lesson we did when we read articles from the Roanoke Times & World

News. He explains that these articles told about the opening of the new landfill and the closing of the old one. Corrine says that the next activity they did was to make an outline for a talk that each student would give at his/her home school. The topic they talked about was waste management, landfills, and recycling. Bob describes the group paper each table did concerning the topics of (1) Closing monitoring, and reclaiming a filled landfill; (2) Opening and monitoring a new landfill; and (3) Alternatives to landfills. Bob says that they used articles, books, and "anything we could find" to research those topics.

Corrine names Dr. John Cairns from Virginia Tech as the next guest speaker we heard in class. She says that his lecture was "whether the U. S. has the right to tell China that they should not be able to raise their energy level in order to produce more [energy] to go along with their population." Bob tells about the next activity. He says, "Ms. Sabre gave us a lecture about restoring landfills and gave us the background on quite a few plants, and the basics on landfill restoration." Corrine shares that the next step was to determine what experiments they wanted to do. She acknowledges that Mara and I "kinda prodded us and tried to get us to think deeper into what we would like to do...what we would like to discover."

Bob explains at the end of the project they did another concept map, similar to the one they did at the beginning of the study. They wrote "landfill" in the middle of the paper. "This time it [the concept map] was much more knowledgeable because we had a couple of months of this landfill unit," he says. Corrine states that they completed their plant experiments and prepared their final reports. Bob says that the last activity, "student presentation of plant experiments and preparation of final conclusions" is today.

John steps to the front of the room and explains how he sees what the students have done relates to "real" research they will do if they go into the sciences as young adults. He shares,

> So often in high school, the lab activities we do, although they may be very good, tend to be short and often times very predictable in terms of the results one is looking for. The experiments the students will tell you about next may get as close as one can get in high school to real university-type research that is both long-term, frustrating, and you don't always know what the results are. You don't know how things are going to turn out. So I think one of the big lessons for all of us was allowing these students to do something that they are going to encounter in a few years when they get to their academic careers.

Before the students present, Mara shares a few things about her involvement in the project.

Restoration Background

Mara steps to the front of the room and says that she will give some background for the students' presentation. She begins by listing the constraints on landfill restoration: ecological, regulatory, social, and financial. Mara shares that prior to this project, she had been doing field studies where she had been on the landfill seeing what would grow. "But," she says, "I had very little idea as to what was going on at a smaller scale, and what might affect the choice of plants for an alternative revegetation mixture." She explains that the students at RVGS have assisted her in looking at the ecological constraints such as:

(1) rooting depth
(2) shoot height
(3) what kind of gasses might affect the growth of plants
(4) what different conditions might affect the survival of plants on the landfill.

Mara notes that the students designed and developed their own experiments. There were also many facets to the data collection. "In gathering their data," she tells us, "the students counted the plants and shoots, weighed the roots and weighed the shoots." Mara explains that ecological restoration requires the collaboration of many different people to help work through these constraints. She also believes the data the students obtained is "of publishable quality." Mara finishes and John quickly explains after the presentations there will be dialogue at each table. From this dialogue between guests and students, he hopes each table will construct two or three overall conclusions from the presentations.

Table Presentations

Students are aware they have five minutes in which to introduce their members, give the title of their experiment, explain their design, share their problems, and give conclusions and recommendations. John tells the group we will follow the order of presentations as given in the packet.

Soil compaction: Rooting depth. Matt begins by giving the name of their study, The Effect of Soil Compaction on the Shoot and Root Biomass, Height, and Germination of Bachelor's Button, Black-Eyed Susan, Kentucky Fescue 31 Grass, Abruzzi Rye Grass, and a Mix of All Four Plants and the students involved: Bob, Ruth, and Corrine. (See Appendix G for copy of the paper.) He explains the seeds they used in their experiment are bachelor's button, black-eyed Susan, Kentucky fescue-31 grass, and abruzzi rye grass. Ruth states that the purpose of their experiment was to determine how the plants grew in compacted and uncompacted landfill soil (see Figures 29, 30, 31). She says that part of the determination of how the plants grew was to look at the shoot and root biomass within the compacted and uncompacted soils. Corrine shares that some of the problems they encountered were determining which plants to use, what size containers, how many plants in each container, and how much water to put on the plants.

Bob gives the group's conclusion. He states, "Soil compaction does not affect the shoot-root biomass, germination, or height of the plants tested." Bob explains that they saw no difference in the plants that were grown in compacted soils with the plants grown in uncompacted soils. This table does not think compacted soils are a disadvantage in the revegetation of closed landfills. "Compacted soil does not seem to harm the growth of the plants," Bob notes. His suggestion from their study is that the landfill consider the use of bachelor button and Kentucky fescue-31 grass as vegetation.

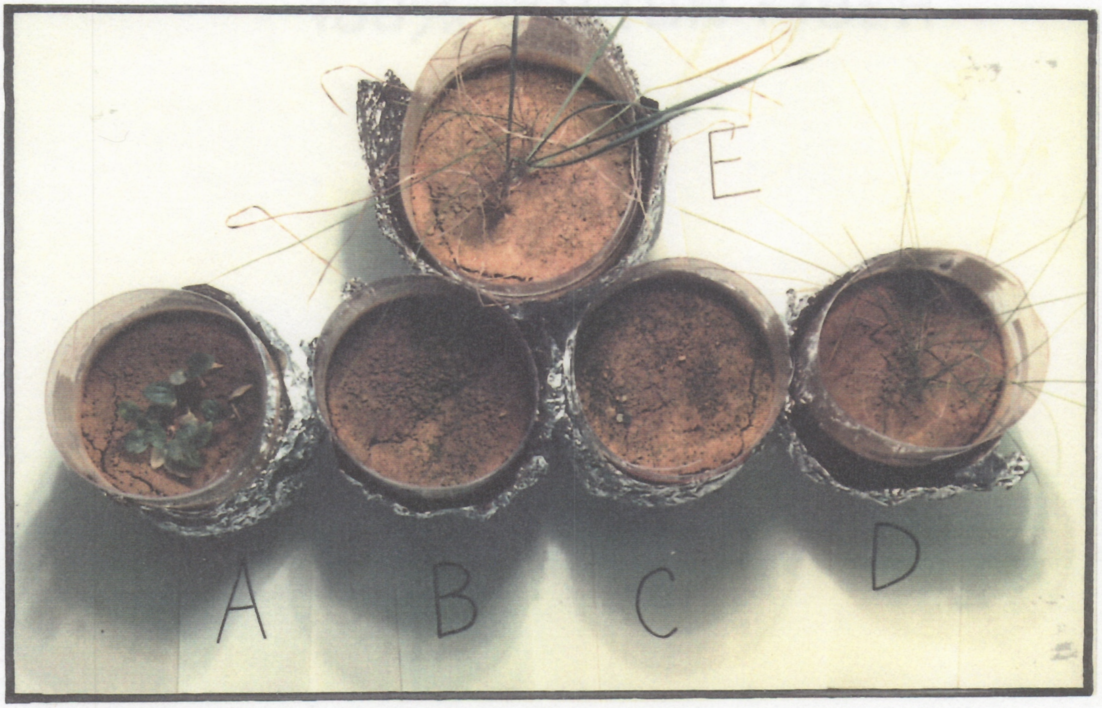


Figure 29. *Soil Compaction: Grasses* Final Plant Growth
Compacted Landfill Soil

A (AA, AAA) -- Bachelor's Button
B (BB) -- Abruzzi Rye Grass
C (CCC) -- Black-eyed Susan
D (DD, DDD) -- Kentucky fescue - 31
E (EE) -- mixture of all plants

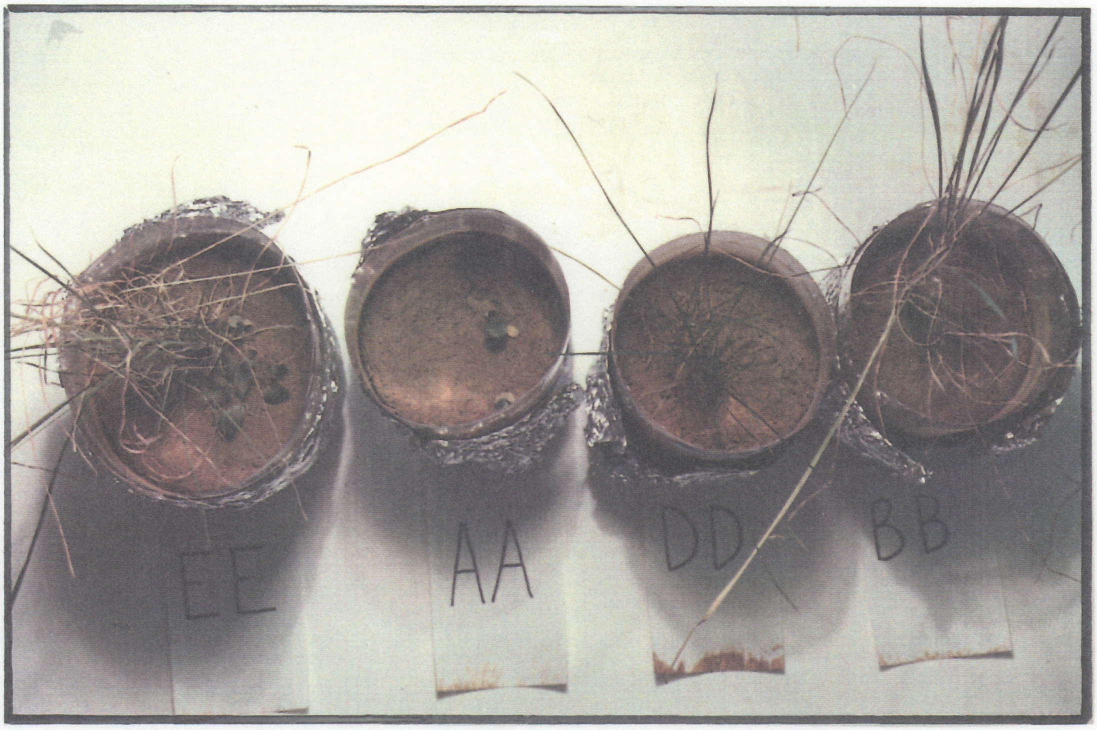


Figure 30. *Soil Compaction: Grasses* Final Plant Growth:
Uncompacted Landfill Soil

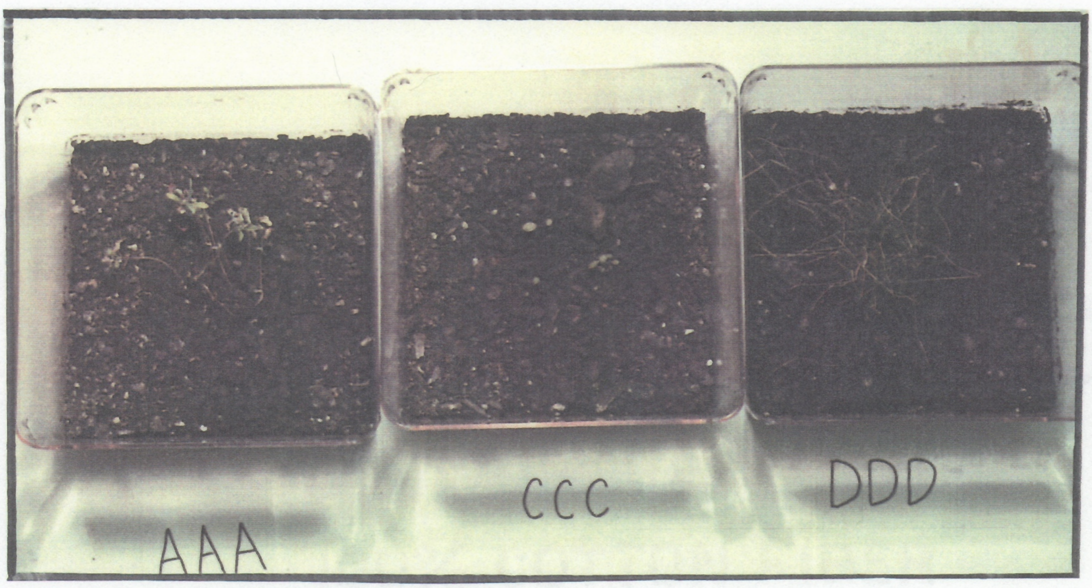


Figure 31. *Soil Compaction: Grasses* Final Plant Growth
Control: Potting Soil

Hydroponics. Judy gives the name of their experiment: The Effects of Varying Amounts of Sodium Bicarbonate in Hydroponic Solution on the Survival of Plants. David and Karen are also in this group. Judy lists the plants they used as cornflower, brassica, and lanced-leaved coreopsis. She explains the reason for choosing to do their experiment hydroponically. "We thought this was the best way to introduce carbon dioxide to the root system," she states.

Karen explains their experimental design (see Figure 32). She tells that they germinated seeds in potting soil and after 7-9 days they transferred the plants into the hydroponic solution composed of water and calcium nitrate. Karen describes the setup of the tanks. "The first tank had no aeration and no sodium bicarbonate. The second tank had aeration but no sodium bicarbonate. In tank three, there was aeration and varying amounts of sodium bicarbonate," she says. Karen continues to explain that in the first trial they had 10% by mass solution of sodium bicarbonate and in the second trial they used a 1% solution. The students were going to do more trials and work toward the threshold, but they ran out of time.

Some of the problems Karen says they encountered were:

(1) not knowing where to start with the percentages

(2) not knowing how much CO_2 there is in the landfill

David shares the group's conclusions. He explains that at a 10% solution, the plants wilted after a few days. At a 1% solution, the plants wilted some, "but not enough to affect them." He also notes that the lack of aeration caused stress, resulting in many of the plants in tank one to wilt after two days. The group's third conclusion was that all species tested worked well in a hydroponics set up. David states there did not seem to be any difference in response among species.

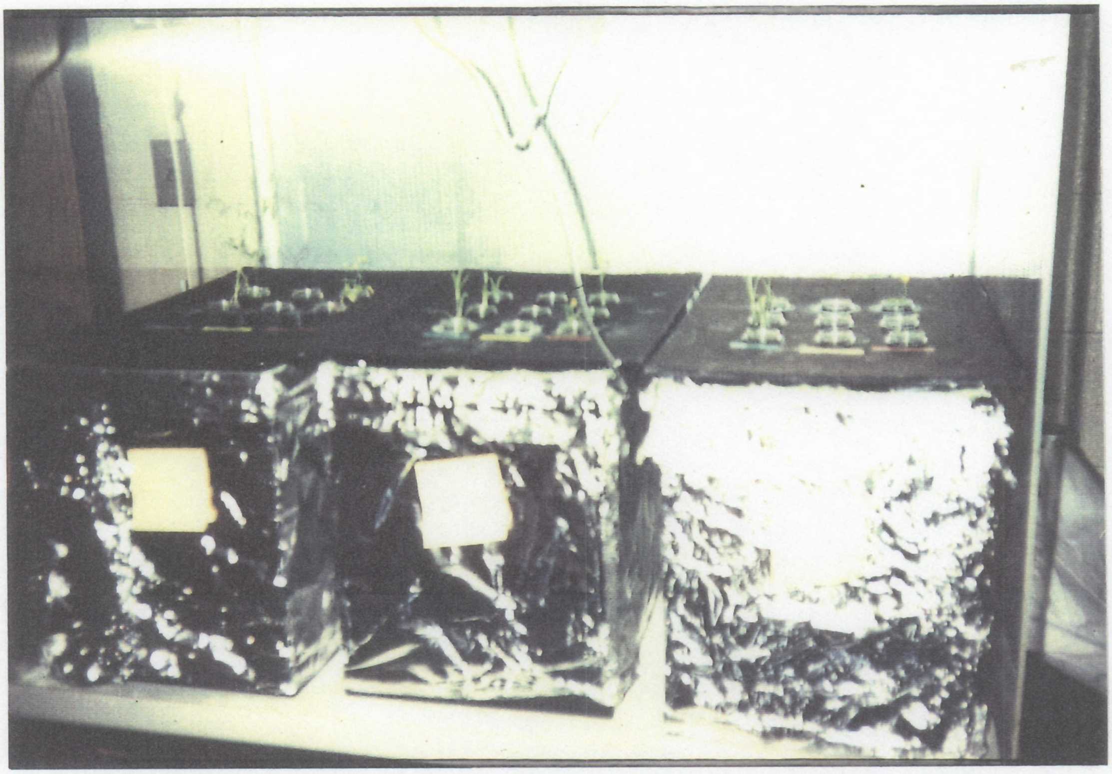


Figure 32. Hydroponics Setup

Grass and wildflower aggression. Karol introduces her table's experiment, The Effect of Species Aggression on the Survival and Growth of Landfill Plants. The members of this group are Karol, Doris, and Ann. She explains why they chose this experiment. Karol says, "We chose this type of experiment because we wanted to see the type of aggression that would be involved when we planted different species of plants on the landfill surface." (See Figures 33, 34.) She acknowledges that when different plants grow together, "sometimes one or more of the plants could grow less or die because of the competition or resources." This aspect of aggression they felt should be closely monitored before new species were planted in a new environment.

Karol describes their experiment. They used three species: plains coreopsis, purple coneflower, and birdsfoot trefoil. They planted 60 seeds of each species separately in a container as a control. They also planted three containers with a mixture of 45 of each type of seed to determine whether aggression affected the number of plants that germinated.

Doris shares the data from the group. She states that on day 35 the plants had reached their peak. The germination rates were:

plains coreopsis -- 85%	Mixture Container 1 -- 17%
purple coneflower -- 60%	Mixture Container 2 -- 33%
birdsfoot trefoil -- 8%	Mixture Container 3 -- 30%

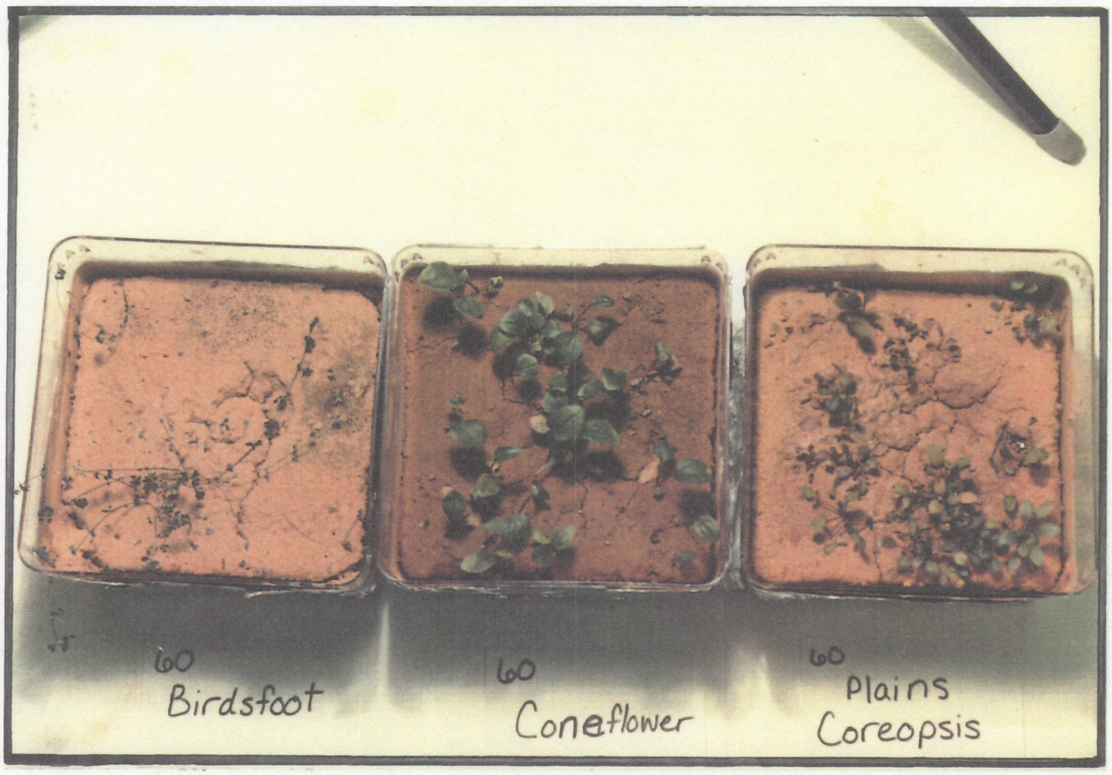


Figure 33. *Grass and Wildflower Aggression* Final Plant Growth: Individual Species

Figure 34. *Grass and Wildflower Aggression* Final Plant Growth: Mixture of Species

Doris says they determined from this germination rate that the plains coreopsis performed much better in isolation than did the birdsfoot trefoil. However, the average height of the birdsfoot trefoil that grew was much higher than that of the other two species.

Ann gives their conclusion. She states that the intermixing of species does have an effect on the survival of the plants. "Conclusions could not be made on the effect of intermixing species because once they started growing, we could not tell the difference between the plants so we could not tell how each one did in the mixtures." Ann says if they do it again, they should begin taking height measurements as soon as the plants germinated. She explains one of the problems they encountered was that the plants grew in a clump which made it difficult to count and measure the plants.

Soil compaction: Grasses. Kusum says that her table investigated The Effect of Loosely-Compacted Landfill Soil and Tightly-Compacted Landfill Soil on the Germination, Height, and Biomass of Various Species of Lolium and Festuca arundinacea. She introduces the others at her table as Divya and Kavita. Kusum gives the purpose of their experiment, "to determine the effect of commercial, loosely-compacted landfill, and tightly-compacted landfill soil on the biomass, germination, height, and depth of shoots and roots of various species of Lolium and Festuca arundinacea. (See Figures 35, 36.)

Figure 35. *Soil Compaction: Grasses* Final Plant Growth: Annual Rye Grass

A -- Loosely compacted landfill soil
C -- Tightly compacted landfill soil
B -- Commercial soil

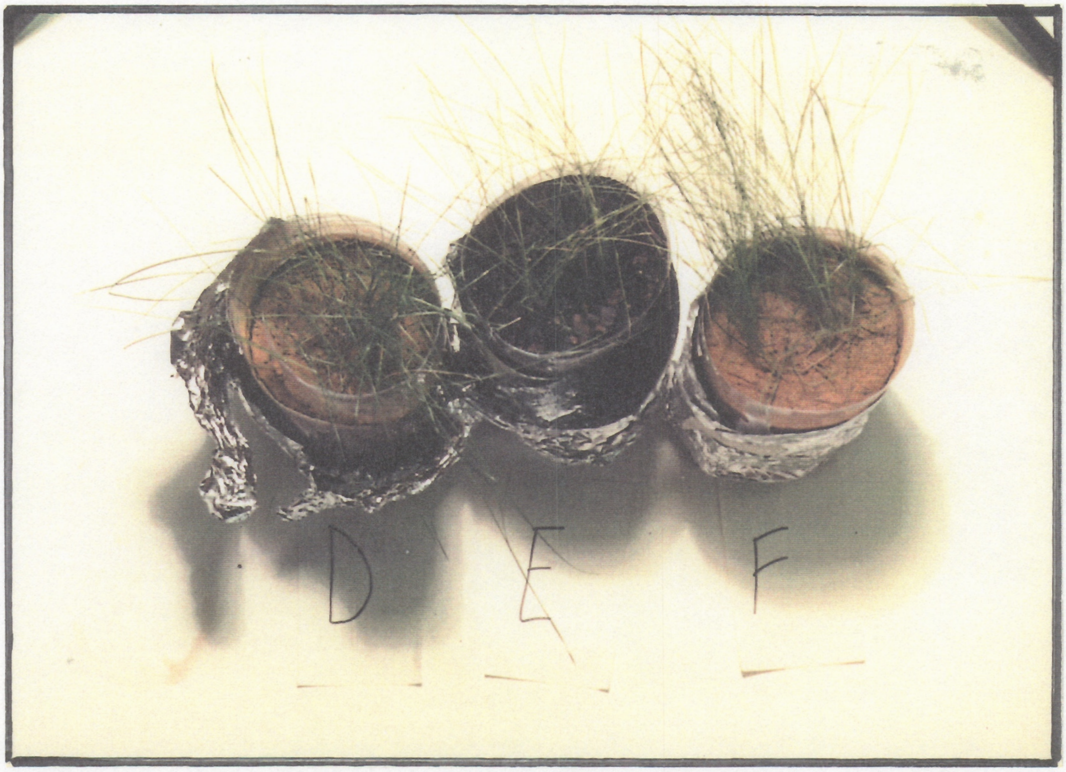


Figure 36. *Soil Compaction: Grasses* Final Plant Growth:
Kentucky fescue - 31 grass

D -- Loosely compacted landfill soil
E -- Commercial soil
F -- Tightly compacted landfill soil

She explains that one of their problems was the same other groups have expressed: which grasses to use, how many seeds to use, how to count all the seeds, and measuring the height. Kusum adds, "One of the major problems we had was how to compact the soil." [She does not explain to the audience how they solved this problem.]

Kavita tells to analyze their statistical data they used the student t-test, "which is basically a statistical test to compare two sets of data to see if they are distinct or sub-sets of the same population." She says they compared annual rye grass in both tightly-compacted and loosely-compacted soil. They made the same two comparisons of Kentucky-fescue

31. Kavita explains that they looked at (1) germination, (2) height of plants, (3) length of the roots, and (4) biomass. With germination, the group discovered that there was a statistical difference between the tightly-compacted soil and the loosely-compacted soil with the annual rye grass. She explains that the t-value was 2.4, and anything above a 2.0 indicates a difference. In all other areas (height of plants, length of roots, and biomass) Kavita says they found was no statistical difference in either species. Neither was there a statistical difference in the germination rate of the Kentucky-fescue 31 grass.

Divya states that her group recommends annual rye grass be used in loosely-compacted landfill soil. She shares that they got the highest germination rates of annual rye grass in commercial soil; the longest roots from Kentucky fescue-31 in commercial soil; the highest height from annual rye in tightly compacted soil; and the greatest biomass from annual rye in loosely compacted soil. She concludes, "But overall, there was no statistical difference in loosely-compacted landfill soil and tightly-compacted landfill soil."

Temperature effects on plants. The other two members of Bill's group, Jason and Jon are not in class today. Bill gives the title of their project as What are the effects of temperature and soil-type on the height, mass, and sprouting rate of Birdsfoot, Purple Coneflower, and Lance-Leafed Coreopsis? Bill explains their experimental design. He says that they had plants at three different temperatures: room temperature and set temperatures in two different growth chambers. (See Figures 37, 38.) One of the growth chambers at RVGS was set at 30°-35°C, and the other chamber at Virginia Tech was set at 10°C. Unfortunately, Bill explains, someone threw away their plants in the growth chamber at Virginia Tech so that the final data reflects only those plants at room temperature and those that were in the plant chamber at RVGS. The group's conclusions were drawn from measuring height, biomass, and the sprouting rate of the plants.

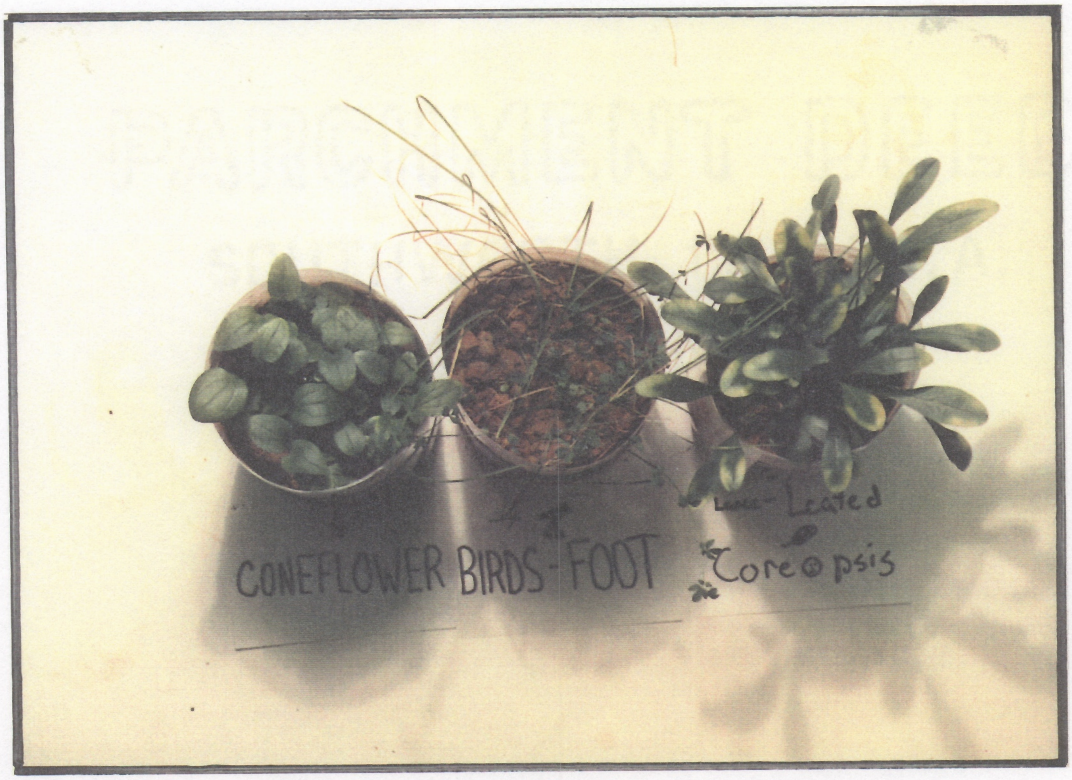


Figure 37. *Temperature Effects on Plants* Final Plant Growth:
Landfill soil at 30^{o} - 35^{o} C

Bill says that the findings of his group was much different than what they expected. The plants in the landfill soil grew much better than the plants in the potting soil. The sprout rates were steady and heights were greater for those plants in the landfill soil. He states that the landfill soil plants also had larger shoot masses and showed less stress. However, the potting soil plants did have deeper root depths and a quicker sprout rate than landfill soil plants. The group also found that the landfill soil plants in the growth chamber set at 30^{o}-35^{o}C had larger sprout biomasses and taller heights than those of the room temperature plants. Bill concludes that "the plants in the landfill soil did not have deep rooting depths, but they grew to be very tall and very healthy."

Figure 38. *Temperature Effects on Plants* Final Plant Growth:
Potting soil at room temperature - 23°C

Slope study. Syann begins by giving the title of their experiment, The Effect of a 25 Degree Slope on the Growth and Survivorship of Coreopsis tinctoria, Rudbekia hirta, and Echinacea purpurea. She lists the other people in her group as Karla and Linda. Syann explains the purpose of their experiment was to determine what effect a 25° slope would have on the growth of their plants. (See Figure 39, 40.) This group chose this experiment because they know a large portion of the landfill has 25° slopes and plant coverage is important to retard erosion. Syann also gives the common names of their plants: plains coreopsis, black-eyed Susan, and purple coneflower.

Linda explains some of the problems they had in their study. The first problem was to figure the slope and then find a way to set the boxes at that angle so they would not slip.

The group decided to prop the boxes up and use duct tape to secure them. The second problem they addressed was how to simulate rainfall. Were they going to water the entire box, or water only at the top and allow the water to run down? [Linda does not share with the audience which choice they made.] Their third problem was unforeseen: a worm. It entered the box and ate some of their plants!

Karla finishes by giving the group's conclusions. She states the group discovered that the plains coreopsis and the purple coneflower grew better in the flat containers, and the black-eyed Susan grew better in the sloped boxes.

Figure 39. *Slope Study* Final Plant Growth: Flat Surface

However, they discovered slope had no definite effect on the survivorship of the three plant species, and there was a fairly good survival rate of all species. Karla states that they definitely perceived the aridness of the soil to have an impact on the plants. She finishes and sits down. This is the last of the groups to present.

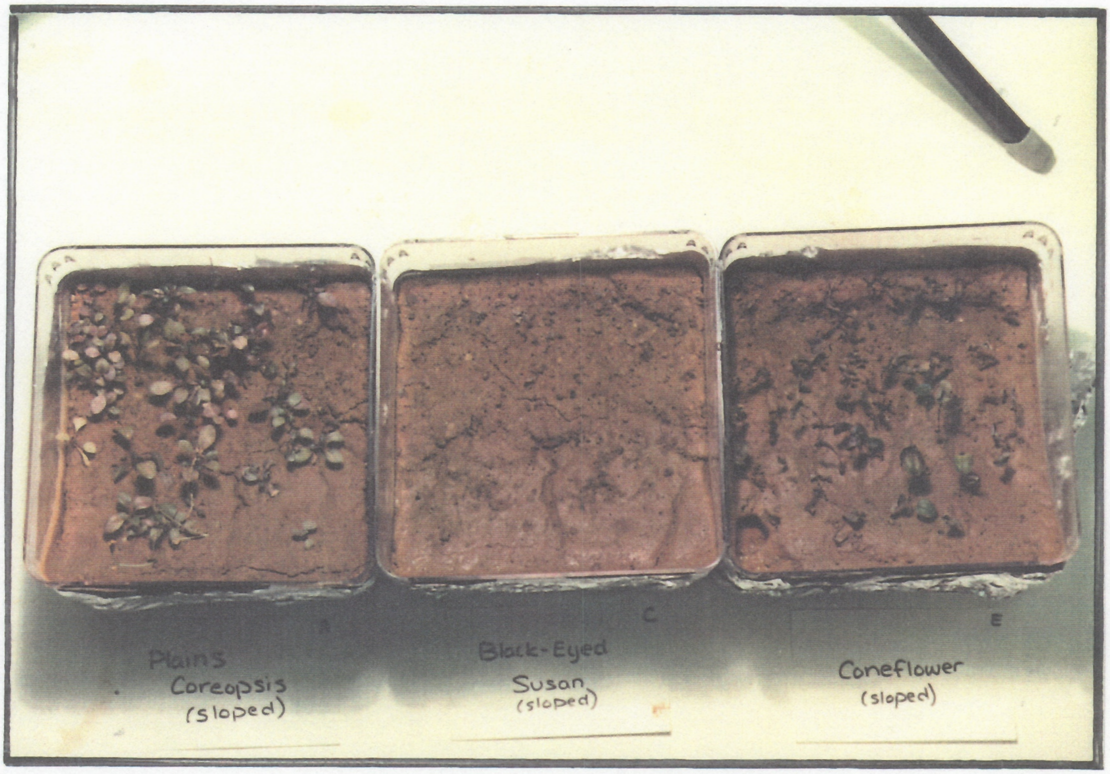


Figure 40. *Slope Study* Final plant Growth:
25 ^{o} Sloped Surface

Presentation Summary

Mara walks to the front of the room to summarize the students' reports. She explains that some of the data the students have gathered will be used by Draper Aden, the general contractor for closure, in considering the revegetation of the landfill. Some of the plants they hope to use will be bachelor's button, purple coneflower, annual rye, big bluestem and little bluestem. Mara says, "The information the students have provided has encouraged me that despite adverse conditions that do exist on the landfill, my plants will be able to grow, given certain constraints. If the plants can survive here, there is a good chance they might survive on the landfill." Mara explains that the cost of using wildflowers on a landfill is very expensive. She explains that this is in part because the operators overseed. They don't know how much seed to put on because germination rates and the soil have not been tested. "One of the things the students have provided me with," says Mara, "is that in two or three months you can set up studies, very inexpensively, run germination tests, and a landfill operator will have a far better idea of what their seeds will do." Mara walks to the board as she continues talking. "Draper Aden expects to put at least two feet of landfill soil, similar to what we used, and then another 6 inches of topsoil on that. The topsoil is supposed to be even better than the landfill soil. You know your plants can survive on this stuff [the landfill soil], my question to you in your groups is, do you think your plants will have an equal chance of surviving in the top soil?" Mara concludes by emphasizing that the students' data will be applicable to the revegetation mixture that Draper Aden is considering for closure.

John steps forward and explains what we will do next. He says,

> We would like to take advantage of the expertise in this room. Students are now landfill experts, no question about it. We have some visitors in here that are excellent in particular areas. We would like to divide into groups with a visitor at each table and spend about 10 minutes having you talk about landfill restoration. What have you learned from doing it? Where do we need to go with the Roanoke Regional Landfill? At the end, we will go around the tables and ask you to summarize what was said at the tables.

The visitors shuffle to different tables. The room immediately fills with a low hum of voices and students become antimated. Everyone seems to have something to ask or say. I set tape recorders at several tables, pick up the video camera and walk around the room taking pictures.

Slope Study Table and *Temperature Effects on Plants* Table Dialogue

Syann, Karla, and Linda are sitting at the *Slope Study* table. Bill has also joined them from his table since he is the only one present from his group. The Project Engineer for Explore Park is the guest at this table. The discussion begins by Syann talking about the problem they had with the germination of the seeds in relation to the watering they did. The group discovered when doing their experiment that some species only germinated at the top of the slopes, while other species germinated only at the bottom. "We do not know if the plants at the bottom [of those that did not germinate] drowned, or the other got washed down," says Syann. Karla comments that we "watered, and watered, and watered, and it all stood at the bottom."

The engineer finds the lack of germination interesting and says, "One of the biggest problems we have at the landfill is the surface runoff." He goes on to explain that Explore has two major ravines that feed from the landfill into a drainage area in the park. He states that they get a lot of siltation...even from the old section of the landfill. The engineer adds that the grasses in that area don't seem to survive, either. He asks how long the experiments were run. Linda tells him that it was a little over two months.

The engineer returns to the problem of the grasses growing in the siltation. "What seems to happen is that the grasses do well right at the first and then over a couple of years what happens is that the annual re-germination coming out tends to die back," he says. As an afterthought the engineer comments, "I was wondering about the compacted soil tests. That's where one group said there was no difference in the compacted soil and non-compacted soils." Karla adds that if they were going to test for re-germination of species, they would need to run the experiment much longer than they did. The engineer tells the groups that part of the problem is that there are no longivity studies. "It just has not been done," he says. He then asks the group what were some of their most interesting observations.

Syann says one of their biggest problems was the soil drying out. Karla agrees, "You would water it one day and come back the very next day and it would be very dry." The engineer asks if the soil they used was landfill soil, red clay. He questions what happened when the soil dried out. Linda tells him that in one box they had big hole! Karla adds that in another they "had a crack, and then it started washing down." The engineer finds their observations interesting. He wants to know if the crack eventually fell in. Karla responds that it didn't happen at first, but when they returned from Christmas they had this huge hole. Linda said they called it a "sink hole." Syann explains that when they dismantled their experiment, they could see large air pockets just underneath the surface of the soil at the top of the box. The engineer speculates, "It makes me wonder what is going to happen when they put this top soil on top of that red clay, if the water might not penetrate the clay and then start running, particularly on a slope of 25%, wash out underneath and then cause the top to fall in. I've seen 'instant' gullies." He adds that he thinks the issue of erosion would be an interesting study.

Karla talks about the difficulty of watering the plants in the slope boxes. She explains that it was difficult to water them evenly. She says, "We ended up pouring most of the water on the top of the box because if we poured it at the bottom, we would just fill up the bottom of the box. It was really hard for us to simulate the rainfall accurately, especially with how much water we had to give these plants. It was a little box, and we were giving them **so** much water!" Linda suggests they show the engineer the picture of their plants. As they look at the pictures, the engineer notices where the soil has "slumped" because of watering and erosion. Bill also shows pictures of his plants where his table studied the effects of temperatures on plants. The engineer notices the difference in the color of the soils. Bill explains they used both landfill soil and potting soil. As they finish talking, I call the groups back together. I ask each table to share with the class some of the things discussed at their table.

Table Discussions Shared

Soil compaction: Grasses table. Divya explains that they talked about the differences in the way students look at restoration as contrasted with the way engineers look at restoration. The table believes the students' perspectives about restoration are more idealistic. Divya says that this idealism is contrasted with the realistic way engineers look at restoration. Engineers deal with the cost of a project, therefore they are more aware of the amount of money involved.

Soil compaction: Rooting depth table. Mark shares that they talked about the cost of using annual or perennial species for revegetation. Their table felt the cost of perennials would be less because the landfill operators would not have to seed every year. Mark says they also talked about how well their plants would survive if there was a 6 inch layer of topsoil placed on the landfill soil cap. He says his group thinks the compacted soils may have had a negative effect on the germination and growth of their plants. They believe the topsoil should enhance the germination rate of their species.

Mara asks the students if they know which of their plants were annual and which were perennials. Several groups respond. To make sure everyone is aware of the definitions, Mara explains that annuals "grow, bloom, and set their seed in one growing season." Examples would be black-eyed Susan and bachelor's button. She says, "Perennials grow, but may take two or three seasons before they bloom and set seed." Examples of perennials are purple coneflower, big bluestem, little bluestem, perennial rye, and occasionally, Kentucky fescue.

Bob asks Mara whether the soil on top of the trash is going to be compacted. Mara answers that "it is supposed to be uncompacted to suit a particular fluid conductivity rate of

10^{-5}cm/sec. This means water can only move < 1.1/1000 of a second through the soil. So that is very tightly compacted." She explains that this will be difficult to measure because of the large number of acres [50 acres] and since the landfill soil has some sand in it, it will be more difficult to compact.

Hydroponics table. Karen says that the people at her table discussed whether the information and conclusions gathered at the Governor's School would be able to be used by other states or regions. Their table seemed to think they could be. They also discussed how they would share with another school what they had learned and explain the problems they encountered at the Governor's School. David commented that everyone not working with the same species made the relation of data difficult. He suggested that different schools be involved in the experimenting, but each school only use three species so they could compare their data more easily. If enough schools were involved, then all the species could be covered.

I share with the students that John, Mara and I are interested in writing a landfill restoration unit to share with other schools. I ask the students whether we should recommend particular experiments to do, or leave it open-ended, giving the schools enough data to design their own experiments. Many of the student had opinions about the best way to do it. Mark says he thinks we should give some ideas first and let them develop their experiments from there. Karen agrees that it is always better to have an idea from which to start. She adds that if each school could share information and build on what has been done previously, there should be better and more specific results. Karla comments that she thinks part of what was good about this unit for her was that "we had to think for ourselves and decide for ourselves." She doesn't think that we should give them so much information that it becomes a "cookbook" approach. Karen agrees that each school's experiments should be different "so they just won't replicate ours." Kusum suggests that each class might want to have two groups doing the same experiment to give it reliability. I add that her suggestion would take care of the problem we had in not having enough time for replications. When the suggestions have all been given, we move on to the next table.

Slope study table and the *Temperature effects on plants* table. Syann explains that their table talked about erosion. When they did their experiment, they noticed that the soil washed away from underneath the top layer of dirt. It caved in, leaving sink-holes and crevices. She shares that they also talked about Bill's group and how unusual they thought it was that in his table's experiment the plants in the landfill soil grew better than the plants in the potting soil. This made their group wonder whether the extra 6 inches of top soil was really necessary.

Syann also explains that they talked about the issue of re-germination. She states in their experiment that 86 of 90 seeds germinated. She questions what those numbers would be if they had done the experiment longer to look at re-germination rates. She acknowledges if the re-germination rates were not good, the plants would eventually die out and erosion would follow.

This leads the principal of the Governor's School to ask whether the placing of the 6 inches of top soil has economic implications. Karla says that she thinks it does. "I'm sure they would be happy to not have to spread topsoil on 50 acres of land." The principal asks the engineer from Explore how much does topsoil cost. The engineer estimates that one cubic yard of topsoil costs approximately $40. One cubic yard at 6 inches of depth would cover 6 sq. feet. He determines that each acre is 43,560 sq. feet, so 43,560 sq. ft. x 50 acres x $40. The room comes alive with the realization of the amount of money needed to cover the landfill with 6 inches of topsoil. The chairman of the Roanoke Valley Resource Authority interjects that all this discussion is moot because the 6 inches of topsoil is a state regulation. He explains, "The research would have to be done to prove that the 2 feet of compacted soil has the necessary nutrients, and wouldn't have an adverse effect on the revegetation efforts." He agrees though that, "economically it would be nice to not have that 6 inches of topsoil."

The engineer from Explore joins in sharing what they talked about at his table. He refers to the pictures of the plants the students shared with him and talks about the observations made in the slope boxes vs. the flat boxes. He walks to the board and points to the drawing Mara made earlier of the 2 feet of compacted landfill soil with the 6 inches of topsoil above that. He explains that based on their discussion, with a 25% slope "what could happen is that moisture could penetrate the topsoil layer, hit the top of the compacted layer and start running underneath...pulling the topsoil from underneath it out." This is what the slope study experienced in their experiment and resulted in sink holes and crevices. The engineer acknowledges the fact that closing procedures are state regulated, but he thinks for the class to do another year's worth of study on this topic would be very beneficial.

The member of the Roanoke County Board of Supervisors adds that if no one investigates this problem, "we will forever be burdened with that state regulation at that expense." He also voices an interest in having the students continue their study another year. The engineer says, "**Nobody** is doing these studies that I know of. It's so expensive and extensive, but there is a lot of testing there that would be worthwhile because it all boils down to the economic issue which was at the heart of the original question."

Grass and wildflower aggression table. Karol explains that their table discussed some of the same things other groups discussed, but they related it to their specific study. She says that a conclusion they came to was that "with more nutrients in the soil, with more topsoil on top, there would be more competition for these nutrients." Because of this, "some of the plants might grow more, and some of them might grow less." This was the last table to share. John stands up and begins to speak.

Guests Sharing

John says, "We are going to put our visitors on the spot. We are going to ask you for your comments, particularly your situation at Explore, or at the landfill, or in the county. If you would share with us a couple of minutes." He asks Ginny to begin.

Ginny tells the students that they are on the "cutting edge" by having taken an unknown and worked with it. She encourages the students to continue studying soil erosion and the effect of sedimentation on the Roanoke River. She suggests this type of environmental study be done by several schools throughout the valley and shared because "we are a very unique ecosystem within our own." Dr. Cairns is also sitting at the same table. He speaks next.

Dr. Cairns says he has three points to make. First, it is important for the students to realize that the information they have gathered here can be used immediately. Mara will use this data in her recommendations to the closing contractor. His second point is in reference to Ginny's "cutting edge" comment. He states that there is a price to be paid when on the cutting edge. The price is that there are not opportunities at this time for *group* science investigations to be presented to scientific bodies. Dr. Cairns explains that what the students at RVGS have done "will probably influence the development of the state academy because they have to make a place for groups like this to present their work...as a group, not as individuals." He cautions that they will have to be patient, though, because it may still take years for it to happen, but a beginning was here.

Dr. Cairn's third point speaks to the students' self-confidence. He asks, "How many of you were apprehensive when you started that the whole thing would fold and you'd all be disgraced?" The class erupts in laughter. He continues, I always have, every time I start something. [I tell myself] this is going to be a terrible mess, and I'll have to hide somewhere. How many of you now feel some confidence that you can start out on an unknown question and get something useful? **All** of you should feel that. If you don't, you're **wrong**! Because you did something good! The next time it should be a little easier. So I'm going to congratulate you. For people like me, one of the biggest joys is seeing groups like this start out on something and get good results.

The chairman of the Roanoke Valley Resource Authority is called on next to speak. He tells the students that bids from contractors for closure will be taken next Tuesday. He acknowledges that there is a conventional revegetation program and the alternate revegetation plan that Mara has been working on. The chairman adds, "Speaking for the Resource Authority, we appreciate much the work you have done, and the work that Mara has done helping to turn the resource that we have at the old landfill and to make it aesthetically pleasing and not detrimental to the environment in the years to come."

The director of general services of Roanoke County and the past chairman of the RVRA speaks next. He explains that municipalities are required to follow many closure procedures which are mandated. He states that we are often required to do certain things and without continued research, "issues like the capping on top may never be addressed and you may continue to do whatever you are doing." He challenges the students by saying that we need to encourage research because it has a tremendous affect on the best way to keep our environment clean.

The member of the Roanoke County Board of Supervisors speaks, "I'm impressed with the work you have done." He also encourages the students to continue their investigations when they return next year. "If there is a way for you to continue to be involved in this particular activity that you try to incorporate it into your academic program." The supervisor also advises the students to use the tools they've learned in this process to investigate an unknown and generalize that use to other endeavors they may encounter in their future education. He also strongly urges the students to share this knowledge with others. He says, "You might take some of this information back to present to fellow students. Some of the activities you have been involved with this year could kind of be a ripple effect. Let others be aware and informed about what is going on."

The engineer from Explore Park begins by telling the students that he read their final reports last night, and "I was impressed with the amount of work that went into each of those." He talks about the far-reaching impact of landfills on every jurisdiction in the United States. He urges longer studies of the types the students have done. He refers to the comment by the director of general services. The engineer states,

> People are doing that [double liners and topsoil on a capping layer] because it appears that would be obviously better, when in fact it might not be better if they had test results to go by. But they don't. They **don't**! So they are doing what appears to be better, but may not be better. So the tests results of this type and continuing studies of this type would be great.

The engineer closes by saying that Explore Park would like to have the cooperation of Virginia Tech, the Governor's School, and others in the region to help in the monitoring and studying of the landfill for a long time to come.

Dr. Glasson from Virginia Tech is the last guest to speak. He tells the students that he has been reading about them through the stories I have written. Dr. Glasson says, "I'm hoping that what Bea is writing about as far as your work here, and what you're doing here will have implications for other science teachers across the nation." He explains that this type of study is the type of reform that is being called for in science education: one that relates science and technology to society. Dr. Glasson concludes by stressing that the open-ended type of investigations the students have done is what we are recommending in schools and we would like to see more of this type of investigations in education. "I think you have done a wonderful job," he says.

<u>Student Reflections</u>

Divya and Kusum stand to give reflections on what they have learned in this study. Kusum begins, "Divya and I just want to talk about the impressions we students had about this project." She talks about the webbing activity they did at the beginning of the study as compared with the one they did at the end of the study. "If you compared the two webbing activities, you can see how much we learned at the middle of December as compared to how much we knew at the beginning. I felt that a lot of us didn't know a lot about landfills at the beginning."

Kusum also talks about the articles they read and the importance of the research they did. "I think a lot of people put a lot of time into the paper and learned a lot about landfills and everything," she says. Kusum lists the speakers they had: Ginny Laubinger, Mara Sabre, Dr. Cairns, and me. She also states that she thinks they learned a lot from working in cooperative groups. She says, "We took in our own ideas about what we felt about the landfill, but we also got to interact with our classmates and take in their ideas and get a broader knowledge about landfills."

Divya finishes by sharing her own personal reflections. She tells what her feelings were about the project when it first started. Her feelings at the beginning of the project were not the same feelings when she finished. She says,

> The thing that I was amazed about was the complexity of this project. When we first started out we thought, 'This is going to be like any other lab. We'd come up with an idea and work with a couple of grasses on different soils.' But then when

> we started getting into it, there were so many different things we had to consider: germination, height, root depth, biomass. A lot of things came into play.

This finishes the presentations by the students and the sharing by the guests. The principal of RVGS has been sitting quietly at the back of the room, watching and taking notes. John asks him if he would like to say anything to the group.

<u>Additional Opportunities for Presentations</u>

The principal asks the visitors for assistance with one of his concerns. He wants to know how students can educate the public about the issues they have been studying. The principal states,

> Often times in the past nine years the visibility of our students is not what we would have it be for their best interest. This project appears to be one in which students might have an opportunity to present some of their findings on this project to professional, civic groups, municipal bodies, boards of supervisors, city councils, etc. Do you have any specific recommendations or possibilities for student groups presenting this kind of data to those groups?

The supervisor speaks up. He acknowledges a conversation he and I had earlier. I told him that the principal had tried to get TV news coverage of today's meeting and was told "it was not news worthy." The supervisor says, "I observed to her that if one of you [students] had a gun out in the middle of the hall, they all would have been over you on the 6 o'clock news, even maybe a live broadcast from the Governor's School." The group laughs, but they know he is probably right. He continues, "That is unfortunate, but that is kind of the mindset." The supervisor goes on to say that the county board of supervisors are receptive to having students speak to them with "succinct presentations." He also tells that a new media available throughout the Roanoke City, Roanoke County, Vinton, and part of Salem is the government educational access channel, channel 3. The supervisor tells the principal who he should contact and explains that the students' video presentation would be aired not once, "but many times during a week or over a month, or over a two- or three-month period."

Dr. Cairns offers the suggestion to present before the Sierra Club or Garden Clubs. He warns them, however, to be aware of people who say, "What a wonderful job you did" or people who say, "How could you go so far wrong?" He explains that people who question you may actually do you more good than those who applaud you because they help you see holes in your work. Dr. Cairns believes that "communicating with other people is another part of your educational experience." He encourages them, "No matter how small it is, you should start [doing presentations] and keep it up." Dr. Cairns also suggests contacting the National Wildlife Federation to write for one of their publications. He even suggests students look at going on national networks. He says they might gain more interest from Dan Rather or the Today Show than they will locally.

The engineer from Explore says that the Regional Landfill Authority Board, the Roanoke County Board of Supervisors and the City of Roanoke Council have work session that are separate from their regular public meeting. At these, he states, the atmosphere is a little freer to make presentations. The engineer also reminds the students that when the people, who are citizens just like them, began on the boards, they did not know any more than the students did when they began. He says, "They think of the landfill just as you did when you first started." The engineer believes that the people on those boards would be interested in hearing from the student "so that they can, in the process, gain some knowledge of what the **real** issues are." He also says that the work they have done might be helpful in the new landfill that hasn't even opened yet.

With the engineer's last statement, we are finished with the presentations and sharings. We have covered many topics and issues this morning. John stands before the group and brings things to a close by saying, “Bea, Mara and I thank the students and our guests today.” With that, the project is complete....at least for this year, unless John and the students decide to continue next year.

CHAPTER 4

ANALYSIS

This chapter describes why this study was done and the importance of the students participating in all four STS instructional goals. Each goal is examined, along with the activities that accompanied it. The students' voices are heard as they tell the benefits or disadvantages they perceived from each goal. This chapter also explores the answers students gave in the final questionnaire. Topics of collaboration and language are investigated. Students tell how collaboration and language fit into their frame of learning. Finally, this chapter analyzes and compares the pre- and post-webbing activities. Primary and secondary concepts are discussed and compared. Students discusses their understandings of these activities.

Purpose of the Study

Waks (1989) states that the purpose of STS education is to foster scientific and technological literacy to empower citizens so that they can participate in the democratic process of resolving the "technologically dominated problems of our late industrial society" (p. 201). These problems can be on a local or global level. Global issues may include health and medicine, world hunger, environmental quality or world population. Local issues are at a more personal level and may include land use, environmental impact, energy issues, personal health, or technology in the workplace.

This study was done so students could experience the process of dealing with a local issue, investigating it, and drawing conclusions. It was also done to assist Explore Park who had asked for community input concerning revegetation of the newly closed Roanoke Regional Landfill. By involving students in the four STS instruction goals (Ramsey, 1989), we hoped they would continue to be involved citizens in solving environmental issues. These instructional goals were adapted from Ramsey (1989) and Rubba and Wiesenmayer (1988). They are:

(1) STS foundation activities and issue awareness activities

(2) STS issues investigation skill instruction

(3) STS issue action skill development activities

(4) Opportunities to apply STS investigation skills and action strategies.

I will discuss the four STS instructional goals and the activities that were done in conjunction with each one. The students will tell their stories through journal entries, reflection papers, and interviews as to how they perceived the process of this STS study. I will show how these students as they proceeded through each goal became more actively involved and environmentally literate about the issues that surrounded the opening, maintenance, and closing of the landfill in the Roanoke Valley.

STS Instructional Goals

Goal I: The Foundations Level

This goal provided students with the knowledge needed to understand and investigate the issues surrounding the revegetation of the landfill. Ramsey (1989) explained that this goal encompasses basic content knowledge about the issue and the larger picture of science and its interrelationship with technology and society. The students were provided a foundation by reading a variety of articles and participating in activities.

A plethora of data about recycling and trash helped to introduce the project. The students did a concept webbing map so it could be seen what information was brought to the study. Yager (1990) states that STS means dealing with students in their own environment and with their own frame of reference. The webbing activity showed us what their frame of reference was. Ginny Laubinger, Environmental Education Programs

Director from Explore Park, talked about recycling and the general problems of solid waste management. We also took a field trip to the landfills and visited Explore. These activities were done at the beginning of the study to give students a foundation upon which they could build. How did the students view these activities? Did they perceive them to be beneficial to their learning?

Students were asked to react to specific activities either through journaling or by writing a short response immediately upon completion of the activity (see Appendix D). I felt students were open and honest in their writings. They told whether or not they liked an activity and how it might be improved. I will share some of the students' perceptions.

Webbing map. Students did a concept map in which they webbed their existing knowledge. They wrote and spoke positively about this activity. No student had previously participated in a webbing activity. Students were surprised at the amount of information each group had in their web. Judy explained that the activity helped her to think about things she had not thought about before. Syann and Ruth recognized that they learned a lot from the others in their group. Peers served as resources to one another in their cognitive development (Wilkinson & Calculator, 1982). Ruth wrote, "Everyone contributed some piece of knowledge that another might not have." The webbing activity was also a means for students to assess what they knew and to draw upon the knowledge of their peers. Doris explained that by looking at the chart she could definitely tell what she knew. David, Syann, and Corrine wrote that they knew more than they thought they knew. After students completed and shared their concept map, they were shown slides and given statistics about solid waste management.

Introduction data. Several students expressed surprise at the numbers concerning garbage disposal. Kavita said that she was overwhelmed by the amount of trash thrown away. "We have no frame of reference with this number. The fact that we don't understand it should scare us the most," she wrote. Lave and Wenger (1991) state that generalizing knowledge lies in the ability to mediate the meaning of the past and the future when constructing meaning of the present. Kavita said that she cannot construct the meaning of the figures because she has no prior knowledge upon which to base it. This number being so large, she stated, should scare most people because they can't relate to it.

Karen also tried to construct meaning of the figures on garbage disposal. She compared the amount of garbage Americans produce to taxes. She said, "These numbers are like the national deficit compared to tax revenue! In both situations, things are getting out of hand." Karla also wondered how long this waste could continue before the earth would no longer be able to support life. Mark explained that with all the publicity he has seen about recycling, he thought there would be more than 10% of our trash recycled. Each student was trying to compare these figures to something they already understood. Students used their previous knowledge and built upon it. As they saw or hear something new, students tried to figure out how it "fit" or replaced what they already knew (Driver & Leach, 1993; Lave & Wenger, 1991).

Field trip. Students last year spoke so positively about their experience on the landfill field trip that the trip was scheduled this year during the first week of the study. Students were impressed and felt that seeing the landfill was an important aspect of their understanding. In her journal, Karla wrote that she thought it was necessary to see the process "up close" in order to understand it. Ruth stated that the field trip allowed her to comprehend the facts and numbers by seeing the trash and the amount of recyclables that were being landfilled. Driver and Leach (1993) state that constructivists see learners as building their knowledge through "physical experiences" (p. 103). It is these physical experiences students say were important to their understanding of the landfilling process and trash facts. Prakash, Kusum and Mark wrote that they were concerned about the recyclables they saw at the landfill. Prakash saw many cardboard boxes that should not have gone into the landfill. Kusum suggested having volunteers pull the recyclables out before they are landfilled. Jason shared that the field trip, as a hands-on experience, taught him the most during this week of introduction. Students related what they saw at the landfill with the statistics they had heard in the classroom.

For some students, the landfill was not what they had expected. Bill was one of those students. He wrote that he did not smell anything and did not see any "obvious environmental abuse." Bill relayed to me later that his only other experience at a landfill was one he visited in which everything was being burned. "It was like going through the gates of Hell," he said. However, Bill did not think the Roanoke Regional Landfill was as bad as he had expected based on his prior experience. Two boys from Patrick Henry High School (PHS) originally thought a dump was just a "big hole in the ground," but after this trip they understood there was much more to it. After visiting the "old" and the "new" landfills, Dan wrote, "I now realize how much thought goes into the design."

Students not only wanted to see the landfill, they also wanted to "experience" it and be active participants. Driver and Leach (1993) state that physical experiences with one's world is a way to construct one's knowledge about the world. The stop at the "old" landfill did not afford a physical experience as students were not allowed off the bus due to safety concerns. Several students commented that they needed to become more involved on the trip than just see things from a bus window. Kavita stated that she felt she spent a lot of time on the bus. "I was dissapointed [sic] that we were not allowed off the bus for all of the sites." Jason wrote "In some ways, seeing pictures would have been just as informative." Syann expressed a desire to see the bailing process which was in operation when we were there. Unfortunately, the students could not see into the building from the bus, and the bus was not allowed to drive into the building. The field trip helped the students understand the positions of the people from the landfills.

However, it was important for students to understand the position of the other main player or "stakeholder" in this issue. Students had visited and talked with people from the landfill, they also needed to get a perspective from Explore Park.

Landfill effects on Explore. Ginny Laubinger, from Explore, spoke to the students the day after we went to the landfill. She gave facts about garbage, reducing, reusing, and recycling. She also talked about the effects of the landfill on Explore Park. Ginny told of the hundreds of tires at Explore that were in the ravines between the landfill and the river. She described the wind blown trash that had lodged in the trees. She also talked about the problems of siltation. Water running off the landfill had carried soil and deposited it around the trees. These trees, she explained, would eventually die because of oxygen depravation. Ginny finished her talk by telling the students what they would do on their field trip next week to Explore.

On the following Tuesday, John, the students and I spent the day at Explore Park. The main purpose of the trip was to meet with representatives of the Society of Foresters who talked about Virginia's forest and the environmental impact trees have had on the Roanoke Valley. John asked the students upon their return to school to reflect on the positive and negative aspects of the field trips to the landfills and to Explore Park. The students turned in a sheet on which they listed the "pros" and "cons."

Several students found that the trip to Explore had raised questions for them. In his reaction paper Bill explained that he was anxious to see "what all the fuss was about Explore." He knew the park had originally been envisioned as an amusement park and therefore was surprised to see the nature trails. Corrine had also thought the park would be more "touristy." The students spoke favorably about the information and activities they did with the foresters. Most found the facts given by the foresters very interesting. Karen wrote that she was surprised that the forester talked about recycling, but gave no figures for the numbers of trees cut yearly for newspapers. Judy said that she found it strange for people to put a monetary value on trees as she had always looked at them for their beauty. Mark remembered a summer enrichment program he took from the University of Virginia in which he had enjoyed studying forestry. Because of this program, he was familiar with some of the activities the foresters had them do.

Doris, Mark, and Bob also wrote positive statements about their trip to Explore. Each one related their experience at Explore to prior knowledge. Doris said that she had been reading in the newspaper about the happenings at Explore. She had some understanding of Explore's purpose. Bob talked of having already known about "many of the simple farming methods, cooking ways, and sewing methods that were shared...." However, not everyone had background information on Explore and saw the trip as positive.

Many students did not understand the objective for going to Explore. The information was not logical to them in the framework of the landfill, and they could not make ties between Explore's settlement, the forester's hike, and revegetation of the landfill. Driver & Leach, (1993) state that learning is not based on "the correspondence with an external authority," but on the construction of "schemes" that are logical and make sense to the learner (p. 104). It made no difference that the external authority, the teacher, had told students the connections, the students could not internalize those connections at that time in the project. Karla wrote, "The tour of the house seemed out of place and didn't really serve any purpose." Karol said that she thought the tour of the cottage was "stupid." She did not care what people did "way back then," but was only concerned about the fate of the world today. Karen, Prakash, and Ruth commented that they thought the purpose for going to Explore was to see the effects of the landfill. Ruth wrote, "I wondered why we didn't see the things at Explore that Ginny had talked about on Friday." Ginny, who knew where the effects of the landfill could be seen had greeted us when we arrived at Explore, but could not stay because of other obligations. Karen also mentioned that she was "hoping to tramp around" to see the effects of the landfill at Explore.

After reading the negative reflections about the trip to Explore and the walk to the Hofauger house and Wrey barn, I replayed the tape of Ginny's presentation from Friday. On the tape, Ginny finished her talk and asked the students if they had any questions. When no one said anything, John asked Ginny to tell the students what they would be doing when they visited Explore. Ginny told them each activity they would do with the foresters: (1) walking the trail and looking at a forest ecosystem, (2) talking about the role of forestry, (3) determining the height and diameter of trees, and (4) boring to determine the age of a tree. Ginny then said,

> Time permitting...we're going to go down into the park. I would like to share with you very quickly what we're trying to do in the park. I need to do a selling job because originally the park was thought up as a way to draw visitors from I-81 and the Blue Ridge Parkway...it has become more and more apparent that we don't need a Busch Gardens in Roanoke. What we do need is a place to trace the environmental component and man's effect on that environment.

Ginny continued to tell about the Hofauger house and the Wrey barn. She said that they were also constructing another barn that was built in 1828 in Salem, and an 1861 school house from Franklin County. Ginny told the students *exactly* what they would be doing at Explore. Because this field trip was set up between John and Ginny, I had not been involved in the planning. I think Ginny and John's focus was the information the students would get from the foresters.

Students who had prior knowledge about Explore Park had more positive learning experiences. They were able to link prior knowledge to new knowledge. Even though the students had been given the "objective" of the trip, those who had little or no prior knowledge about Explore had difficulty in making connections. For them, what they saw was not what they expected to see. Yager (1991b) helps to explain what happened when he states that learning does not depend on the teacher, but rather on the interaction of information, how it is processed, and existing knowledge of the learner. Bill identified the problem best when he wrote, "We didn't tie the landfill problem in with the Explore Park design." The field trip to both landfills and Explore Park gave students the foundation they needed before they could proceed to the next goal, that of understanding the specific issues of this study.

Goal II: The Issues Awareness Level

This goal encompassed students understanding their need to become involved in the issue investigation, evaluation, and resolution. This goal also sought to provide students with the specific knowledge they needed to understand the issues surrounding landfills. Ramsey (1989) explains that learners should understand the beliefs and values held by the members of society who have an effect on the "origin and resolution of issues."

To facilitate this goal, the students participated in several awareness activities. One activity was an "Issues and Values" lesson (see Appendix C). In this lesson, students learned to identify the issues and values from articles in the local newspaper written about the environment. They identified players, positions, and offered solutions. In a second activity, students heard a talk by Dr. John Cairns on "Issues Beyond Landfills." The class was exposed to environmental problems on a global level, especially ones dealing with China (see Appendix D). In their third activity, students participated in a simulated letter writing activity to the Director of the Roanoke Valley Resource Authority (RVRA) in which they shared thoughts and concerns. Students exchanged letters and addressed their peer's concerns (see Appendix D). These three activities were instrumental in building knowledge about landfill issues.

Issues and values activity. Students were introduced to issues through a series of newspaper articles that had been written in the local paper (see Appendix C). These articles told of communities in the area trying to cope with the new EPA regulations for closing current landfills and opening new ones. The articles discussed ways in which these localities were trying to find alternative methods of solid waste disposal. Article titles were: "Garbage in, compost out: Salem studies green option" (Poole, 1993), "Is out-of-state trash big bucks or big problems?" (Coccaro, 1993), "Giles [County] to pay dearly to send trash out of county" (Kittredge, 1993), "Halt to landfill work requested" (Turner, 1993), and "Trashing a neighborhood?" (Poole, 1993).

The purpose of this activity was to expose the students to a series of steps they could use to dissect and evaluate an issue. Ramsey and Hungerford (1989) cite as one goal of STS education the continued use of investigation and resolution strategies by students throughout their lives. By learning this skill, it is hoped that students will continue to dissect and evaluate issues as adults and become actively involved in the resolution process. Yager (1991a) postulates that the ability to successfully use investigative and resolutive strategies empowers the student to make changes.

In the *Issues and Values* activity the students read newspaper articles and worked collaboratively. In their group they were to decide:

(1) what is the issue

(2) who are the players

(3) what are the players' values and beliefs

(4) what are possible solutions

The students shared their findings with the rest of the class. Each table had different articles so that students were exposed to more topics than those they read. How did the students feel about the issues and values activity? Did they learn from it? Their journals gave insight to these questions.

Students felt the issues and values activity was a learning experience. Corrine said, "This made me more aware that most issues have *real* people and *real* problems involved." Bob said that by looking through the articles, he realized how many places are dealing with the closing of landfills. He wrote, "Before this unit, I never realized how serious our waste problem is in the world." Judy referred to the article her table read where an affluent neighborhood in Salem was trying to keep a landfill out of their area. She stated that the rich neighborhoods made it a "bigger affair" than poorer neighborhoods would have when trying to keep a landfill from being built near them. Judy continued to say that the issues we've talked about in class "are issues most people never think about until it is too late." She was glad we brought them up. Ruth commented that hearing another table's presentation made her aware of the mud and sediment that was washing into people's homes at the new landfill. Karla found herself identifying with the people about whom she read. She wrote, "To know what drives someone's opinions is kind of like stepping into their shoes." Students who recognize the need to "step into another's shoes" possess an important characteristic in issues resolution. This understanding by players facilitates the finding of solutions to issues. It is hoped that by raising students' awareness, the next step will be their wanting to become involved.

<u>Need to become involved</u>. STS problems need to be issues that are relevant to the students (Roth, 1993; Yager, 1991a). The topic of landfills and landfill restoration should have been relevant to these students' lives. However, not having been exposed to the topic, students were not aware of its relevancy. We tried to show this relevancy when implementing Goal I. Not all students identified with the issue and took ownership (Ramsey, 1989). Matt states in the interview the only future benefit he saw to learning about landfills was if he were to appear on *Jeopardy*. Jon said that he was never convinced there was a problem.

Throughout Goals I and II, students reflected in their journals or exit slips the need to become involved. Karen was willing to become involved and take part ownership of the problem, but she resented being made to feel it was *all* her fault. On her trip to the landfill she wrote, "They [the tour guide and Catherine from RVRA] pointed out things that could have been recycled (almost as if we, personally, had done it all) and then calmly say 'we don't do that' when asked about sorting out the recyclables." Karen questioned who owned the problem of recyclables being landfilled, the citizens or the landfill operators. Ruth wrote about the need to become involved. She stated, "Each individual needs to be informed and touched by the fact of our destruction to the point of change." It is difficult to determine whether she is including herself, but one can assume she is.

Exit slips from students at PHS told of how the trip to the landfill made them aware of the need to be involved. Rachael wrote, "After seeing how much land is used in landfills I will take recycling much more seriously." Katherine explained how the trip "dramatically changed my views about trash." She said that she recycled paper, plastic, and drink cans. However, she never gave thought to where the other trash went. She now realizes that everything she puts into the waste can fill up the landfill. Students have begun to realize the need to become involved at the local level, but it is also important they also become involved at a larger level.

Issues beyond landfills. In addition to the articles about local issues, students were also exposed to values and issues on a global level. Dr. Cairns, Director of the University Center for Environmental and Hazardous Materials Studies at Virginia Tech spoke to the students of the issue with China in which China wishes to double its energy consumption per capita by the year 2000. [When China does this, they will only be using 7 1/2% of the energy per capita America uses!] The concern is that China's population is so large that a per capita increase would be disaster. This increase, Dr. Cairns asserted, will contribute to global warming; and, if the predictive models are correct, the environmental results will be bad for everyone in the Northern Hemisphere. This situation is a global STS issue. The link is a science $\leftrightarrow$ society interaction in which society, by increasing its energy consumption will have an impact on science (i.e. that of the atmosphere). It might also be a technology $\leftrightarrow$ science link as increased technology allows energy consumption to be increased. Additional energy consumption also has an impact on science through global warming in the atmosphere (Ramsey, 1989). Dr. Cairns points out that America is using more than it's fair share of energy and poses the question to the students, "How can we solve this?"

Students discussed this issue with Dr. Cairns in the classroom, and then wrote reflective papers (see Appendix D). Students gave much thought to this problem and it's possible solution. For most students, this was a new problem. David expressed that this was the first time he had ever heard the things Dr. Cairns spoke about. Judy took the talk personally. She wrote, "I felt guilty after hearing about China's problem." Karla said that Dr. Cairn's lecture "was another reminder to me of how very important it is to respect the fragile ecosystems that support mankind." The students had a strong sense of what was "right" and "wrong" with the player's positions.

Many of the students had negative feelings toward Americans on how to distribute energy globally. Kavita wrote, "Americans are rather spoiled." She believed that most people in America were not willing to cut back on any of the variables. Prakash exclaimed that Americans are "addicted" to wealthy and luxury. She stated that we can't live with *basic* needs because our technology won't allow us. Ethel agreed with Prakash that Americans need to cut energy consumption, but will not be able to because of their "wasteful lifestyle." What do they recommend we do about the energy inequality given their perception that Americans are "spoiled?"

Students strongly expressed their opinions onwhether America should tell China to cut back on their energy consumption. Karen stated that we should cut back on our own consumption before we tell others to cut theirs. Jason wrote that "nothing can be done until the U. S. makes some sacrifices, and then we may have a case." Prakash saw America as a "prominent, technologically advanced nation" and as such, she said that we should set the standard for other countries to follow. Jon, whose previous journal entries and reflection papers had consisted of two or three sentences, unleashed a barrage of statements that filled four pages. In his paper, Jon talked about the need for the government to do as little regulating as possible. In referring to Dr. Cairn's suggestion of possible energy allotment by the government, Jon said it bordered on "socialism." The only reason Jon saw for the government to intervene was when human life is in danger, "which in this case, I don't think it is." He felt environmental awareness was healthy, but an "apocalytic [sic] view" of the world was not healthy nor accurate. Jon did not feel that America needed to tell China to not increase their energy consumption. He thought humans have always made their environment "more comfortable or less comfortable, but there will always be humans and no action on our part can change that." Jon, along with his peers was becoming an active participant in this study. Another way for students to participate and have an understanding of players' values is to have to put themselves in the other person's place. This was done through a simulated letter writing activity.

Simulated letter to the landfill director. Students wrote letters to the director of the Roanoke Valley Resource Authority Board (RVRA) and then traded letters. They answered their peer's questions and concerns (see Appendix D). Ruth understood the purpose of this lesson. She wrote in her journal, "It helped us see what our peers were concerned about and what they didn't understand. It also made us think about their questions and search for answers from what we learned." When I read the letters, I was impressed with the depth of understanding and appreciation the students had for solid waste management issues. In many ways, it was a mini-assessment of their foundational knowledge of the issues. Students had to have certain information to ask questions and be able to answer the inquiries of their peers.

Many students praised the RVRA for their attention to environmental concerns at the new landfill. They wrote of the benefits of the new liner and collection of gas and leachate. Syann thought that the new geotextile liner dealt more effectively with leachate, and wrote, "The newer site is definitely safer for the surrounding environment." Several students praised the technology to be used at the new landfill and said they were confident that environmental needs would be taken into consideration during development.

The same feelings of environmental safety and concern, however, were not felt for the old landfill. Many students were concerned over the lack of recycling done at the old landfill. Suggestions of having paid personnel or volunteers to sort out the recyclables was given by several students. Mark wrote, "If people aren't going to do it at home, nothing should stop the haulers from seperating [sic] the trash." Kavita questioned the ability to restore a landfill. She did not agree with the restoration plans and thought it should not be revegetated. She said that the plans for the highway spur and the planting of vegetation are too "idealistic." She wrote,

> Do they really believe that they can bury tons of trash, dump some dirt, grow some vegetation and all will be well and back to normal? If it is out of sight, can it truly be out of mind? I seriously question the extent of man's ability to control mother nature.

Kavita thought the planning for the new landfill was good, but artificial. Even with the pleasant entrance at the new landfill Kavita said, "No one can make garbage attractive." Mark answered Kavita's letter and diplomatically addressed the above concern. He responded, "As director of the Roanoke Resource Authority, let me assure you that we are doing everything in our power to appease the concerns of the citizens involved with the landfill." This probably was not the answer Kavita was looking for, but it did acknowledge that Mark recognized her concern and knew that the RVRA had made efforts to involve citizens in as many of the decisions regarding the landfill as was possible. Once students had a foundation for the issues, they were ready to investigate species choices.

Goal III: The Investigation and Evaluation Level

This goal exposed the students to concepts and skills necessary to investigate and analyze the issues and to evaluate alternative solutions. Ramsey (1989) explains that this goal seeks to involve the student in doing investigations, collecting data, interpreting the data, and communicating with others about the process. One way students were exposed to this goal was through Mara's presentation in which she gave them background information about plants and landfills, and then designed their own plant experiments. In this goal, students became active participants in the study. Using hands-on techniques and foundational information, they investigated, evaluated, and constructed meaning for themselves.

Mara's presentation. To help the students investigate plant choices knowledgeably, Mara gave a presentation in which she talked about the environmental problems encountered when growing plants on the landfill. Based on the background information she gave, students took seed catalogues and chose which species they wanted to use. They designed and set up their experiments. Data collection in which they counted and measured their plants began October 29 and finished on February 7. [John watered the plants, but no data was collected during the winter holiday and the month of January when students were taking mini-courses.] Students reflected on this process in their journals, in the questionnaire, and in the interviews.

In her presentation, Mara helped students to understand the conflicts and frustrations in choosing species for revegetating the landfill. Students seemed to identify with her [she is closer to their age than John or I], and empathized with her work on the landfill. Karla wrote, "I understand her frustration. I have experienced the same sort of problems in my research." Kavita commented that she hoped her table's experiment would help add to Mara's knowledge of grass growth on landfill soil and in her research on soil compaction. David and Ruth expressed surprise at the difficulty of deciding on a revegetation species for the landfill. David wrote, "I never realized all the things that had to be done just to grow plants on a landfill." Bob wrote in his journal that he was surprised that the plants in Mara's project have never been tested before for their effectiveness. This entry was written early in the study and Bob had not yet realized that *his* contribution will be that test.

During her presentation, Mara had each table draw a design for restoring a landfill. Some made parks, another put a greenhouse on it, one group built a cemetery, and one table built an amusement park. Ruth wrote, "This activity emphasised [sic] how much planning needs to go into a landfill cover project no matter how simple the project may seem." After each group shared their picture, John asked them to list the pros and cons of their landfill design. Many groups had to rethink their decisions. According to Snider (1989), John has brought the students into a disequilibrium concerning their landfill design. He has challenged the students' thoughts, and they are having to reorganize their thinking in order to solve the problem. Ruth continued to reflect on the process, "That [the rethinking of the design] showed that there are going to [be] problems with regulations and decisions with any ideas right off. And problems are going to arise throughout a project of that sort." Ault (1989) states that people who are successful problem solvers "seem to tolerate ambiguity" (p. 46). Ruth has realized that there are multiple pathways around obsticles, and that there are not always easy answers to scientific questions.

However, not all students agreed with the results of the design activity. Kavita questioned some of the table's designs. She thought they were "a little unrealistic and too idealistic." This is an interesting observation on Kavita's part as she helped to design a graveyard for the homeless on top of her table's landfill. After students had designed a restoration plan for a landfill, they had to find out what type of vegetation they could plant on it.

Designing plant experiments. Mara gave the students basic information about plants and landfill conditions so they would be able to make species choices. However, students had difficulty understanding what Mara meant about plant rooting depths. Mara had talked about a plant's ability to control erosion on a landfill being very important. She also talked about the regulations regarding rooting depths. Bill stated that he felt obstacles concerning plants and state regulations made Mara's project insurmountable. He acknowledged that he had been confused up to this point and wanted to know if the plants with two foot roots that Mara spoke about were the exception. Jason and Syann also questioned the rooting depth of plants. Mara had explained that species with roots over 6" were not allowed on the landfill for fear of penetrating the final capping layer. Jason wrote, "I don't really see how you could have roots only 6" deep and prevent erosion effectively." Syann acknowledged that the 6" rule made it impossible to plant trees. The rooting depth issue was an important understanding students needed to grasp in order to make plant selections for the landfill.

As Mara, John, and I talked with the students about their experimental designs, we noticed increased enthusiasm about the project. This excitement came from the fact that the design was truly their own. With the excitement also came frustration because as with any new design, there were not always answers to their questions. Once students realized it was okay to *not* have all the answers, they began searching for answers themselves. Ost & Yager (1993) state that many biology courses teach a "limiting form of ideology" by emphasizing a sole correct answer (p.284). However, Ost and Yager also postulate if science as a "habit of the mind" is to be fostered, there must be a reduction of authority and students must feel the freedom to question. Students in this study began to feel that freedom as the project progressed. Prakash and Kusum talked in the interview about having to work things out for themselves. Prakash said, "Well, we just thought that you'd [Bea] be here and you'd just tell us to do this, this, and this. You would kind of lay it out for us or something, but you've let us come up with our own experiments." Kusum added that they had been taught to think on their own because they had to come up with their own experiments. She continued to tell how they had to think about what they had to do. Kusum says that they couldn't say, "Well, they [Mara and Bea] said, 'This is how its going to be,' so it must be right." Prakash finished by saying, "Right! We learned from our mistakes!"

Syann also talked about the importance of designing their own experiment. She said in the interview that the freedom to do what they wanted to do was very important. Syann saw students constructing their own labs as better than being handed a worksheet. She commented that usually they are told, "This is your lab. These are the direction. Do this, and copy the procedure into your lab book." Syann acknowledged that "stuff like that is really boring."

Reaching the point where they were ready to set up the experiments was exciting to many students. Several wrote about setting up their experiments in their journals. Karol explained that she liked the "hands-on" approach to science because she becomes bored doing desk work. She wrote, "In fact, I feel that I learn more when I am actively involved with a project in this manner!" Corrine recalled the excitement of setting up the experiment and then wrote her hypothesis as to which species she thought would be best on the landfill. To her, learning was not dependent upon proving her hypothesis. She wrote, "I could be wrong in my educated guesses, but that is okay -- I will learn more if I am wrong!" Wilkinson and Calculator (1982) wrote, "The opportunity to learn is the opportunity to make mistakes" (p. 161). I was pleased that Corrine felt that the atmosphere was such in the room that she felt it was okay to make mistakes. Bob explained that he thought it was good for him to do this experiment because prior to this, he did not even realize that compacted soil affected landfills. Mark and Prakash said that they can't wait to see the results. These students have been working in what Vygotsky (1978) calls the "zone of proximal development" (ZPD). Vygotsky argues that a beginner's edge of development is somewhere between what s/he can do independently and what s/he can do in a group of more capable peers. These students have been learning with our assistance and the assistance of their peers how to work with plants in landfill soil. Given the opportunity to do a research problem next year, students who chose to work again with landfill soil will need less assistance and will be able to extend the complexity of their experiments.

Setting up the experiments was exciting. However, to some, excitement came because of the purpose of the project. Students began to understand the importance of what they were doing. Prakash said that she felt "pretty important" because she was helping to provide information on what types of plants would grow well on the landfill. Everyone, students and adults alike, felt that designing the experiments and working with the plants was building toward the most exciting part of the study: that of sharing their findings.

Goal IV: The Citizenship Responsibility Level

Ramsey (1989) describes this level as one that tries to provide learners with the necessary skills to come to a resolution of STS issues. He explains that it is not necessary that the learners take action on issues, but they should be afforded the opportunity if they so desire. Researchers find this goal in STS instruction critical if there are to be socially responsible citizens (Ramsey, Hungerford, and Tomera, 1981). The main activity of this goal was the students presenting their projects, conclusions, and recommendations before a group of environmentally aware citizens who were stakeholders in the landfill revegetation issue. Students did considerable planning for the meeting. They had overheads and handouts of their projects. The students conducted a major portion of the two-hour meeting in which they shared a synopsis of the study and explained their experimental designs. How did students feel about themselves and what they had accomplished? Students reflected on the final activities in their journals.

Project sharing and recommendations. Students had positive feelings towards the time spent with the seven guests who listened and shared ideas. Several students wrote that they were surprised at the level of importance of the people there. Karen wrote, "I was not aware that all of the local/area 'experts' were participating in the final aspects with the class...." Prakash reflected the same feeling, "We did not know that so many important people were attending this event." David said, "It was really neat to have many different people here that play entirely different distinct roles relating to landfills."

The importance of the people attending this meeting helped the students realize that others considered their work important. They felt a certain sense of empowerment because people they considered important took the time to talk to them and give feedback on their work. Students' self esteem was enhanced through this activity. Ruth felt that the visitors' presence validated her work. She wrote, "Throughout this project, I had not been able to realize the full importance of it...I never realized *our* data was going to actually be useful. But now I am able to say, 'Why not?'" Prakash was surprised that the visitors took the students so seriously. She explained that she came to that conclusion "because of all the positive feedback we received on the experiments that were conducted." Prakash wrote that she perceived that the guests felt the students had valid information. "All of this talk really made me feel important. I felt that I had really contributed to a good cause," she wrote. Jason also thought the program was a "great experience." He saw it as the reward for all the work that had gone into the landfill experiments. Jason stated, "To have our work reviewed and praised by a wide range of officials was really exciting. To know that our experiments could help begin to confront problems with landfills was also very uplifting."

Students saw what they did in the classroom could have an impact in the community. Doris stated in her journal, "It was amazing to me to see how a group of high school students working for the good of a community can change for the better their environment." Karen wrote, "*Even* a high school project can make an effect on the world around it." Kavita said that it was nice to know that after five months of experimentation, their projects can make an impact in the community, and provide a foundation for other groups who might also wish to study landfills. Bob wrote that the guests' comments made him believe that the knowledge they had gained may help the Roanoke Valley. Even though Bob was not excited about the amount of knowledge he has gained about landfills, he recognized it was necessary if one was going to implement change. He said, "I also realized yesterday that I know more about landfills than I could possibly care to, but I guess that's part of accomplishing the task that was set before us -- making a difference." But, *did* the students make a difference?

Reactions to students' presentations. What did the guests think of the students' presentations? Unfortunately, the guests did not write in journals as did the students. Mara did, however, have the opportunity to see two of the guests at other environmental activities. She spoke separately with the current chairman and the past chairman of the Roanoke Valley Resource Authority. The chairman said to Mara that he was very aware of how hard the students had worked and felt that the results were appropriate at a larger level. He thought what the students did in the classroom in small containers could have a bearing on what could happen on a landfill. The chairman also commented that it was good for students to see that science can be frustrating and to realize that there are no easy answers. This realization he felt was apparent by the students who presented.

Mara also spoke with the past chairman of the RVRA. He, like the chairman, had positive comments about meeting with the students. The past chairman said that he was glad that students were able to bring something full circle. He stated that the students took a problem, researched it, experimented with it, and presented their findings. He also referred to the number of environmental civic leaders at the meeting and stated that it was important for people in the community to see that students could contribute something important at the community level. Mara said that both men were glad they had the opportunity to listen to the students' presentations. Students could only make recommendations, but the chairman and past chairman had voting rights on the Roanoke Valley Resource Authority Board. Did the students make an impact?

I asked Mara whether anything had been said at the last board meeting about the students' presentation. She had not been able to attend the May meeting because of school obligations. However, she said something happened at that meeting to make a change in the board's recommendation for reseeding. Originally, sixty-five acres had been designated to be reseeded. The proposal was for only a few acres in showy areas to be planted in wildflowers. The remaining acres would be reseeded with grasses. The decision has now been made to reseed the *entire* sixty-five acres in wildflowers. Even though actual seeding has not yet begun, it appears that the students' findings were taken seriously. When students realize they *can* make a difference in societal issues, they will be more apt to initiate social action under other circumstances.

Questionnaire

Students were given a questionnaire at the end of December (see Appendix F). They had completed the Foundations and Issues Awareness goals and were in the midst of Goal III, Investigation and Evaluation. This open-ended questionnaire was developed from themes that were constructed when listening to the audio tapes and from questions posed by John and Mara. Two reoccurring themes were noticed: (1) the dynamics of collaborative groups, and (2) the language of students in these groups. Collaboration was important to STS goals because it built on the constructivist theory (Yager, 1991b). Students constructed meaning through the language and social interaction with their peers (Driver & Leach, 1993). It seemed important to discuss these two aspects of the study. Even though they were not defined as an STS Instruction Goal, they permeated all phases of the study. I realized either theme could be a dissertation in itself. However, I will treat each one as an aspect of the study and not as the focus of it.

Collaborative groups

Students were asked whether they liked working in groups and how they thought it affected their learning. Fourteen of the twenty students stated that they liked working in collaborative groups. When asked why, Joel answered that it was more fun and not as stuffy as a regular classroom. The more common answer, however, had to do with the quality of learning produced. Kavita explained that one learned more when "putting their minds together." She also stated that collaborative groups helped to develop "creative thinking." Other comments from students had to do with working with other people. Kusum wrote that one had to learn to compromise when certain topics had to be agreed upon. Divya explained that by working in groups in the classroom, it would help you in the future when you "start working with people in the real world through your job."

Another reason for working collaboratively was that students felt that they could understand material better when it had been explained to them by a peer. Linda said that it was easier to ask a friend for help than a teacher. Judy voiced the same thought. She explained that it was easier to talk to a peer who was going through the same stage than to say, "Excuse me, teacher, I think this." She was concerned that the teacher would reply, "That's totally wrong!" Karen wrote that if one person in the group understood the material, then s/he could explain it to the rest. These students appeared to feel more comfortable learning from their peers than the teacher. However, not everyone viewed collaborative work as positive. What about those students? What were their reasons?

Three students voiced dissenting views. Two students wrote that they definitely did not like working in groups. Another student gave reasons both for and against being in groups. Interestingly enough, these responses all came from the same table, the *Soil Compaction: Rooting Depth* table. The remarks from this table for not wanting to work collaboratively were:

> *Mark*: I don't like working in groups because I do not want to be responsible for anyone but myself. Although I do learn well in groups, I don't want my work to affect others' grades.
>
> *Corrine*: Because my group didn't do much to complete our work. (I wrote our entire paper with not much help from any of the other three at my table.) When the other members do take part though, I feel as though I didn't learn what the others focused on.
>
> *Ruth*: Sometimes, I'd rather do things by myself. I also belief [sic] that working in groups can cause you **not** to learn as much as you would on your own. It releaves [sic] you of responsibility that you need to take on sometimes. Sometimes, some projects are better to do in groups, and sometimes you will learn more that way.

Not everyone in the group felt this way at the beginning of the study. Ruth had positive things to say about working in a group in October and again in November. On October 5 she wrote, "I found it helpful to be in a group because we could all put our individual information together and agree on how to design and present our information. Everyone contributed some piece of knowledge that another might not have." On November 4 she wrote, "This is definitely a **group** project. If we weren't in groups, we wouldn't have been able to split the work to make it go faster." Corrine made no earlier mention of how she felt about working in groups. Bob was positive about working in groups throughout the entire project. He said, "I am glad we are working in groups, because with our combined effort [it] creates a much better result than being alone." He wondered why group work had been "so looked down upon" as he thought it was such a good way to learn. What happened to this group between the time the project began and the time it completed?

I talked with this table at some length when we had our interviews in March. Mark told me he thought group work was really helpful because "sometimes it's scary to have to do something by yourself." He commented that it is a lot easier in a group. When I asked the group whether they thought collaboration helped or hindered learning, Corrine stated that she didn't think collaboration hurt learning. Ruth added, "It helps to hear what other people are thinking along the lines of what you are thinking." Were the students telling me what they thought I wanted to hear, or were they reticent to say what they really felt because of peer pressure? The topic of collaboration also came up when I talked with the entire class about the project. Bob spoke up and said that he thought collaboration was good for some things, but that it became difficult to do it throughout the entire study. He stated that to be so dependent on each other and not have opportunities to work after school or on the weekend made it very difficult. His suggestion was that designing and executing the plant lab collaboratively was good; however, he felt confined by having to write the two assigned reports collaboratively. I perceived the students from this table say that collaboration is good, but the teacher should choose carefully the time and place for it. The class, with the exception of the *Soil Compaction: Rooting Depth* table, supported collaborative learning.

Student use of language

Another question in the questionnaire had to do with how students communicated with one another. In listening to the tapes, it was discovered that one student would begin a statement and another would complete it. There were also teasing and put-downs, especially of the girls by the boys. In talking to the students, it was discovered that they were somewhat aware of their language patterns but not to the point that it bothered them. Several students commented that when someone else finished their sentence it was a validation of their thoughts. Kavita explained it as "if we were all thinking of it in the same way and you're thinking of it in your head, so you don't really care if someone else says it because you're still thinking it." This pattern seemed to support the students' thinking that they are all "on the same wavelength" and it strengthened their friendship. When I spoke with the *Hydroponics* table, David stated, "I think it is part of the learning process. It's cooperative work. Everybody puts in something, and everybody get something out of it." This connection between the students' social world and their learning is supported by Lave and Wenger (1991). They state that learners are a part of both their learning and the broader social world in which the learning takes place. Students felt it was important to be able to talk about other things beside the task at hand. David saw learning and social interaction going hand-in-hand. In order to work collaboratively, students felt it was important for them to be comfortable with their group. They saw this being done through talking about other things. Doris said that she did not think social talk interfered with her learning. "I think it helps, because you **trust** the person. If you can talk to someone more freely about anything, you are going to talk to them about experimental stuff too...be open to new ideas." Manning and Lucking (1992) agree that for collaborative learning to be effective, students must get to know one another, communicate accurately and straightforward, and accept and support one another. This type of dialogue allowed students to be linked with and recognized by each other and was at the same time a catalyst for intellectual growth (Newkirk, 1992). **This** is what Doris was saying was necessary for a group to work together.

The fourth section of analysis is the comparison of pre- and post-webbing activities. When one works with students through a unit of study the obvious question is, "What did they learn?" As students and I compared the two maps, it was easy to see where their growth was.

Pre- and Post-webbing Activities

Students did a concept webbing map at the beginning and again at the end of the formal part of the study. They enjoyed participating in this and felt that the map allowed them to draw upon each other's knowledge and visually see what they knew. For some students, when they "saw" their knowledge on paper, they realized they knew more than they thought they knew.

Were the students able to recognize an increase in their conceptual knowledge about landfills from the beginning of October to the end of December? When Bob and Prakash talked about the activities done in the study to our guests on March 31, Bob said, "When we did the second map, we could tell we were much more knowledgeable after a couple of months." Kusum mentioned in the interview that there was a **big** difference in their second concept map. [Their first map had 6 primary concepts and 22 secondary concepts. Their final map had 12 primary concepts and 57 secondary concepts.]

<u>Analyzing concept maps</u>

The maps were analyzed to compare results of the pre- and post-webbing activities. The number of concepts webbed from the center word, "landfills," were counted and were labeled *primary concepts*. The number of concepts webbed from the primary concepts were counted and those words were labeled *secondary concepts*. A comparison was made of the of the pre- and post- concept webbing activities.

Table 2. Comparison of Pre- and Post-webbing Activities

	Pre-activity	Post-activity
Governor's School		
Primary concepts	6 - 10	4 - 12
Secondary concepts	14 - 92	16 - 57
Avg Primary	7	8
Avg Secondary	34 (22)*	38
Patrick Henry		
Primary concepts	3 - 8	
Secondary	7 - 33	
Avg Primary	6	
Avg Secondary	19	

*The "outlier" in the secondary concepts was the *Temperature Effects on Plants* table. They had 92 secondary concepts. However, in looking at their map, it appeared that one thought led to another so that direct links to the landfill were sometimes difficult to justify (see Figure 10). If one does not use the data from the outlier table, the average was 22 secondary concepts.

This information was contrasted with the concept maps done at Patrick Henry High School. There was little difference in the initial knowledge students from the Governor's School and Patrick Henry High School if one does not include the information from the outlier table. There was only one point difference between the schools in the number of primary concepts they knew and three points difference in the number of secondary concepts. Patrick Henry High School did not do a post-webbing activity as they did not participate in the entire study. The students at the Governor's School did their post-webbing activity on December 16 at the end of all formal instruction.

In looking at the tables as a class, students included many of the same primary concepts they had the first time. However, the number of secondary concepts rose considerably. In the pre-webbing activity, only one table, the *Temperature Effects on Plants* had secondary concepts in excess of 36. [They had 98]. In the post-webbing activity, four tables had above 47 secondary concepts. The *Soil Compaction: Rooting Depth* table was the lowest in the classroom with 20 secondary concepts. This was an increase in the average of 1 primary concept and 16 secondary concepts when compared with the pre-webbing activity. [This comparison excludes the pre-web statistics for the outlier table.] Based on the analysis of these activities and the perceptions of the participants, content knowledge was greatly enhanced through this study.

CHAPTER 5

REFLECTIONS

This chapter shares with the reader how participants looked at their own growth as they journeyed through this study. The classroom teacher, the scientist, the students, and the educator-researcher are heard. It was important to understand each person's perspective on the impact this study has made. This chapter also discusses the implications of this STS study. Links are shown between the data and the relevance to current research. Additional research is discussed.

Classroom Teacher

John and I talked during the study about how things were progressing and what adjustments we wanted to make when we moved from one activity to another. However, we did not sit down and do a formal assessment until the end of the study. Maybe it indicates how well everyone worked together. It is March 17, and we have taken the plants apart to measure the above ground biomass and the root biomass. The students have written their papers. Mara and I have only one more meeting with the students to discuss their findings. Since this is the last week and everyone has formed an impression about the study, now is a good time to discuss those impressions.

Students are doing a chromatography lab when I arrive. I enjoy being in the classroom when the students are in labs because it gives me an opportunity to talk casually to John and to wander about the room and talk to the students. As soon as students finish at 11:00, John and I sit and talk over lunch. I hope his answers will better help me understand the role of the classroom teacher in this collaborative STS study. (See Appendix F for copy of questions.)

John's Role

Because John, Mara, and I were three adults having to work in such close proximity for several months, I wondered what John saw as his role in this study. John tells me he thinks he played many roles. His first role was to "provide the opening for you, a place for you to come in." His second role was one of doing things that I couldn't do, such as deciding where and how things would fit in the schedule. He also looked at the semester [when we thought this would be just a one semester study] to see what products he could reasonably expect from the students. These included papers for them to write, articles to read and respond to, discussions, and presentations.

When I ask John how he thinks his role changed over the course of the study, he says he doesn't think it changed that much. However, he does think he "let go more." He says, "The farther we went, the more I found myself stepping back and letting you and Mara direct the students and take over in the room. I was finding that I was more comfortable just staying in the background." John explains that he feels the students interact with him for the rest of the year and they should interact with someone else when there is an opportunity. He also says, "You and Mara did such a good job that I didn't feel like I needed to stick my nose in, so I was watching, taking pictures and sitting back." John thinks it would be interesting to find out students' perceptions about our roles. [I made a note to include a question in my student interviews.] John acknowledges that Mara and I set up our roles more informally with the students when we allowed them to call us by our first names. John reminds me that he had made it very clear to the students the first day of class that **he** would be the one giving the grades, not Mara and I. "I got the sense that the kids liked that, and it was probably easier for them to talk to you, especially when you were sitting around," he says.

STS Projects

I knew John was familiar with STS projects because of the literature he has shared with me. He also told me he has done STS projects at RVGS in previous years. I wondered how this unit was different from other units he taught during the year. John says he thinks this is probably the most time-consuming unit he has ever done. He explains one reason for this is that STS projects always tend to take a lot of time. The other reason he says is, "Since it was the first time it was done, one could not plan realistically how much time it would take because we would add things or subtract things...." He says on those days we planned a specific activity, such as the webbing activity or the value and issues lesson, we stayed on schedule. John thinks we lost time in three places. He thinks STS projects always get off schedule when students are working on a group product. Because the students at RVGS come to school from several localities, they are not able to work together after class. He must give the students time during class for collaborative work. "You never seem to give up front the amount of time it ends up taking them," he says. The students were responsible in this unit for two group papers: their literature review paper, and their conclusion and recommendation paper. John feels the students are good workers; they do not slack off to get more time.

The other place John thinks we lost time in this unit was with the plant labs. It took several days to sieve the dirt before we could plant. It took several more days when we were taking the plants apart and were measuring roots. "Once you've started, you could not end it. I would guess there were two solid weeks of class time I wasn't counting on, just related to the plant project," John concludes.

How will John try to make up for "lost" time? He has decided because of the time the students have spent working with plants, he will not do three plant labs that he normally does. He feels the students have experience with growing plants, taking care of plants, and measuring and weighing plants. For those three labs, he thinks he'll share with the students the data collected from last year's class. They will discuss it without doing the labs.

Strengths and Weaknesses of an STS Project

I wanted to know what strengths and weaknesses John sees in teaching a collaborative STS unit. He says, "If the kids like the project, they learn a lot. It is not always just science content [they learn]....usually some surprising things come out of it. You don't always know what it is." He thinks the plant lab was a good example for the students to see how "real" research happens. John says that for students at RVGS, their science fair projects go on longer than the typical science fair projects. He continues, "But these kids pretty well come out of high school thinking research is something you do in one week, or maybe four weeks, or...maybe one **night**." John thinks the amount of time the students were involved in this lab is closer to the real time associated with doing regular research. This reminds us of the two girls in his class who came to Virginia Tech last year to do some water quality experiments. They had been invited by Dr. Young to use the equipment in the pesticide lab to collect their data. The girls gave no thought that they might have to come back a second day to complete their experiments. John says that "...maybe the extractions could be finished that day, but we weren't in line to use the gas chromatograph because it wasn't our turn...we had to wait." He thinks the students are not used to those logistics of science, so it is good the students this year saw some of this.

Another positive thing John sees in the unit is that the students have an opportunity to see adults other than himself. He refers to the adults on the field trips and the speakers that came in. John does think the students at RVGS are used to a variety of adults, but "the more they see, the better the interaction we have."

John says the biggest negative aspect to an STS unit is the inordinate amount of time it takes. He thinks his colleagues in the building also share this concern. John normally does two STS projects a year, one each semester. The fall STS project is traditionally environmental with the spring project focusing on a biotech or medical ethics issue. His previous STS projects have been library research and reading writing reports, presentations, and discussions; labs have not been a major component. John says he plans to do the biotech STS project, but will have the students read the articles and talk about the issues, but not write papers. I tell him it will be interesting to see if they use the concepts and vocabulary we used in the "values and issues" lesson we did in October.

John's Professional Growth

Hopefully, teachers will grow along with their students when doing something new. I ask John what professional growth he thinks he may have had during this study. The first thing he lists is learning about landfills. Before this study, he really didn't know anything about them at all. He also notes, "Being able to observe more and not have the responsibility to run the class, I could sit back on days and get a feel for some of the interactions that are going on that normally you just can't do." He realizes the teacher doesn't have to be in charge of every moment. He thinks another adult or the students themselves can be in charge. "The students do a pretty good job of it around here." John was impressed watching the students work on the plants. He says,

> I thought these kids would give up on that plant lab...with the sieving. I thought at some point they would just say, 'I'm not sieving any more.' Not come out and say it, but just quit. Just sit there and expect one morning they would walk in and the dirt would just be sitting there for them. The same with the tearing apart at the end. I was amazed with watching them. Mara had said that they had to get every single little tiny root out of there. Well, they **did**! They were serious about it. And that was impressive to me.

John feels he has learned that most of the students will act very mature and he can trust them to "push it" when something has to be done. He thinks part of this push and conscientiousness comes from the fact that it is not just the teacher asking them to do something, but they see Mara and I involved, and they know we will share this data with other people. "I know from other labs that they don't finish them or always do them as conscientiously as they did **that** lab," concludes John.

When asked whether he would do another collaborative unit with people outside the school, John answers, "No problems with that. It is a wonderful way to do it." John says that in his other STS projects he's had people to come in for a day and give a talk or lead a discussion, but never where the unit was ongoing and the planning was happening as a team.

STS vs. Basic Science Debate

John reads the literature and knows there are those who are proponents of STS and those who endorse "basic science." I ask him, "What would you say to each side?" John believes that STS has its place, "just like everything else." It concerns him that we have educational philosophies that "come and go." "They think everything in education has to go according to that plan. In five or ten years they see it doesn't accomplish everything and so they drop it and go on to something else, rather than trying to pull the best from different areas," he says. John relates that five or six years ago, RVGS invited Robert Yager for a three day conference. He also attended an NSTA meeting where he heard a talk by a teacher who taught his entire curriculum through STS projects. John's feeling after listening to Yager and the classroom teacher was,

> There is no way that I could cover the content here, the amount of content and the depth of content if the whole year was STS oriented. And Yager's argument is the kids will get so interested in an issue they will naturally want to learn the content. I

don't think that is necessarily true about high school kids. It may happen sometimes, but not at other times.

John thinks that STS should "fit in" and not be an "add on." He also says he believes if he taught STS all year long, it would bore the students. He finds that even doing it twice a year the students say, "Do we have to do this again?" John thinks there should be a variety of things: STS, labs, lectures, and class discussion. "Use it all," he advises.

John's Last Word

After I finish with the questions I think address those areas in which I want more information, I ask John, "What would you like to say as your 'last word?'" John's first thought is that he thinks the landfill unit, if written up appropriately will be good to disseminate to teachers. He thinks we need to write the plant labs so they will be more manageable. He likes the sequence of activities in the unit and thinks it will be of interest to other teachers.

John's second thought is that he thinks what he, Mara and I did is a good example of collaboration between a teacher and people outside the classroom. He says that it is an example of collaboration working well. "And that, people need to hear about...both at this level and at your level, and know it works," he says. John thinks success depends in great part on the personalities of those involved. He also knows that teachers, with their teaching load and duties, have little time to pursue the coordinating of outside people to come in. It is beneficial if they have someone else to help with those needs. John says that an important part of making a collaborative process successful is everyone's ability to be flexible. "Our original goal was that we tear the plant roots apart before Christmas. Mara looked at the plants and realized that they had not grown. So we had to make the decision, 'Okay, let's keep it going.'" He says it is important the collaborators be willing to do that.

One of the things John feels most helpful was the three of us looking at the graphs and summaries of the students' plant projects. After the students finished the rough draft of their conclusions and recommendations, John and Mara came to the house. We sat around the table discussing the papers. We placed each paper in front of us and talked about it. John thinks it is a good experience to have more than one person having input on an important paper. He says by doing this, we get many different viewpoints. One person sees something that someone else misses. John says this exercise gave him many more things to tell the students about possible revisions than if he had looked at the papers alone. He doesn't think we would have had the same quality of suggestions if each person had looked at the paper independently.

John finishes with an interesting point. "What we got out of the study 'collaboratively' is the same thing we hope the students will get out of it. We modeled. We did some of our own cooperative learning in the process." John has given me his viewpoint as the classroom teacher. How does Mara perceive the project after five months?

Scientist

I met Mara Sabre when she first came to Virginia Tech, before either of us had any idea we would be working together on the landfill restoration project. In the fall of 1992, Mara was a new graduate assistant who would have as part of her responsibilities teaching a lab. I was assisting with the Graduate Teaching Assistant Training Program. This was a fall orientation program where new graduate students could sign up for a seminar to help them plan their introductory statements on their first day of teaching. The students stood before their peers and gave a five minute mini-introduction. We videotaped their presentation, and they came back to collaboratively evaluate the video. Mara was in one of these sessions. I remember her being friendly and eager to learn, but extremely nervous in front of the group.

When we met the second time, we knew we would be working on the landfill project together, she as the scientist and I as the educator. I felt as uncomfortable and uninformed about landfill construction and management as she did about the classroom. If we were going to make this project successful from a scientific and educational perspective, we were going to have to spend time talking. When her schedule permitted, Mara accompanied me to the classroom. She observed John, the students, and me. During the spring at PHS she often said, "I will do anything, just don't ask me to teach." I did not know what response she would give when John asked her in September to talk to the students about her experiments on the landfill and some of the issues she saw in making a final vegetation selection. She laughed and agreed to do it. We talked about what she wanted to say and the activities she wanted to do. In mid-October, I videotaped her for two days while she stood before the students and shared. I was proud of the "teacher" I saw. Because of this background, I was eager to interview Mara at the end of this study to see where she thought her role was and how she thought she had grown.

It is March 17, and I was in Roanoke this morning interviewing John and the students. I must be in Blacksburg at 5:00 p.m. so Mara and I can have dinner and talk. We are to meet at the dinning hall located on campus. At dinner our talk centers on our work, but I do not begin the "interview" until we finish eating. (See Appendix F for copy of questions.)

Mara's Role

I ask Mara the same question I asked John earlier, "What did you see as your role in this study?" She pauses for a moment and then answers, "I don't know. It was not so much like one particular thing, like an advisor or a consultant. I knew as a scientist I would be expected formally to present what the scientific problem is." She also knew it was her responsibility to help the students design their experiments and then come up with reasons or possible explanations why they are getting their particular results. Mara does not feel there was anything "written or defined for me." She sees the roles constantly changing. She says, "It was kind of like, well, this week I'll be this, or maybe this week I'll do this."

Does she think her role changes over the course of the study? She thinks so, and she likes her role at the end of the study better. At the beginning of the study, she felt she was the scientist, that the revegetating of the landfill was her project, and she was there to ask the students for help. As the study progressed, she viewed herself as another person in the classroom, a helper. She felt her role shifted from that of "biologist."

Strengths and Weaknesses of the Study.

Because of the amount of time Mara has given to this project, not only working as the scientist in the field, but as a science educator in the classroom, I ask her if she would be willing to do a collaborative unit like this again. She answers, "Yes...but I also know my time limits a lot better." Mara says since this was her first exposure to working in public schools, she didn't know how to plan and anticipate the amount of time it would take. Mara reminds me when we sat down to do our planning in September, she had said we could do the plant lab in a month. In reality, the plant lab was begun the end of October and not dismantled until the end of February. However, during that time we did have the holidays and then lost a month and a half because of intercession and inclement weather. [Intercession is during the month of January when regular classes are suspended and students pursue special interest studies.] She is not sure whether we could have done the study in any less time, but she does think it could have been smoother if we had anticipated some of our problems. She continues, "This teaches me how to plan, now that I've been through it in a very positive way." Mara sees this as a good foundation and the next time she will be "a little bit more organized, plan better, and be a little more flexible so that the students can do more."

I question Mara what does she mean when she says "a little more flexible." Does she think we weren't flexible enough? She explains that she is referring to the experimental designs. She thinks if there had been time during the summer to try out different experiments she would have had a better idea of the amount of time it would take to do the labs and the possible observations the students might see. Mara doesn't think we spent enough time looking at possible experimental designs before beginning the study. She thinks this information will be good to include in the unit we write. Teachers need to have an awareness of the amount of time the unit will take.

What strengths does Mara see in teaching this way? She says the importance for her coming from college, graduate school, and the real world is that this type of teaching is "interactive." She thinks the role models all change. She says,

> I don't know exactly how the students perceive us, but looking at the students, I relied on them as a resource rather than somebody who was 16 years old and adolescent. I think it is important for students to be learning now that adults are resources. They are not people to be feared or people standing off in the background, waiting to send the magic words of exactly how to do something exactly at the right time. **They** [adults] have problems, **they** [adults] have challenges. Each can use the other as resources. That is a real important strength that just a regular lecture class would never get across.

Mara's concern is that this style of interactive teaching which includes group problem solving and the use of human and literary resources is not reinforced in other disciplines, the students might think it is something that is a "uniquely weird biology thing that John

Kowalski wanted to teach." She thinks the students will lose a lot if they are not exposed to this style again.

Mara's Professional Growth

What professional growth does Mara see for herself as a result of this study? She laughs as she says she sees professional "progress." She says she never realized how much planning goes into doing this type of unit. She attributes part of this lack of planning because she didn't know her audience. The other part she attributes to the fact that in the summer of 1993 she had just finished her first year of field study and her first year of graduate school and she was still getting organized. Mara comments on the number of people we've had to interact with in the study: Ed McMichael (PHS), John Kowalski (RVGS), Catherine Whitman (RVRA), Randy and Jared (Roanoke Regional Landfill), Ginny Laubinger (Explore), and Dr. Cairns (Virginia Tech). That doesn't include the list of people she deals with at a scientific level: Rupert Cutler (Explore), Olver Engineering Co., Draper Aden Engineering Co., and John Hubbard (RVRA). She realizes you must take the time to plan for something that involves this many people. "You have to learn not only how to keep yourself from getting biased with different groups, but just how to think ahead," she says. Mara thinks she did not anticipate as well as she should have what materials we would need next. Again, she says it was "positively reinforced; nobody gave me a tongue lashing. That's really important when I am still hesitant with the students."

For personal professional growth, Mara sees that she can move and communicate easily in both academic and non-academic, or scientific and non-scientific worlds. She thinks this experience will give her some very positive long term reinforcement when she begins to look for a job and meet different audiences. Mara realizes she is still growing academically, and is confident her learning comes with proper planning. "Professionally, that is absolutely essential because it reduces my role. I don't think of myself as a scientist anymore."

Mara launches into a discussion [which we have had before] how science departments at universities keep to themselves and do not engage much in collaborative work. She thinks that in biology, except for some interaction with chemistry, fisheries & wildlife, and forestry, the concept is foreign to them. "That's not science anymore!" she says. Mara thinks she is trying to satisfy both a scientific audience and a non-scientific audience. She states, "I'm being able to do it. But my goals are different on both ends. I'm not interested in something that is purely educational, but I'm not interested in something that has a hypothesis and results, either."

I know it concerns Mara about the "role of the scientist" in the classroom. We talked about it many times on our trips to Roanoke. She didn't want the students to perceive "the scientist" as a person set apart on a pedestal that could only answer scientific questions. She wanted the students to understand that being a scientist is not something "alien and foreign." I ask her how she feels about that now. She thinks the students' perception depends on how that person is introduced and brought into the classroom. "I think it was done very well in our case." She says, "I felt like I was just 'one more adult' in the classroom." She also comments that Dr. Cairns' introduction was handled well when he talked to the students.

Student Benefits

What does Mara hope the students get from this study? She says that any time she has worked with students, the biggest thing she hopes is that they understand that "science is not magic." She acknowledges that things will go wrong but it's okay. "An experiment is not something that is written in stone." She says that at the end of an experiment you end up with a lot of data so how you define your question is important. "You can have a more or less valid experiment relative to the question you've asked, but you can still come up with something totally different at the end, and it can still serve the purpose of the project in general."

Mara thinks the students got out of the study what she had hoped they would get out of it. They learned to accept the fact that there were no right or wrong answers. These were not verification labs. She says she never heard anyone say, "It's your fault. It's my fault." When the students made a mistake, they came to her and asked, "We did this, is it going to be okay?" Her response was, "What do you think the implications are going to be?" She also hopes the students realized that their project could be really small, but still have significance. She would like to ask some of the students, "Well, do you think that what you did made any difference at all?" It was not her goal for the students at the completion of the study to know about "plants and roots." She says, "What I wanted them to know was that there were certain things that you can use as indicators. You have to **look** at plants. You've got to **handle** them. You've got to **mess** with them. I wanted to make them 'user friendly' with experiments and their own designs, and they did that...."

Mara thinks the students do not really understand the idea of a control. She says this may be because it is only the second year of science for many of the students. "That wasn't my goal, either, at the time. My goal was not to teach them the scientific method," she states. She does think she should have gone back after reviewing the drafts of the students' experimental designs and said, "Okay, let's visualize this one more time." [She thinks four tables had written controls in their designs, however, once experiments were under way, we realized only two tables had set up controls.] She says if students had said, "No, I don't think that there is any point in putting a control because we are never going to see soil like that on the landfill," or "We want to know what they are going to look like on the landfill, we don't care what they look like in real life," she would have accepted either as justification for not doing a control. However, it concerns her that at the end of the experiment the students will look at their plants and say, "Oh, gee! It grew!" She was not certain if they knew at the beginning of their experiments what plants would come up and what plants would not come up if they didn't have a control.

Mara's Last Word

The time I allotted for the interview is quickly ending. I have one more question before we both rush to class. I tell Mara I took a class in which the professor wrote at the bottom of the paper, "What is your last word?" I have designed the questions in this interview to answer those things that are important to me. Is there something important she would like to say in a "last word?" She sits there for a long time before she answers. I thought maybe we were through. She finally says, "I think it would go back to the university...the idea of interdisciplinary work." She asks me how receptive I think parties and stakeholders are to this kind of STS work. By parties, she means the schools, the departments at the universities, and businesses. Mara continues, "There is plenty of literature in the education journals, and there's lots of **talk**...I've heard in the Peace Corps about interdisciplinary work, "practical ecology" and stuff like that. But I'm not **seeing** it taught in the colleges. And it is not taught as a discipline. It is taught on the side."

I mention to her that I remember her talking about Dr. Cairns supporting this type of teaching. She agrees, but says he can get away with it because he is a "maverick." She thinks if she was a student coming in and wanting to interact with certain other departments, depending on the advisor, they would discourage her by saying, "You have to do a scientific degree," or they would just tell her, "That's not science." Mara believes these people discourage others because they have no role models. She thinks there should be inter-departmental collaboration and collaboration between the university and the public schools. She says students in disciplines other than education should be involved in the schools; they should be doing part of their research with the schools, or with community groups. "That is not something we are being trained to think of as biologists. We go to seminars and we are lectured to. How about an STS project where you go in and the professors and students are forced to **do** experiments to learn?" I tell her I think that is the point John was wanting to make with the three of us doing a presentation on collaboration. We were having to collaboratively work together in areas in which everybody brought a part of the puzzle to the situation, but nobody had the whole piece. Mara adds, "And nobody knew what the piece was going to look like."

Mara thinks people who have taught STS projects should work collaboratively with non-experienced people [who may be somewhat rigid and require class control] so that the new person "could feel a little bit of loss of control, but not so much that they would feel it was pulled out from under them." She hopes this way of teaching would be enough of a difference so that both students and teachers could see a change in the hierarchy of the classroom and a change in the teacher's interaction with other people. I interject that it would be interesting to get the students' perception of what they think our roles were. Mara says she saw John as the authority figure, but that he willingly gave it to us on occasion. I agree that it was part of his willingness to give it up that made our working together so effective.

Mara thinks it is much easier for the group if you start with a single authority figure. She says the group can then take their cues from that group leader, "The authority figure can relinquish the authority and the people can pick it up as necessary." She thinks it is more difficult to work together when there is no pre-established figure or there are tenuous holds. She also thinks this would be a problem if the group was **told** to do an STS project, where no one had previous experience. Mara says she thinks before a teacher starts an STS project in which there are going to be multiple people in the classroom, it is important for that teacher to think about his/her role, who s/he is, how does s/he view the people that are coming in, and how the people are going to be introduced so that everyone feels comfortable.

I make the comment that I was not sure what my role was going to be when we began the project. I recall never having the time when I taught to be able to make the necessary outside contacts for projects. Much of what I did in this project was be the "hands and feet" when we needed something. I believe it is important to have a person who is free to do this. Mara responds,

> ...the way you are describing yourself is a tertiary role. I saw a bunch of bubbles right now, 'teacher, scientist, and hands and feet!...hands and feet have to go right up there because there really was no teacher and there really was no scientist. John relinquished his role as teacher except for grades. I relinquished my role as scientists until someone asked me what they were looking at.

Mara says I was more of a "troubleshooter." She says John had the classroom as his main focus and she had her experiments on the landfill as hers. She thinks I was looking at the total picture. Mara comments:

> You guided us almost like several threads, and we would bump in and out sometimes. We had our own little schedules to deal with, but this was your project. You were the one who kept the threads together. Your persistence was not irritating, which means there's more of a 'mesh.' You were a planner, a manager. You managed our time. John managed the teacher time, but you managed **our** time. You kept my time in mind, you kept John's time in mind. You were the administrator.

Students

I interviewed the students on March 21 and 29. They were working independently on these days so I did not disturb the class. I had a series of questions to ask each group. However, if the answers lead in a different direction, I added other questions. (See Appendix F for copy of questions.)

The questions I will focus on here are (1) What skills [if any] do you think you developed to help you with decision-making; (2) How has this unit has made you change the way you think about landfills; (3) What [if anything] did you learn that will be useful to you outside school; and (4) What suggestions do you have for me when I go back into the classroom and teach an STS unit. I will discuss the other questions as they relate to my analysis later in this chapter.

Decision Making Skills

The students and I find a quiet place to talk. I ask, "What skills [if any] do you think you developed to help with decision-making?" Karen shares that she has learned how to set up an experiment. She says she went for an interview at Roanoke College and talked to a chemistry professor. He told her about the research projects student do at the college. Karen says she now thinks she has experience in setting up her own research. She does not think she would have gotten this experience if she had done labs from a workbook. She states, [In a workbook] "you follow certain steps...but you don't really have any input as to what you are going to do. I think this way we decided how to do things and what **we** wanted to find out. We already have a head start in how to decide an experiment."

Kusum and Divya say they believe this project made them think. Kusum, as does Karen, likes the idea of designing her own experiment. Kusum comments, "...instead of saying, 'Do this, this, and this,' you've taught us to think on our own. I mean we had to come up with our own experiments." She also says everyone did a good job of coming up with different variables to test. "Not only did we have to come up with our experiment," shares Kusum, "but we also had to think about **how** to do it." It was frustrating because she had nothing to compare her results with. Kusum relates, "When we were trying to decide whether we were doing the experiment correctly we could not say, 'Well, they [Mara and Bea] said this is how its going to be, so this must be right.'" Divya laughs and states, "Right! We learned from our mistakes!" Kavita says she thinks it's important to decide things as a group. She comments when you do things by yourself, you make all the decisions. She thinks it is important to talk about who wants to do what job and then compromise.

Conceptualizing Landfills

I ask the students, "How has this unit has made you change the way you look at landfills?" Several students roll their eyes and laugh because they realize how much they have learned. Bill, Jason, and Bob state everything they know about landfills they learned in this unit. Students recognize that they really didn't know anything about landfills before doing this project. Kusum says, "I had not really **thought** about it. Who thinks about landfills!? One day that you're not doing anything...[you think] Landfills!" She laughs! Both she and Corrine say an important part in understanding the project was the field trip. Kusum agrees that going to the sites was really an experience. She continues, "You learn a lot just looking at it...not just by somebody telling you what it looks like." Corrine simply states, "I saw it." Jon , however, is not sure how this new landfill information fits with his view of the world. "I know more of the problems now, but I still don't know how truly important those problems are." He acknowledges that the problems are obvious, but has not decided what he thinks the long term affects might be and if they will be as serious as some people say.

Relevance of the Study

How do students think what they have learned will be useful? Most students find that their awareness has been raised, and they think about landfills outside class. Bob admits every Thursday when he takes out the trash, he thinks about where it is going. Bill comments that he sees articles in the paper all the time now about the landfill. "I just never noticed it before. I never bothered to read," he admits. Karla says the things she does now are more "environmentally friendly" than before. David says he has used his information about landfills to write an essay to try to get scholarship money for college. He submitted his essay in January, but hasn't heard anything. He states, "It's just a big difference in what I know now and what I thought."

Several of the students have taken the "landfill project" to their other classes. Judy took the information she learned about landfills and used it to support a debate they were having in government class. She tells about her class doing a mock senate, and one of the bills was about recycling. Judy relates, "All these people were, you know, 'It's going to cost so much money to force foreign companies to recycle their products, and put stuff in recycling packaging and all of that.' So I got out my biology notes and [read to them], 'We're going to have landfills in our backyard in 10 years.'" Karen is also in the government class with Judy. She laughs and says, "Judy's sitting there spitting all these facts, and our teacher is saying, 'Where did she get all this information?'" Kavita also comments that landfills came up as a topic in her American History class. The class was talking about landfills being a topic of discussion even back in the early 20th century. Kavita says, "Mark and I kind of gave our bit." Kavita admits understanding things in the paper about landfills better now, and when she gets old enough to vote, she thinks she will understand the issues better. However, not everybody thinks information about landfills will be useful.

I ask Jon since he now knows what some of the problems are, what does he think **he'll** do next? At first he doesn't say anything. I wait a few seconds and then rephrase my question. I ask, "Will you just say now that you know the problems, or will you read more and find out for yourself how serious the problems are?" Jon answers, "Probably what I'm going to do is, yeah, just probably let it go and forget about it." Jon admits after he has heard about landfills all day at school, he doesn't want to think about landfills once he gets home. "I'm sick of landfills," he comments. Mark doesn't see any relation to what he has done in class with life outside the classroom. He says this has basically been just a unit he has studied. "I haven't actually come across anything that I would actually have to use the information that was given in this study."

Student Suggestions

I ask students to give me suggestions for doing an STS project when I return to the classroom. By asking this question, students have an opportunity to tell me what they like or don't like about the study. I will use some of their suggestions to improve my teaching. Karla and Linda talk about the importance of "doing" things and being actively involved. Linda states, "...you seem to get more excited and more interested in stuff because you can actually **see** what you do and not just read about it." Ann and Doris talk about the importance of being creative and not having a lot of "busy work." Doris says that just reading a book and answering questions is not learning. "It's a waste of time, for the student and the teacher," she comments. I tell Doris and Ann that sometimes teachers have students answer questions so they can learn the vocabulary. Correct vocabulary help the students talk about ideas. What do the girls suggest a teacher do when she must cover the material from the book?

Karol shares a technique her government teacher uses. She relates that different groups are responsible for different sections of the chapter. The groups have to get up before the class and share their section. "You are more apt to listen to a peer when they are talking to you than you are your teacher, anyway," states Karol. She thinks that group work and presenting before a class "bring you to task more." Doris comments on having to get up in front of the class. She shares that she was very shy in elementary school. Doris wishes her teachers had required more group work and group sharing. She thinks she is not as shy now and attributes it to having to make presentations in middle school.

Syann shares that one of the things she really liked about this project was the freedom to choose to do what was important to her. "Every group got to decide what their lab was going to be, what their purpose was going to be, and how they were going to do it," she says. "Being handed directions, doing it, and copying it into a lab book," she comments, "is boring." Kavita and Bill both talk about the importance of deadlines. They agree that deadlines are necessary. Bill adds that teachers should stagger the deadlines so everything is not turned in at the same time.

Divya and Kusum like the webbing activities we did. By doing a map at the beginning of the study and another at the end, they can compare and see how much they have learned. They also like cooperative learning. Kusum says, "You know how to work with people and communicate, as well as learning. So you'll just get diversified benefits." Corrine and Bob are not as enthusiastic about cooperative learning as are Divya and Kusum. Corrine tells me, "Don't do lots of group projects. Maybe do one or two, but not a lot." Bob adds that the plant experiments were okay to do as a group because they did everything in class. Bob and Corrine acknowledge that it is difficult to do a report as a group because they have no time outside class, and they live too far apart to get together to work on them. They prefer doing the labs collaboratively, but they want to be responsible individually for any reports.

The students seem to enjoy sitting casually and talking about the different aspects of the project. We chat approximately 20 minutes per table. One of the nicest complements comes from Karla as she walks back into the classroom. She says, "That [the interview] makes me feel good. No one has ever asked me for suggestions before!" Her opinions do count.

Educator Researcher

My own growth was formalized last as I did not think it could properly be reflected upon until the process of collecting data was finished. What was anticipated as ten weeks in the classroom had expanded to more than five months. This gave much upon which to reflect: the students, the interaction with the classroom teacher and the scientist, the involvement of political and business aspects, and the STS project itself. Upon looking within, there was teacher, collaborator, administrator, and concerned citizen. This project and various academic courses have changed the view of my role as educator. In less than three months I would be back in the public school classroom. What changes did I foresee in conducting my room and setting the climate for learning? I will reflect on some of the same questions asked of John and Mara when they were interviewed I will then discuss the goals for my students when I return to the classroom.

Interview Questions

My role. What did I see as my role in this study? My role was less defined than was that of either John or Mara. John was the teacher, and Mara was the scientist; I was neither. Upon entering the field, I felt somewhat awkward because of no previous experience at the high school level. As time in the field progressed, I slipped more easily into the role of teacher. That was in response to John's encouragement to share in the teaching. In the broader scope of the project, however, my role was probably more aptly named "coordinator."

I was aware of Ed's, John's, and Mara's schedules and spent numerous hours setting up activities to match individual schedules. School schedules, in addition to personal schedules, had to be taken into consideration. Each school had days the students were not in biology class. Patrick Henry began a new extended class schedule this year that made coordination with RVGS especially difficult. Students at PHS were in biology class every other day. The schedule was noted as "A days" and "B days." This made advanced planning especially complicated. The students from Patrick Henry were in biology on "B days." If there was inclement weather and a "B day" was missed, the next day in school was a "B day." In addition to PHS's schedule, the students at RVGS did not have biology on Wednesday. Classroom schedules also had to be coordinated with Mara's and my schedules. Mara had classes at Virginia Tech on Tuesday and Thursdays during the fall semester and, therefore, could not always go to Roanoke. These schedules had to be taken into consideration when planning activities, field trips, or guest speakers.

There were several activities it was hoped that representative students from each school would attend. One activity was a trip to a Roanoke Valley Resource Authority board meeting. The RVRA held its November meeting at the science museum at the Center in the Square. After the board meeting, there was a tour of the museum's *Garbage* exhibit which had been supported in part by RVRA. The exhibit gave a history of garbage and had activities students could do to better understand the current issues surrounding solid waste management. As the meeting would be most of a morning, students from RVGS said they could not take the time from their other classes to attend the board meeting and visit the museum. Several students from PHS wanted to attend, but permission could not be obtained for them to leave the school grounds. A Roanoke school employee or a teacher was needed to accompany the students.

Another activity for students could attend was the grand opening of the new landfill at Smith Mountain Gap. The opening was December 1. Catherine Whitlaw asked whether students might participate by sharing some of the things being done in the classroom. Unfortunately, the project had not progressed enough by December 1 for us to participate.

However, tickets for the train ride and tour of the new facilities for a student from PHS, Mara, and myself were obtained. It was a day-long event in which the transfer station on Hollins Avenue, the tipping building, and the excavation site for the landfill at Smith Mountain Gap were toured.

The science museum held another event during the middle of February. Students were asked to participate by bringing in their plants and talking about the landfill. The event was held the second Saturday in February. However, because of winter holidays, Intercession, and inclement weather the students had only been in biology class three days since December 16. Since the students had been away from their projects for 10 weeks, it would have been difficult to have a display ready. Although the role of coordinator was my initial role, it was not my only role.

Even though my role as coordinator continued throughout the year, a second role emerged throughout the course of the study. My involvement in the classroom setting became more active during the project because John shared teaching responsibilities. There was also a comfortableness in answering the scientific and environmental questions students posed as the study progressed. Even though John, Mara, and I had loosely defined roles, each was eager to help the other when the need arose. This ability to assist whenever necessary was a strength in the study.

Participant compatibility. John, Mara, and I talked about our ability to work together as one of our strong points. We envisioned ourselves as a "team." This ability was a necessary component in teaching collaboratively. Each listened when we planned and adjusted their schedule to benefit the study. This degree of cooperation does not always happen when people try to work collaboratively. I agree with John that we had the right mix of personalities. Like John and Mara, I would be interested in doing another collaborative project. One topic discussed during planning was what we perceived each of us, as individuals, were getting from the study.

My professional growth. There was much professional growth on my part as a result of this study. The opportunity to work with advanced high school biology students was a new experience. Students were not as intimidating as had been imagined. With additional content background, this level student would be exciting to teach. Scientific information about landfill construction, monitoring, and maintenance, recycling, and solid waste management issues was also added to my knowledge. Becoming more assertive when working with the public sector as it related to school activities was important. Given another STS study, it should be easier to navigate through the bureaucratic red tape. There was hesitancy on my part at times when making contacts with people. For whom I was the spokesperson? Was it the Center for Environmental and Hazardous Materials Studies, the Roanoke Valley Governor's School, or me, the doctoral student in education at Virginia Tech. Once officially assigned a school, this question will be resolved.

This project was also an opportunity for students to teach me things to do when I return to the classroom. The construction and management of the classroom and what student understandings to be should have a direct impact on the student learning. What are some of these changes?

New Teaching Strategies

Classroom changes. First, it is important for students to be able to construct their own personal knowledge. In a given unit, students should be allowed to investigate aspects they find interesting and become the "class authority" for this area. The search for this knowledge could encompass the library, computer networks, and private or governmental agencies.

Second, students should be encouraged to participate in a variety of activities both individually and collaboratively. Students need to have some control how they interact in the classroom. Learning styles are different, and not everyone wishes to work collaboratively all the time. However, in most life situations, learning is not done in isolation. Students throughout the year would be required to participant in a certain number of individual studies, collaborative studies, with the remaining to be the learning style of their choice. Working collaboratively and individually assists students to learn to participate in both settings.

A third goal is for students to share the knowledge they have learned with others. "Others" can include their classmates, another class, the school body, the community, or students from another school. Learning needs to go beyond the immediate four walls. Middle school students can adopt elementary students, or upper elementary students can adopt primary students and share products made to illustrate knowledge. Students who can explain their knowledge are more apt to understand the concepts. Sharing benefits both the giver and the receiver. The recipient gains new information and an excitement of science. The giver has a purpose for doing science and an enhanced self-image. Many elementary and middle school are within walking distance from each other. "Blocking" schedules in the middle schools where teaching teams have extended classes could help facilitate such a partnership.

A fourth goal involves community service. Students can help identify areas of environmental community service in which they can participate. Everyone needs a purpose, and students can be most enthusiastic about causes in which they believe. Students can find a local interest to study and work toward improving. Students like to be involved in positive activities, but it often takes the direction of an adult to open the door to those opportunities. These activities can impact student understandings.

Student understandings. It is important for students to realize that studying science is a journey, not a destination. Because science is a process of discovering, new findings oftentimes prove previous understandings to be incorrect. It is educator's responsibility to help students and teachers realize we make this journey together. As teachers, we should be facilitators of knowledge, not dispensers of it.

It is also important for students to realize that our natural resources are finite; responsible choices must be made on how to use them. Often, because our resources are so readily available, students don't think of the possibility of these resources being limited or non-existent. With the understanding of limited resources, students' behavior may change so they will consider what results their actions may have on the environment. Students also do not think about one country's environmental actions having an impact on another country. Students could generalize the environmental consequences of their actions to a larger scale and thus understand the possible environmental consequences of one country's actions on the world.

It is important for students to see the inter-relatedness of different subjects. Skills learned in shop can be used to build things for science. English skills can be used to write letters to obtain information or voice a concern. Math skills can be used to represent data collected. A knowledge of social studies can also help students better understand how mankind has developed his world and the resulting environmental impact this development has had.

My purpose in making classroom changes and looking at student learning is to help the student: (1) know and appreciate their scientific world so they can protect it (Ramsey & Hungerford, 1989); (2) become scientifically literate so they can participate more fully in everyday living and become better decision-makers in issues of science (Ramsey, 1989); and (3) realize we often pay a price in natural resources for our technology-oriented society (Yager, 1988). Ultimately, I hope as an educator to make an impact on students so they can understand and enjoy science, and that they, in turn, will make an impact on others.

The reader has shared in the students' perceptions of the activities that were done in this study. The stories were told of how those involved: the classroom teacher, scientist, students, and educator researcher saw themselves change through this process. The roles of collaboration and language in the construction of knowledge as perceived by the students were also told. However, this has been only one study that was done in one location with a unique set of circumstances. What does this study have to offer the larger picture of STS research?

Implications

What links can be made between this study and other research done on STS projects with students? This study is unique in that it involves high school students in the process of investigating plant species for the revegetation of a landfill. However, in the broader context of STS investigations, it is helpful to look at the study in relation to the outcomes of STS education and whether they were met.

Harms and Kahl (1981) assert that science education should encourage students to:

(1) become informed citizens who can handle science-society issues

(2) develop a sense of responsibility

(3) appreciate the possibility of science being able to abate problems in society

(4) create a sense of "custodianship" of the natural world

Ramsey (1989) states it more succinctly, "the ultimate instructional objective is for students to become effective citizens in the world community and be able to contribute to the solution of science-related social issues." This is what the students in this study achieved as they progressed through the four STS foundation levels.

Most STS units teach the first two goals of foundations and awareness, but never allow students the opportunity for investigation and application (Ramsey & Hungerford, 1989). When a study includes the investigative level and action skill level, time often becomes extended and outside resources become involved. It is because of these factors that many teachers include only the foundations and awareness goals. In support of Ramsey's et al. (1981) research of students who have proceeded through the four STS instructional goals, students at the Governor's School met the goals of science literacy and environmental involvement. This finding is supported in this study from the student interviews, classroom observations, and conceptual webbing activities. Clearly, involvement in stewardship and citizenship requires extensive instruction beyond the foundations and awareness goals to include the goals of investigation and action-skill development.

Project 2061 (Rutherford & Ahlgren, 1990) and Benchmarks (American Association for Advancement of Science, 1993a) strive for scientific literacy among the students by recommending less topics of study, but at a greater depth. The students in this project studied one topic in depth and saw how it connected with other sciences and disciplines. Normally, in the course of a year, the students would have completed many more topics. Students told how they volunteered information in other subjects about landfill issues when they saw a connection with the daily lesson. However, in order to investigate a topic in greater depth, more time was used than might normally be allocated. What was originally thought could be accomplished in twelve weeks extended to almost twenty weeks. Studying topics in depth will undoubtedly have impact on curricular decisions on the local, state, and national levels.

Time management and flexibility for planning are important considerations for teachers involved in STS studies. In this project, an increase in the time needed for the labs meant there had to be flexibility in the schedule. For example, when the scientist realized the plants had not grown enough to collect data, the classroom teacher had to be willing to adjust the schedule to provide the additional time needed. In making this decision, the teacher was aware of the constraints on his time and the need to cover specified topics during the course of the year. He also realized that certain plant biology labs usually done had already been covered in the landfill project. It is my belief that plant labs done in connection with the landfill project were probably more meaningful to the students than plant labs done as a part of the curriculum in the regular course.

Another relevant implication pertains to the creation and identification of the *community*. As students become involved in an STS project that extended beyond the community, the nature of the learning community changed. At the beginning of the project, the community consisted of classroom students. The purpose for this community's existence was that the students had chosen a unique setting at the Governor's School in which to study mathematics and science. Over the course of the study the purpose for the community's existence changed. The community within the classroom was redefined as it became part of a larger community. Students became initiated into this new community by doing research, taking field trips, listening to speakers, and integrating into their own beliefs those aspects they deemed worthy. The students evolved into a community of knowledgeable young citizens who were concerned about solid waste issues and restoration of closed landfills. The outside community was also brought into the classroom setting via speakers and dialogue with civic leaders. Students wrote in their reflective papers the importance of seeing things first-hand and having the opportunity to talk to civic leaders.

Students in this study had the opportunity to investigate these issues under the mentorship of a teacher, scientist, and a teacher-researcher. Even though most classrooms are not fortunate to have several mentors, having mentors allowed the students to observe adults who were modeling collaborative and investigative techniques.

During problem solving activities, students involvement and ownership of their own work is essential. The project began with a high amount of uncertainty by the scientist, the classroom teacher, the researcher, and the students. In the sense of "pure research," it was not known what problems would be encountered nor was there a clear vision of anticipated outcomes. Students became owners of their research as they defined the problem and designed their own experiments. The scientist, classroom teacher, and I were surprised at the commitment students made to their projects over the twenty weeks. One group, the *Hydroponics* table, wanted to continue their experiment, but had to dismantle it because the equipment was needed by another class. The students had a personal interest in their experiments because they chose to study those things that interested them. With choice came ownership, and with ownership, sustained interest.

In summary, I believe the following conclusions can be drawn from this study. First, learning is enhanced when one topic is studied in depth and connections are made to other sciences and disciplines. Second, students who can make ties between what is happening in the classroom and what is happening in the community will be better prepared to deal with issues because they realize they must draw upon a variety of resources. Third, students who are allowed to make choices in the course of their learning take ownership of what they are doing. When they "own" a project or activity, interest is sustained through to its completion. It is hoped that this interest extends through time beyond the classroom.

The final question is, "Did teaching an STS project which included all four instructional levels accomplish the goal of helping students become more environmentally aware and active?" Further research is needed to determine if these students have made a change in their attitudes and behavior *over a period of time* extending beyond the initial study. Future longitudinal research may also provide insight into the long-term impact of STS classroom studies on student involvement in community action.

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APPENDIX A

Schedules and Research Artifacts

Schedule of Activities - Phase I

Activity	Date
Introduce study - Ed McMichael Students draw a landfill - audio taped	April 20
Background information on "garbage" Ginny Laubinger - video taped	April 29
Students work independently on research papers	
Reference and notes check	April 30
Progress check	May 7
First draft	May 21
Landfill Field trip - Catherine Whitlaw Video taped and audio taped	May 26
Paper presentations Construction and maintenance of a landfill Closing and monitoring a landfill Restrictions on restoration. Procedures to open a new landfill Previous restoration methods. Explore's plans for the landfill. Restoration plans for the "new" landfill.	June 7

Schedule of Activities - Phase II

Activity	Date
Introduce study (PHS) - Bea Taylor Webbing activity	October 4
Introduce study (RVGS) - Bea Taylor Webbing activity Table 1 - audio taped	October 5
Landfill Field trip - Catherine Whitlaw Student journals	October 7
Explore Park as a stakeholder - Ginny Laubinger Trash and landfill issues	October 14
Experimental plots on the landfill - Mara Sabre	October 15
Species choices for experiments- Mara Sabre	October 18
Experimental designs Table 2 - audio taped Table 3 - audio taped	October 18
Issues and values - Bea Taylor Table 2 - audio taped Table 3 - audio taped	October 19
Student journals	October 25
Setting up experiments Table 2 - audio taped Table 3 - audio taped	October 29- November 2
Letter writing activity	November 4
Beyond landfills - Dr. John Cairns	December 3
Student reflection papers	December 10
Paper Presentations Closing, monitoring, and reclaiming a filled landfill Opening and monitoring a new landfill Alternatives to landfills	December 14
Post webbing activity Table 2 - audio taped Table 3 - audio taped	December 16
Questionnaire	December 16

Growth Perspectives Interview - Dr. John Kowalski Interview - Mara Sabre	March 17
Student interviews	March 21, 29
Final presentations	March 31
Reflections on final presentations	April 1
Sharing findings with students	May 30

Transcription from Hydroponics Table

J. You'd have to have a triangular shaped tray, kinda.

K. Something that sets like....

J. Yeah. See, that's a triangle, Kim. (laughter)

K. Depends. Well, you could, if you had the long tray, you could set it like that, but the dirt would probably fall out.

J See, if you have a tray and you tilt it, it's still not actually like...there's...

K. Well, the plants will grow straight up to light. They won't grow straight up as to the sides of the pan. It **would** work, but how would you prop it up and keep it propped up?

D. Put a book under it.

K. A book! But that's not the type of slope we're looking at. We're looking at a slope like this.

J. 25 degrees

K. 25 percent

J. A quarter, so what's that? Like....It'd be a....

D. 5 or 6

K. Like over 1.4 something....

J. I'm trying to think where the degrees is

D. At ~~prime~~ of X

J. Like four five would be forty five degrees. No, that's a half.

K. A half has five degrees.

J. Oh, a half pi. A fourth would be.

K. Would be like say, right there.

J. It would be like, I'm trying to think. It would be like.....forty-five, whatever that is, wouldn't it? Am I thinking right or not?

K. Four. Let's see. Half. One half pi is 90 degrees. A fourth pi is 45 degrees. I don't know.

J. Let's see. 90 degrees is here.

D. This is (g). (girls laugh)

J. This is here. So like, 45 degrees is like what?

K. 45 would be 50%

Date: Wed, 20 Oct 93 08:04:20 EDT
From: mara sabre <MSABRE@VTVM1>
Subject: experiments
To: jkowalski@rvgs.vak12ed.edu

Hi John and students,
Got your designs from Bea yesterday. HAve a couple of quick questions and then as the day goes on I will let you all know what I can get to you and when. (I apologize now for all spelling and grammatical errors). First, I can find an air pump for the hydroponics exp't, but the tanks must all be of the same size, and be either 5 or 10 gallons max. For Justin, Brad, and Joel--the design for your sunlight and nutrient content exp't looks good, 2 questions: 1- how will you measure a) the difference between normal and harsh sunlight? How will you create harsh sunlight and normal sunlight? 2-how will you measure the response of your plants to sunlight? 3-how many pots of each plant species will you need? Is there space to replicate your experiment? 5-How will you test for nutrient content, or are you designing an exp't to look at the effects of a particular nutrient?

For Dana, Johanna, and Kim--exp't design seems fine (see above on tank size). I am looking for the solution recommended for normal growth in hydroponic solution, and we may have to go with a more standard species so we can have seeds big enough to begin the experiment. What is your control for the experiment? What is the relevance of including a tank that is nonaerated but has no CO2 added to it?

I will write more later on today--good luck and I hope all is gioing well with you. Again, my E-mail address is msabre@vtvm1.cc.vt.edu
Mara

NOTES FROM BEA TAYLOR

I appreciate your helping me understand better how students learn. As I work with student teachers from Virginia Tech, I hope to share with them things they can do to make learning more meaningful and exciting. The pictures and videos I have been taking will make the experience more "real" for them....just like the trip to the landfill made the experience more real for you.

The tape recordings will also help me understand how groups work together to share knowledge and previous experiences in constructing current knowledge. One person says something and someone else builds upon it. This is not the way teaching has always been. Each person sat quietly and had to "get it for himself". I want to show that sharing information is important and a better way for students to learn.

Many of you have interesting questions and thoughts in your journals. I have tried to answer your questions. For some of them, I have asked you to think a little deeper. I also have questions of my own. I would appreciate it if you would try to answer my questions when you do your next regular entry. I hope this unit is more than just a regurigation of what happened that day; I want you to wonder why and "what if..."

For your next journal entry, I would like you to draw upon your experiences and readings and write a letter to John Hubbard, Director of the Roanoke Valley Resource Authority. (He's in charge of the new landfill, and also is Carolyn Wagner's boss.) I would like for you to ask him any questions you might have about what you have seen, heard, or read in the paper. You might also tell him your impressions or concerns about the new landfill. Imagine this as a friendly conversation or interview.

Mara and I are excited about starting the experiments. We are learning along with you! As we go along, don't forget if you have questions, you can write us on e-mail and we will answer probably quicker than if you wait for us to be at school. My e-mail address is: btaylor@radford.vak12ed.edu

Happy trick-or-treating!

Researcher Journal Entry

Journal - March 17, 1994

Went to Governor's School today to begin interviewing the students. I felt very uncomfortable because I didn't know what they would say and would there be long "blanks" in the discussion. John had said that the students would be doing a lab but that it would not take all period long and I would have time to talk with them later.

I met with Mike first. It was a little stilted, but didn't go too badly. I think he said pretty much what he thought about things. I then talked with Yasmin. She gave me good feedback. Mike doesn't say much when he is at the table with those he feels comfortable with, why do I think that he would be comfortable with me? I think their comments are really going to firm up some of the stances I'll take on my analysis. I did say to several of the students that I would like to talk to them, also. I will go back on Monday when there is supposed to be a substitute and will hopefully finish up, then. I would like to "do" 7 or 8 more students.

After class, John and I sat down and talked. I was very pleased with what he had to say. Again, I think I got very good feedback from him. I think it will make writing this section on "A context for growth" fairly easy.

Rick Shelley stopped me as I was leaving. We stood and talked in the doorway for several minutes. He asked me if he could interest me in coming back to Roanoke to teach at the Governor's School. I told him I was flattered, but I didn't know enough science to teach at that level. He said, "Well, at least you're being honest." I was complemented!

Walked over to PHS to see Ed. He said that Jordan and Jason had not done anything. Jordan said it was because Jason hadn't brought back in the trees. I don't know if they are going to finish with the project or not. I wrote Jordan a message and told him that "Mother Nature" was going to be faster than he at breaking dormancy of the trees.

Had supper with Mara and did my interview with her. We started at Owens but had to move to the car because the noise got so great I couldn't hear her and I knew that it would be very difficult to try to transcribe the tape. She had some good things to say. It is interesting though, she starts a thought and then switches her words to better express herself. I think I do the same thing. I wonder if it is a gender thing, or are we just not thinking before we speak. I guess it is move obvious to me because I had just talked to John and he talks in complete sentences. I'm going to be happy to get this section written! I thought it interesting that they both said some of the same things to my questions.

Transcription Outline

Seating chart...................... i
Dates of Activities...................... ii
Mara's journal , Aug 11...................... 1
RVRA Meeting Agenda, Aug 19, 1993...................... 2
RVRA Meeting, Aug 19, 1993...................... 3
*neighborhood wants road repaved
*Handi-dump concerned about new rates
*RVRA says looking at "long-term plan"
*sponsor "Garbage and All That Trash"
Science Museum proposal...................... 6
Journal, Mara & Bea planning, Aug 20...................... 7
*plant experiments
*soil (compacted/noncompacted)
*germination rates
*intra-specific aggression
*inter-specific aggression
*rooting depth
*hydroponics
Journal, Sept 16...................... 8
Governor's School planning with John, Sept 16 9
*field trip
*lecture - Ginny Webb
*Bea - introduce and webbing activity
*Mara - research projects
*Want students to:
-work in small groups
-journal
-complete questionnaire at end
-give recommendations for seeding
-conduct a community survey
*Tentative dates:
-Oct 4..introduce
-Oct 7..landfill field trip
-Oct 14..Ginny Webb (Explore)
-Oct 18..Mara explain her research
-Oct 18 - Nov 15..students work with experiments
-Thanksgiving...papers and projects completed
Journal (Ed), (John, & Rick), Sept 28...................... 12
*Ed - going to have to drop out
*Suggested class do:
- intro, webbing, fieldtrip & Ginny
-exit slips
-we work with interested students
-reflection paper of what learned about fieldtrip & Ginny's talk
-work through VaPEN
*John & Rick
-permission slips had to do with study, not the class
-who owns the manuscript?
-is RVGS co-author?
-possibility of presenting collaboratively?
-can Mara and I judge science fair projects Feb 5, 8:30-1:00
-why VJAS won't allow collaborative work
Journal, Intro. Project at PH, Oct 4...................... 15

APPENDIX B

PHS Assignments and Student Work

Honors Biology
Science, Technology, and Society Project
Landfill Restoration Part I - Construction, Maintenance, Closing, & Restoration of Landfills

oduction :

Human population growth and the improvement of living conditions has increased the stre the environment. Accompanying this growth is the need for additional sites for disposal of wastes, industrial and household. This places further stress on the environment. In order to maintain a balance for a healthy ecology, it is going to be necessary to restore sites whose usefulness as disposal stations has been completed. Restoration, as defined here, is the "recreating both the structure and functions of the damaged ecosystem" (Cairns, 1991). "In the past five years, 20 % of the nations 6000 landfills have closed, and another 30 % are scheduled to be closed in the next five years"(NSWMA report, 1992). It has also become increasingly difficult to find locations for landfills because of the opposition of the public to having such a facility near them. This opposition might be tempered if, before a landfill was opened, there was already a projected restoration plan that has been understood and agreed upon by the public.

Purpose :

1. To acquire baseline data on construction, maintenance, and closing of landfills.
2. To relate the above information to the closing (Fall,1993) of the current RoanokeValley Regional landfill and subsequent opening of the new landfill.
3. To determine the positive and negative aspects of the various land restoration options available to Explore Park.

References :

1. Articles : recent and current information from newspapers, magazines, periodicals. At least five articles (more is better) must be used.
2. Personal Communication : At least three (3) personal contacts by either phone, letter, or in-person interview. Letters, interview topics, and questions need to have **prior** instructor approval. One of the three contacts should have an opposing view from the others.

Information to be Gathered :

1. Select specific problem/issue/concern.
2. Collect background information on the topic (This should be brief).
3. Identify "players" and their positions on the issue. "Players" include leading authorities, special interest groups, local, state, & national organizations, industries & companies, etc.
4. Explain the beliefs and values of the players that contribute to their positions on the issue.
5. Suggest alternative actions to the present course of action.

Products of the Project:

1. Compose an issue analysis report (<6 pages).

2. Members of each group will get together to compose a report that summarizes all group findings. This report will be the primary source of information for students in school year 1993-94 to continue research into the landfill restoration project of Explore Park.

3. Fifteen minute oral presentation for each group. This will include appropriate visual aids such as overhead transparancies and handouts.

Project Due Dates:

Fri. 23 Apr 93 : Define topic.

Fri. 30 Apr 93 : Reference and notes check.
Evidence of attempts at personal contacts and list of potential contacts.

Fri. 7 May 93 : Progress Check.

Fri. 14 May 93 : First draft of issue analysis report

Fri. 21 May 93 : Final draft of issue analysis report

Tue - Thu. 25-27 May 93 : Oral Presentations

Issues:

1. How are landfills constructed ? How are landfills maintained ? How long are landfills used ?

2. What are the steps to closing landfills ? What are monitoring procedures in closing and closed landfills ? (In Virginia prior to Oct. 93 and after Oct. 93)

3. What are the restrictions on restoration of closed landfills ? What are the requirements, procedures, etc. to open new landfills ?

4. What are the restoration methods previously used on reclaimed land ? What are Explore Park's plans for restoration of the closed landfill ? Are there plans for restoration of the new landfill once it closes ?

Group Presentations

Landfill Usage

I. Roanoke Valley Regional Valley Landfill

a.) Trash picked up from homes

b.) Each vehicle brings it's trash to the landfill, is weighed and charged $25 for every ton of trash. Receives over 900 tons of trash daily.

c.) Trash is dumped into a primary building and sorted. Drums and c checked for hazardous wastes.

d.) Garbage is then compacted into a 4ft. x 3ft. x 5.5ft. bail of solid trash. Each of these weighs about a ton and a half.

e.) Ten bails are loaded onto a flat bed truck and emptied at the burial site

f.) Trash then compacted by a 90,000 lbs. compactor truck

g.) Covered in about 4 in. of soil

II. Smith Gap Landfill

a.) Trash collected

b.) Wastes transported to the transfer station. Loaded on rail cars.

c.) Cars are sealed and locked and travel on the rails to the Smith Gap Landfill Tipper Building.

d.) There, the cars are emptied and the contents inspected

e.) Trash is carried to the burial site by truck

Group Presentations

Landfill Construction

I. Choosing a location

a.) neighboring land owners

b.) water table

II. Smith Gap location selection

a.) enclosed by mountains

b.) not visible to motorists

III. Interior lining - REQUIRED

a.) layer of plastic

b.) layer of sand and gravel

c.) another layer of plastic

IV. Interior lining - SMITH GAP REGIONAL LANDFILL

a.) 2 feet of compacted clay

b.) Geotextile & Geomembrane Liner - 60 mil (approx. 6/100 in.)

c.) 18 inches of stone drainage layer

d.) Geotextile layer

V. SMITH-GAP LANDFILL

a.) Roanoke Valley Resource Authority controls design, construction and operation

b.) expected to be completed by October 1993

c.) 1st in U.S. to be a totally rail hail waste disposal system, will eliminates trucks

d.) costs about $33 million - funded by revenue bonds, from waste disposal fees

Landfill Life Expectancy

I. Life span (in general)

a.) dependant upon population surrounding it

b.) size of landfill

c.) environmental issues may cause condemnent

d.) no certain time limits on landfills

II. Life span (specific)

a.) Roanoke Valley Regional Landfill has served Roanoke City, Roanoke County and Vinton since 1976

b.) Smith-Gap Landfill is expected to be in use for 60 to 70 years

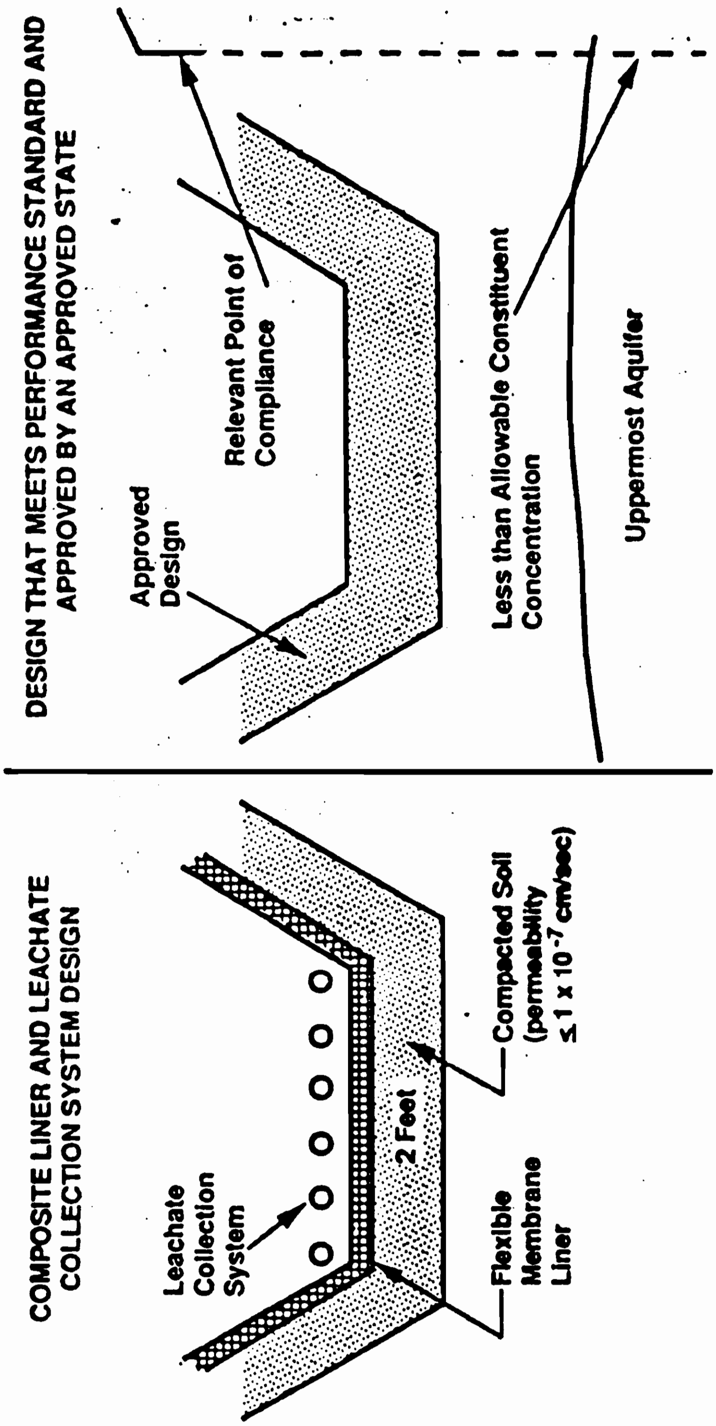
How are Landfills Maintained?

1. Old Landfill
   * Considered ancient compared to new landfill maintenance
   * Receives 900 tons of garbage daily
     - Vehicles are charged $25 for each ton of trash they bring in
   * Trash is taken to primary building to be made into bails
   * Trash is carried to site to be buried, compacted by a 90,000 lb. compactor truck, and covered by 4 ft. of earth.
   * Old Landfill will be monitored for 10 or 30 years (depending on closing date) for leachate, seeding, and gases.
2. New Landfill
   * Waste is transported to the transfer station, loaded on rail cars, and taken by train to Smith-Gap Landfill Tipper Building.
   * When the trash arrives to the Tipper Building it will be inspected and then taken by truck to burial site.
   * No hazardous wastes are going to be allowed into the new landfill, it will be inspected at the Tipper Building.

Figure 4

DESIGN CRITERIA

New MSWLF units and lateral expansions must have one of the following designs:



BILLING CODE 6560-50-C

APPENDIX C

Issues and Values Lesson

Vocabulary

Environmental problem
Occurs when the condition of something or someone in the natural environment is threatened by a change.

a. man-made events
b. natural events

Issue
A problem becomes an issue if two or more people disagree about the problem and/or its solution.

Players
Are the individuals, groups, or organizations involved in an issue.

Position
Each of the players has a specific idea about what should be done about the issue. This idea is called the player's position.

Beliefs
Is an idea that a person hold. The person thinks or believes that the idea is true. In reality, it might or might not be, but the person believes that it is. Often these beliefs are strongly related to one's values.

Values
Values are specific ideas which help an individual decide what is important or worthy. It is the comparative worth a person places on something. Might involve money, status, beauty, religion, etc.

VALUE DESCRIPTORS

The descriptions below attempt to name and define values that might be held by individuals. These definitions, as well as the list itself, are incomplete.

Political:	the activities, functions, and policies of governments and their agents.
Economic:	the use and exchange of money and materials.
Religious:	the use of belief systems based on faith or dogma.
Ecological:	the maintenance of the integrity of natural systems.
Scientific:	concerning empirical research; knowledge gained by systematic study.
Cultural:	pertaining to the continuation or preservation of human knowledge, beliefs, values, art, customs, etc.
Educational:	concerning the accumulation, use, and communication of knowledge.
Aesthetic:	the appreciation of form, composition, and color through the senses.
Social:	pertaining to shared human empathy, feelings, and status.
Recreational:	pertaining to leisure activities.
Egocentric:	pertaining to a focus on individual self-satisfaction and fulfillment.
Ethnocentric:	pertaining to a focus on the fulfillment of ethnic/cultural goals.
Health:	the maintenance of positive human physiological conditions.
Ethical/Moral:	pertaining to present and future responsibilities, rights and wrongs, and ethical standards.

Note: There are many types of values. This is only a partial list.

Examples of Value Statements

Each set of statements below reflects a specific value.

1. **SCIENTIFIC VALUES:**
   Example 1: Conducting research on cancer is extremely important.
   Example 2: Data indicate that higher speeds cause more traffic deaths.

2. **ECONOMIC VALUES:**
   Example 1: Preventing acid rain will be very costly to some industries.
   Example 2: Doctors are rich; I want to be a doctor.

3. **MORAL/ETHICAL VALUES:**
   Example 1: It's your responsibility to prevent forest fires.
   Example 2: Do to others what you would have done to you.

4. **POLITICAL VALUES:**
   Example 1: Endangered species laws are needed to protect certain animals.
   Example 2: The teacher's classroom rules were strict..

5. **AESTHETIC VALUES:**
   Example 1: Red sunsets are beautiful.
   Example 2: The bubbling sound of the mountain stream was pleasant.

6. **EDUCATIONAL VALUES:**
   Example 1: To remain strong America needs informed citizens.
   Example 2: If rain forests are destroyed, we might never learn their many secrets.

7. **RECREATIONAL VALUES:**
   Example 1: Catching a six pound bass is a big thrill.
   Example 2: Recess is the best part of school.

8. **HEALTH VALUES:**
   Example 1: Cigarette smoking can reduce the length of your life.
   Example 2: Meals should contain foods from each of the four main food groups.

9. **SOCIAL VALUES:**
   Example 1: All my friends have new sweaters. I need one too.
   Example 2: When my family moved, I missed my friends the most.

10. **EGOCENTRIC VALUES:**
    Example 1: If it feels good, do it.
    Example 2: This is good for my family, so it should be done.

11. **CULTURAL VALUES:**
    Example 1: The tribe used the same marriage ceremony for centuries.
    Example 2: The Aztecs believed in human sacrifices.

12. **RELIGIOUS VALUES:**
    Example 1: Prayer is the only solution to the problem.
    Example 2: The Bible says that it is sinful to steal.

Value Statement Worksheet

1.
Conducting research on cancer is extremely important.
Data indicate that higher speeds cause more traffic deaths.

2.
Preventing acid rain will be very costly to some industries.
Doctors are rich; I want to be a doctor.

3.
It's your responsibility to prevent forest fires.
Do to other what you would have done to you.

4.
Endangered species laws are needed to protect certain animals.
The teacher's classroom rules were strict.

5.
Red sunsets are beautiful
The bubbling sound of the mountain stream was pleasant.

6.
To remain strong, America needs informed citizens.
If rain forests are destroyed, we might never learn their many secrets.

7.
Catching a six pound bass in a big thrill.
Recess is the best part of school.

8.
Cigarette smoking can reduce the length of your life.
Meals should contain foods from each of the four main food groups.

9.
All my friends have new sweaters. I need one, too.
When my family moved, I missed my friends the most.

10.
If it feels good, do it.
This is good for my family, so it should be done.

11.
The tribe used the same marriage ceremony for centuries.
The Aztecs believed in human sacrifices.

12.
Prayer is the only solution to the problem.
The Bible says that it is sinful to steal.

ISSUE ANALYSIS WORKSHEET

THE ISSUE:

THE PLAYERS AND THEIR POSITIONS	THE PLAYERS' BELIEFS	THE VALUES

APPENDIX D

Student Documentary Materials

Student Journal Entry

Tuesday Oct. 5

Presentation by Ms. Bea Taylor

Ms. Taylor's presentation was very informative. She went over many facts I had not realized about the landfills and wastes produced by Americans. I did not know the immense ~~amou~~ amounts of trash produced in America each year. She stated that ten percent of all trash is recycled. I had thought that this figure was much ~~high~~ higher considering the publicity of recycling. She then stated that over half of the trash not recycled is recyclable. I felt this figure was staggering and I wondered why so little is being done with so much. WHY DO YOU THINK PEOPLE DO NOT RECYCLE?

Before Ms. Taylor's presentation, I had never heard of leachate. It was very suprising to learn that the people who make ~~toxic~~ landfills know about the toxic chemicals, but do almost nothing because it involves too much time & money.

Landfill

Student Journal Entry

Positive

We got to learn how the landfills worked, both old and new.
We were able to see how much better the new landfill is.
We got to see how much space the trash takes up.

Negative

We really didn't get to see very much at the old landfill. We weren't able to get out and watch the baling process, etc.

The male guide at the old landfill didn't seem to know exactly what to do with us. he didn't give us too many facts, and it was hard to hear him.

Forest Walk

Positive

I learned a lot about trees and how they grow.
The core samples were neat.
Our guide was really nice and seemed to know what he was talking about, and he readily answered questions.
We got to do things besides just sitting there and listening. we had hands on activities like finding the diameter and height of a tree, finding its age, and getting core samples.

Negative

It was cold.

I didn't really learn much about how the landfill affects Explore.

Nov. 3, 1993

Letter to RVRA Director

Dear Mr. Hubbard,

I recently visited the old Roanoke City Landfill and the site for the new Roanoke Regional Landfill. I was very impressed with the new landfill. The improvements made in the lining were impressive as they dealt more effectively with the problems of leachate and methane gas. The newer site is definitely safer for the surrounding environment. I also like the way the trash is checked for hazardous waste. However, I think that not only should all hazardous wastes be removed, but all recyclable items should be taken out as well. We need to motivate the people to recycle as much as possible, and we also need to take out of the landfill waste any recyclable items they may have missed. But we need to be careful not to make people think that it is not necessary for them to separate their recyclable goods because the city will do it anyway. That is why I think that we should fine people for every pound of recyclable items they try to throw away. When the trash is picked up to be taken to the landfill, it should be checked for things that could be recycled, and these are taken out and taken to a recycling center. The person who tried to throw the items away is then fined according to the weight of the items. That way people will be motivated to recycle, but things that are just thrown away will be caught and recycled anyway. This also punishes people who do not recycle by costing them money.

Another question I have concerns landfill reclamation. Plants grown on former landfills cannot have root systems over six inches deep. This eliminates many plants, especially trees. However, I believe that trees are necessary in reclamation. They help prevent erosion provide habitats for animals, attract people, and they have their own natural beauty. I believe it would be worth while to have a deeper cover of soil over the old landfill in order to plant trees and increase the possibilities of what can be done on the land.

If the rule about six inch root depths is kept, then more research is needed to determine which plants should be grown at the landfill. Most grasses have root depths greater than six inches. However, not a lot is known about the root depths of most plants, so it unclear which plants should be used. Other factors, such as nutrient content will affect the plants' growth. Therefore, I believe much testing is needed before planting anything on the reclaimed landfill soil.

I am really excited about the new landfill program, and I hope you will take the time to consider my questions and suggestions.

Sincerely,

Nov. 5, 1993

Simulated Response From RVRA Director

Dear ,

~~It~~ I am very pleased to hear of your concern for the new landfill. Your suggestions ~~show~~ about recycling and reclamation are very sound ones, and ideally, ~~the~~ would ~~implement~~ be implemented at the new landfill. Problems, arrise, however, in their practicality. It would certainly be ideal if all of the ~~trash &~~ recyclable material could be ~~extracted~~ removed from the garbage; however, this would involve a great deal of time and money. ~~within~~ Because the trash could not be processed very quickly, ~~the~~ removing recyclables would also be very inefficient. Fining those who throw away recyclables is ~~also very~~ difficult because most household garbage comes to the transfer station in trucks. ~~and~~ The owners of the garbage therefore cannot be traced.

The deeper topsoil cover on the old landfill could also pose problems in terms of the time and money needed to add the extra footage of soil. You ~~ar~~ make a good point, however, in that more research needs to be done concerning the plants used as landfill cover.

I really appreciate your concern about the landfill, and will take your ideas into consideration.

Sincerely,
John Hubbard

Reaction Paper to Dr. Cairn's Talk

Dr. Cairns Lecture

Dec. 10, 1993
AM 2

In his lecture, Dr. Cairns discussed a variety of factors which correlate to environmental impact around the world. The three major factors were population, affluence, and technology. Throughout his talk Dr. Cairns compared the changes in these factors between China and the United States. I really liked the way that Dr. Cairns placed an emphasis on how affluent and wasteful the United States is. I don't think that we as a nation have a right to try to limit the energy consumption of others when we already use so much more than our fair share. I do think that the U.S. needs to start taking some measures to cut energy consumption, however, this will be difficult because Americans are used to a very wasteful lifestyle. I think Dr. Cairns made a very good point when he said that what we think of as necessities, other countries think of as luxuries. ~~This is not only true for class~~ Our lifestyle is much more wasteful than the other wealthy industrialized countries.

- In order to combat this problem, I think that Americans need some additional motivation. The fact that our environment may suffer drastically in the future is too much of a long term consequence to motivate people to sacrifice. Most people respond best to short-term consequences, therefore the government needs to either impose more regulations on energy consumption or provide more economic incentives to cut back. Perhaps by increasing the taxes on ~~energy such~~ as gas, electricity, etc. Americans would be more motivated to use public transportation and would buy ~~buy~~ appliances that consume less energy.

Reaction Paper to Dr. Cairn's Talk

I found Dr Cairn's lecture very intriguing. He really made an effort to present his information as clearly and concisely as possible. I didn't understand everything but his primary message came through loud and clear.

Dr. Cairns presented us with a frustrating dilemma of energy consumption, a classic case of "haves v. have-nots." The Impact equation was especially inventive. I was a little surprised, however, at Dr. Cairns attitude towards the problem. He seemed intent on impressing upon us both the urgency and the futility of finding a solution. One would think that a person of his experience would at least offer some guidance or clues to an answer.

Another thing I noticed was Dr. Cairns seeming eagerness to look to other countries for solutions. While this is certainly helpful, I would remind Dr. Cairns that ideas which seem perfectly sensible to the French or the Swedes might be complete anathema to Americans. The fact that most people aren't well-versed in ecology or the facts of biodiversity and habitat destruction may have something to do with that but it is a reality nonetheless. Our energy consumption problem will inevitably become a matter of politics and ideology.

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

University Center for Environmental and
Hazardous Materials Studies

1020 Derring Hall
Blacksburg, Virginia 24061-0415
(703) 231-5538 Fax: (703) 231-9307

December 14, 1993

Dr. Cairn's Response to Students

Dr. John Kowalski's Biology Class
Roanoke Valley Governor's School
  for Science and Technology
2104 Grandin Road, SW
Roanoke, VA 24015

Dear Class:

Mara and Bea have shown me your comments, and I really appreciate knowing that some of the points got across as well as they did. Some of you had questions, and I'll answer them in the order in which I was exposed to them.

1. . - John Holdren and Paul Ehrlich, who developed the I = P X A X T equation, used energy because John Holdren is in the Energy and Resources Program at the University of California at Berkeley. However, there are a number of other ways of determining affluence. For example, last summer, I taught a class in Colorado where water is extremely scarce. Nevertheless, in one small city that I examined, the per capita daily use of water was approximately 236 gallons a day for all purposes, including such things as filling swimming pools and watering lawns. Another way to measure affluence is how much of the natural resources we "use" are thrown away rather than recycled. This does not fit precisely the dictionary definition, but it does fit the one in the equation. Another is how much energy we use for each calorie we obtain from the agricultural industry. For example, in affluent countries, food is often highly processed, whereas, in developing countries, it is usually from nearby sources and in the form that it was produced on the farm. You and the rest of the class might be interested in developing more ways to categorize affluence.

Your second question is, does this mean that if the population continues to grow, we eventually totally destroy the environment - I doubt if human society is capable of totally destroying the environment, although most ecologists would disagree with this. I would not recommend changing population growth rates in such a way that humans presently alive suffer. Another way to look at the problem is, if we preserve our natural resources as opposed to using them as rapidly as we are now doing, which strategy will permit the largest number of humans to inhabit the planet over a long period of time? Your generation will provide the answer to that question, not mine.

2. - Technology is the most difficult part of the three units in the equation. For example, many Americans have huge lawns which could be replaced by ground cover that doesn't need cutting

or some other form of vegetation not requiring the attention that grass does. Alternatively, the grass could be cut by human labor, which would use less fossil fuel energy but would be much more expensive as things are now done. Another way to look at the technology problem is how we get to and from work. In Japan, most of the commuting is by high-speed, very efficient transportation. Because of the way in which their population is distributed, this is much more acceptable than in the United States. There are also the so-called clean technologies, such as heating water for domestic use with solar collectors or even producing household electric energy with solar collectors or windmills with the energy stored in batteries. It was because of the difficulty in handling the technology part of the equation that Holdren focused on energy because the amount of energy needed to accomplish a particular task is one of the best ways to measure technological efficiency, as is the case for getting commuters to work by public transportation. If we measure technological efficiency in terms of convenience -- that is, the most convenient to the individual rather than the most energy efficient -- then, of course, one comes out with a different answer. I am delighted that you and others raised some of these issues because they are the sort of thing that your class should really discuss and exchange ideas on. I have not only children and grandchildren, but 72 graduate students got either Ph.D.'s or M.S. degrees with me and I have had literally thousands of students in university classes. I hope they will have a good life, but this will not happen unless we plan carefully.

I am really optimistic about what we could do (although this obviously didn't come across as strongly as I had intended) but pessimistic about what we will do unless there are discussions such as the one that your class has held. I have enjoyed teaching for most of my lifetime because I really do have faith in the ability of present students to solve problems when they graduate. Yours is the first generation to be faced with problems in a global context, and my generation is the first to become aware of them in a global context. Awareness is a necessary precursor to solutions and the fact that I offered no solutions is not due to a lack of interest, but rather because I think the solutions should be based on social decisions rather than scientific decisions, although I hope scientific evidence will play a big part in the social decisions.

3. - Do you think that, if environmental literacy were increased worldwide to the level that your class is achieving, that a compromise could be worked out among the countries of the planet between the year 2030 and the year 2050 when ecologists predict that changes will be forced on us if we do not make them ourselves?

4. - I agree that we must use the words "clean technology" very carefully in the broadest possible context.

5. - I can't answer your questions on either acid rain or global warming because the worst of the predictions are based on models rather than hard empirical evidence. The models are, of course, based on available evidence, but on problems of a global scale or even a large regional scale, they are incomplete because we have not gathered much of this type of evidence in the past. Additional questions you might want to consider: (1) Even if an event such as severe global warming is improbable (but still possible) and the consequences appear to be very severe if this occurs, should we take whatever measures possible to prevent it? (2) Do you think there are things that would reduce the probability of global warming that would also be beneficial to human society? For example, developing a U.S. energy policy that would include more emphasis on public transportation and energy efficiency. (3) How many things can you think of that would help reduce the probability of global warming that would be good for human society even if the predictive models are wrong?

Although I did not respond to each letter individually, I did read all of them carefully and am honored by the fact that you took time to write! I was also pleased by the fact that you questioned many of the issues raised -- you should! I am constantly re-examining my own thoughts and expect everyone else to do the same thing. There are a few other points that ran through many of the letters, to which I did not respond individually but to which I would like to respond collectively:

1. I went over the Swedish consideration of developing a per capita energy policy, but that's all it was. It is not yet in force. Despite the fact that Sweden is a monarchy, it does have many attributes of a socialist society. Furthermore, it is a small and comparatively homogeneous country compared to the U.S. and, therefore, a consensus is easier to reach. Even then, the tentative policy that a member of the Swedish National Academy of Sciences discussed with me is still under consideration and will probably be bitterly opposed by substantial segments of that society.

2. I am a firm believer in maximum personal choice! I think human society will make the most informed choices about the environment as environmental literacy increases. I also feel that human society functions best when motivated by a set of guiding beliefs commonly shared (the Greeks called it ethos) which make formal legislation unnecessary because of social pressures to act for the common good. I have corresponded extensively with colleagues in many countries and think our guiding beliefs are frequently more similar than our economic status.

3. The problems are indeed challenging and difficult but are amenable to solution with presently available information. Furthermore, we have just entered the Information Age and have just

become aware as a society that we are in a global marketplace. Communication and gathering of information has greatly improved, but our ability to make social decisions in the face of this overwhelming flow of information has not. This is a transient problem only requiring the computer literacy I saw in your class and the environmental literacy which you are acquiring.

4. When I was your age, I was taught that an atom couldn't be split. An exceedingly difficult scientific problem was solved in doing so, but many societal problems were then created. Unfortunately, our abilities to solve scientific problems have surged far ahead of our ability to solve societal problems. About half my correspondence is with colleagues in other countries. I am, for example, an overseas reader for dissertations in a number of universities in India where the students ride bicycles to their research sites. I correspond with one of the chief environmental scientists in Russia where there are many more severe environmental problems than there are here. Despite the turmoil in that country, he is optimistic about resolving these problems as are colleagues in eastern Europe and various parts of Asia. I think if they can be optimistic about the future of the relationship between human society and the environment, it should be less difficult for us to be so. Look at the marked efficiencies in energy use that we developed during the period of oil shortages that occurred in the early 70s in this country.

I was delighted that the class did not fall into the all-too-frequent trap that persons advocating the protection of the environment were not against human society or that people who wanted human society on the whole planet to be raised out of poverty were against the environment. I don't think it's a "them against us" situation -- that is, "them" are all the organisms out there and "us" are humans -- because all living things need healthy conditions to flourish.

It was great fun meeting with your class, and I am delighted that I provoked some interest and discussion! I believe the solutions to these problems are primarily in your hands, although I intend to do my part.

Good luck with your studies, and, again, many thanks for helping Mara and Bea with the landfill project!

Cordially,

John Cairns

John Cairns, Jr.
University Distinguished Professor
of Environmental Biology
and Director

JCAIRNSjr:thm

APPENDIX E

RVGS Assignments and Student Work

RVGS Assignments and Student Work

Where Does All the Trash Go? Landfill Issues in the Roanoke Valley

A cooperative learning project conducted by biology students
at the
Roanoke Valley Governor's School for Science and Technology
and
Patrick Henry High School
in conjunction with
Virginia Tech and Virginia's Explore Park

Sponsors

John Kowalski
Roanoke Valley Governor's School for Science and Technology

Ed McMichael
Patrick Henry High School

Bea Taylor and Mara Sabre
Virginia Tech

Virginia Webb
Explore Park

Carolyn Wagner and John Hubbard
Roanoke Valley Resource Authority Board

American Society of Foresters

STATEMENT OF THE PROBLEM

How much trash do each of us produce? What happens to the trash after it is taken away from our homes and businesses? What is the economic cost of trash to individuals and society? What effect does it have on the environment? Can trash be a political issue? Until recently most individuals did not concern themselves with these questions. Why is this situation changing? Why are communities asked to recycle? Why is the cost of trash removal increasing at a much higher rate than the rate of inflation? These and other questions are the focus of this interdisciplinary unit which will examine the current landfill situation in the Roanoke Valley.

Unit Outline

SCHEDULE FOR GOVERNOR'S SCHOOL STUDENTS

October 5	Introductory lecture by Ms. Bea Taylor and Dr. Kowalski
Oct. 4 - Dec. 17	Each student maintains personal journal.
October 7	Field trip with Patrick Henry students to the old and new Roanoke landfills conducted by Carolyn Wagner and John Hubbard of the Roanoke Valley Resource Authority Board.
October 8	Lecture by Ms. Virginia Webb of Explore Park on the impact of the landfill on the Roanoke area and Explore Park.
October 12	Field trip to Explore Park to learn forestry management techniques and see the effects of a nearby landfill on a natural area. Volunteers from the American Society of Foresters will conduct the classes.
October 15	Lecture by Ms. Mara Sabre of Virginia Tech on landfill restoration and student research project with restoration plants.
October 4 - 29	Students prepare written and oral reports on selected magazine and journal articles and videos related to the environment.
Oct. 14 - Nov. 19	Student cooperative learning groups prepare papers on one of three topics. Managing an old landfill, Technology for constructing a state of the art landfill, Alternatives to landfills.
Oct. 18 - Dec 17	Student cooperative learning research projects with plants suitable for landfill restoration.
December 20	Summary session with oral presentations by the students. Patrick Henry High School students are invited to attend and participate.

GOVERNOR'S SCHOOL BIOLOGY
Dr. Kowalski

LANDFILL PROJECT
Assignment 1
due date: October 8, 1993

Read the article "I learned that it just keeps getting deeper" by Richard Wolkomir which appeared in the April, 1990 issue of Smithsonian magazine.

Prepare a paper in which you list (in your opinion) the ten most important or significant ideas, thoughts, concepts, etc. Please summarize each idea and indicate why you think it is important or significant in three or four sentences. Your paper must be double-spaced typed.

GOVERNOR'S SCHOOL BIOLOGY
Dr. Kowalski

LANDFILL PROJECT
Assignment 2
due date: October 22, 1993

WASTE MANAGEMENT BASICS

You have been asked to present a 45 minute lecture on solid waste management, landfills, and recycling to a science class at your home high school. Your talk should include scientific, social/political, and economic aspects of the topic. Please prepare a lecture outline for your talk suitable for use on an overhead projector . Your outline must be typed. The outline should contain the following sections.

1. A one sentence statement of each important concept you will cover in your lecture (all capital letters).

    2. A listing of topics under each concept (complete sentences).

        3. A listing of important facts, points, ideas, etc. under each topic (phrases or complete sentences).

Your outline will be graded on its completeness, accuracy, and organization.

You may use any resources you have for preparing your outline. However, your primary resources are the following two articles.

> O'Leary, P.R., Walsh, P.W., Ham, R.K. Managing Solid Waste. Scientific American, vol. 259, December 1988.
>
> Miller, G.T., Jr., "Living in the Environment". Wadsworth Publishing Co., Belmont, CA., 7th.edition, 1992. pp. 519-539.

GOVERNOR'S SCHOOL BIOLOGY
Dr. Kowalski

LANDFILL PROJECT
Assignment 3
due dates: See listing below

LANDFILL GROUP PAPER

OBJECTIVE

Students working in groups will investigate one of three topics related to landfills and solid waste management.

- Closing, monitering, and reclaiming a filled landfill.
- Opening and monitering a new landfill.
- Alternatives to landfills.

All aspects of the issue should be investigated including the scientific/environmental, social/political, and economic. Issues specific to the Roanoke area and /or Virginia as well as issues of national scope must be part of your presentation. Both qualitative and quantitative information should be included. The paper must be prepared using a word processor and include relevant data tables, graphs, charts, etc.

REQUIREMENTS

1. A current landfill-related issue with implications to Roanoke or Western Virginia is selected and the stakeholders (players) and their respective positions concerning the issue identified; their beliefs and values explored; and alternative actions or strategies to the present situation offered.

2. Bibliography and computerized literature search is compiled. The computerized search must be done using both General Science Index and Reader's Guide. Other databases may be used as needed.

3. Relevant data on the topic is clearly organized and presented using appropriate computer software and, if appropriate, statistical measures.

4. At least one resource person is interviewed who can provide access to information relevant to the topic.

5. An issue analysis report based on research involving both library and human resources is written by each group.

6. A group presentation (oral with visual aids) to the class (10 minutes) is conducted.

ISSUE ANALYSIS REPORT

Approximately 7-10 pages (double-spaced typed) describing the issue, the players involved and their beliefs and values, and possible solution strategies.

Must include tables of data, graphs, and narrative analysis of the data.

Bibliography: Evidence of a computer search of literature and contributions of resource individuals must be presented. References must include books, journals, and personal contacts (minimum of 10). The bibliography should include only those references actually cited in the paper.

DUE DATES

1.	10/22/92	Selection of group members and topic. (5 points)
2.	11/5	Turn in evidence of library searches including computerized literature searches, books, pamplets, articles, etc. that will be used to write the paper. (20 points)
3.	11/19	Report on personal contact and materials obtained from the contact person. (20 points)
4.	12/3	Typed draft of issue analysis report. (20 points)
5.	12/10	Final draft of issue analysis report and one page summary. (25 points)
6.	12/14	Group oral presentation. (10 points)

Opening and Monitoring a New Landfill

December 6, 1993
Biology - AM-2

There are many different aspects involved in opening and monitoring a new landfill. There are many stiff government regulations that each municipality must comply with. There are also social, economic, and environmental questions to consider. With so many different views and players, opening a new landfill can be a very long and difficult process.

Government regulations (Federal, State, and Local) greatly influence where, when, and how landfills are opened. Over the last few decades, the United States has begun to realize the need for laws regulating solid waste disposal. As the years have passed, these laws have gradually become stricter and more specific.

On October 20, 1965, the 89th Congress passed Public Law 89-272, also known as the Solid Waste Disposal Act. This act gave national attention to the problem of solid wastes. It not only publicized the problem, it also guaranteed the funding "provided for development and experimental approaches... [in] all phases [of solid waste management/disposal], particularly the engineering, planning, sanitation, and health aspects..." (Mantell,1975 -a). In the document's own words, it was an act "...to authorize a research and development program with respect to solid waste disposal, and for other purposes." (Mantell ,1975 -a). Though this act was later amended (recorded in House Report No. 899), the Solid Waste Disposal Act gave political and economic exposure to solid waste management.

Since 1965, population growth has increased the flow of solid waste and the need for proper disposal. Technology has allowed for new techniques of 'proper disposal' and how to improve it. Research has presented facts making it obvious to the government that new laws needed to be passed regulating the disposal of solid waste. The most popular form of solid waste disposal is the sanitary landfill, or what used to be the dump before regulations forced them to clean up their act.

Currently, new landfills are being installed and opened at an awesome rate. These installations are regulated by government laws. Some such laws prohibit the disposal of hazardous wastes in sanitary landfills. Special, carefully monitored disposal is necessary. Many cities have Household Hazardous Waste Collection Programs. (See Table 4.5) The Roanoke Valley Resource Authority sponsors a yearly Household Hazardous Waste Collection Day to gather those wastes not allowed in the landfill (McCue,1993). Also, the Smith Gap landfill in Roanoke County will sort out hazardous wastes before dumping the collected household wastes into the landfill, as did the Roanoke Regional Landfill.

Several of the regulations that the Roanoke Valley Resource Authority faced delt with hazardous wastes. EPA Regulations for Tdentifying Hazardous Waste, 40CFR 261, 45FR 33119 of 1980 (most recently amended in 1987) set forth requirements used in identifying hazardous wastes restricted from landfill disposal. Also, Virginia Hazardous Waste

TABLE 4.5

COMPARISON OF HOUSEHOLD HAZARDOUS WASTE COLLECTION PROGRAMS[1]

PROGRAM	# HOUSEHOLDS IN SERVICE AREAS	HOUSEHOLDS PARTICIPATING	OPERATIONALS[2]	COST/ HOUSEHOLDS PARTICIPATION	MAJOR WASTE DESTINATION
Fresno CO., California	110,000	600	$ 20,000[3]	$ 33	Secure landfill (CA)
Marin Co., California	60,000	1,000	38,928	39	Secure landfill (CA)
Orange Co. California[4]	750,000	3,313	281,271	86	Secure landfill (CA)
Palo Alto, California	15,000	250	20,000	80	Secure landfill (CA)
Sacramento, California	230,000	1,024+	34,713[5]	34	Secure landfill (CA)
Santa Barbara, California	55,000	375	22,863	61	Secure landfill (CA)
Lexington, Massachusetts	10,000	137	8,000	58	Secure landfill and incineration (IL)
Bedford, Massachusetts	4,297	132	8,100	61	Secure landfill (NY) & and incineration (IL)
Lebanon, New Hampshire[6]	13,194	240	13,718	57	Secure landfill (NY) Fuel blending (CT)
Morris Co., New Jersey	138,000	98[7]	20,000	204	Incineration (SC) & secure landfill (NY)
Albuquerque, New Mexico	100,000	1,012	53,524	53	Secure landfill (SC) and incineration (ARK) Storage facility (NC)

Rhode Island	State Program	583	25,666	[illegible]	Incineration & some to landfill ([illegible] RI)
Travis Co., Texas	234,432	450	59,193	132	Landfill (LA)
Fairfax Co., Virginia	244,000	724	112,560	155	Incineration (TX & LA)
Waukensha Co., Wisconsin	93,000	228	33,068	145	Secure landfill (SC) Incineration (IL, NY)

Notes:

1. Prices vary according to amount of labor/labor costs, mileage to facility, waste treatment/disposal method used, prices of individual firms, number of participants, type and amount of waste collected, and cost reductions given by hazardous waste management facilities involved with the program.

2. Includes operational expenses such as sorting and packaging the material, transportation, disposal and equipment.

3. Disposal costs were provided free of charge by the hazardous waste management firm.

4. This involved four separate sites on four different occasions.

5. Costs were low due to inkind donations of waste management firms.

6. Towns in New Hampshire and Vermont were invited to participate.

7. This figure included 2 farmers and 2 other unspecified sources.

8. Data obtained from: Matheis, A. 1987. "Collecting Household Toxics, Is It Worth the Effort?", Waste Age, 18 (2): 76-85.

Management Regulations, Code of Virginia, Title 32.1, Chapter 6, Sections 32.1 - 177 of 1980 (as amended) provide "for the control of all hazardous wastes that are generated in or transported to Commonwealth for the purposes of storage treatment or disposal of resource recovery."

Many other regulations, both federal and state, affected the planning and construction of the Smith Gap Landfill in Roanoke County. EPA Guidelines for Solid Waste Storage and Collection, 40CFR 241; 41FR 6766, effective 1976, include requirements and recommendations for solid waste storage and collection. EPA Guidelines for State Solid Waste Management Plans, 40 CFR 256 help the development of State Solid Waste Management Plans and lay out recommendations and requirements.

EPA Regulations on Criteria for Classification of Solid Waste Disposal Facilities, 40 CFR 257, 44 FR 53460 of 1979 establish criteria determining the health or environmental impact from solid waste disposal facilities.(Olver Incorporated Consulting Engineers and Environmental Laboratories, 1988)

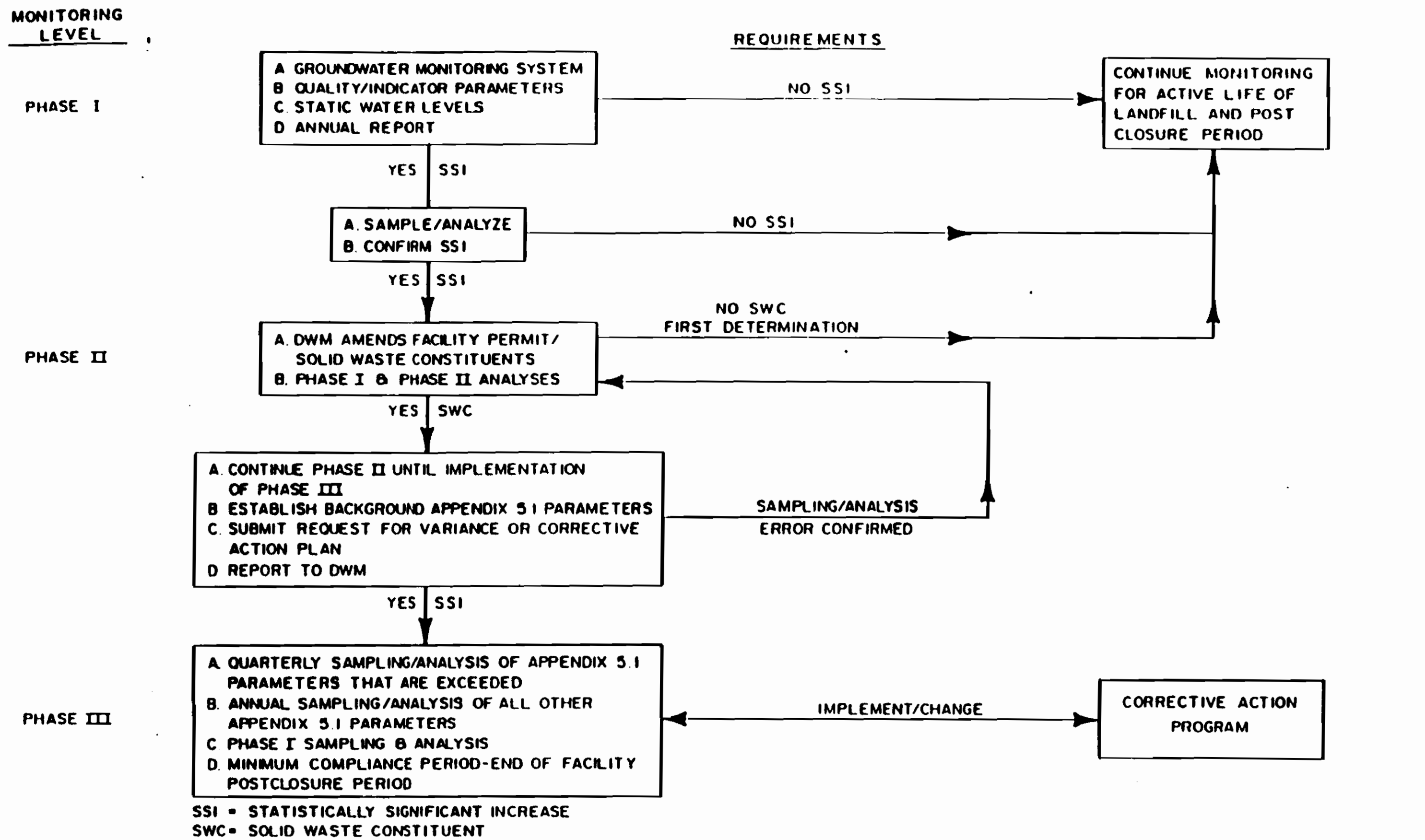
The new landfill at Smith Gap ran into some problems over the summer with sediment-control regulations.(Poole, Tue. Aug.3, 1993). Erosion control problems had been overlooked in the push to get the landfill open by November and many downstream waters were exposed to a lot of siltation. Sediment basins and drainage areas present in the approved plans that could have lessened this problem were not yet completed. After a storm in April 1992 that dumped 5 inches of rain in a 24 hour period created major problems with mud washing into nearby homes, the Roanoke Resource Authority was ordered to complete the sediment ponds. It was in October when the ponds were finally completed and by August 1993, the engineers were rethinking the design of the ponds after the July 1 storm dumped 2.5 inches of rain in two hours.

A citizen of Roanoke County, W.J. Keeling, has had trouble with governmental regulations concerning his tire dump.(Poole, Wed. Dec. 1, 1993). The illegal dump is believed to contain around 3 million tires. It poses a huge fire threat and is illegal. Roanoke County officials have been tring to force Keeling to clean up the dump since 1983 after a huge tire fire in Frederick County but have been unsuccessful because Keeling lacks the resources to clean up the dump. This unfortunately means that the money to clean it up will have to come from public taxpayer funds.

Social aspects of opening a new landfill are many. Nobody wants a landfill in their backyard and often no one wants a landfill anywhere remotely close to their property. Many people feel that the landfill would be detrimental to their property value and create a health risk. The big garbage trucks, loud noise, and dust created makes it difficult for a municipality to find a suitable site. Aside from the afore mentioned considerations, the city must look for an area that is large enough to handle the amount of solid waste that the particular area will produce, easily accessable for large trucks but far enough away from any residential areas, and geologically suitable for a landfill.(Mantell, 1975 -b). Thus, opening landfills can tend to be a very lengthy and drawn out process.

The Roanoke Resource Authority ran into these types of problems when the planning for the new landfill began four years ago. Once the site was selected, the Resource Authority had to work with nearby residents to insure the protection of their property value and their health. The Resource Authority set up a program that guarantees that if the owner can prove a loss in property value due to the landfill, then they will be reimbursed for that loss.(Protecting Your Property Value ,1993). The Resource Authority also had to protect the nearby groundwater supplies according to specific regulations from the Department of Waste Management. (See Figure 6.1) The Resource Authority set up a drinking water protection program that insures that if residents' drinking water is contammminated, then a clean source of replacement water will be provided for free by the Resource Authority.(Protecting Your Water Supply ,1993).

The Resource Authority also had to comply with standard design regulations. The bottom layer of the landfill must have layers of compacted clay and high density plastic. Perforated pipes run between and above these layers. They collect leachate and channel it to a treatment center.



DEPARTMENT OF WASTE MANAGEMENT
GROUNDWATER MONITORING REQUIREMENTS
FOR SOLID WASTE MANAGEMENT REGULATIONS

FIGURE 6.1

NO SCALE
JOB NO. 11136

FEB. 28, 1989

Wells have to be present so that groundwater contamination can be checked for. A soil supply would need to be nearby so as to cover the trash once it is pushed into place. Pipes that are sunk throughout the layers collect methane gas. This could be burnt off as gas or converted into electricity. A drainage ditch would be needed around the landfill to carry off rainwater.(Rathje, 1991) For a visual idea of a typical landfill, please refer to Illustration 1.

The design of the landfill is also an effort to lessen the social impact. The trash will be taken from the pickup to a transfer station located at 1000 Hollins Road. Here, the trash will be transferred to rail cars to be taken by train to the Smith Gap landfill. The transfer station was designed to resemble a Norfolk & Southern Railroad building from the 1900's and will be an attractive addition to the neighborhood. The rail system will also cut down on the distance that the garbage trucks will have to travel. The entrance to the landfill is also well landscaped to disguise the landfill and add to the community. This design was chosen by a commitee consisting of representatives from the three members to the landfill system, Roanoke City, Roanoke County, and the Town of Vinton, along with members of the Resource Authority. The commitee looked at several different designs and chose the best and most suitable designs for the new landfill.(Carolyn Wagoner, Resource Authority). The landfill is currently about two months behind schedule due to the rainy weather this past spring

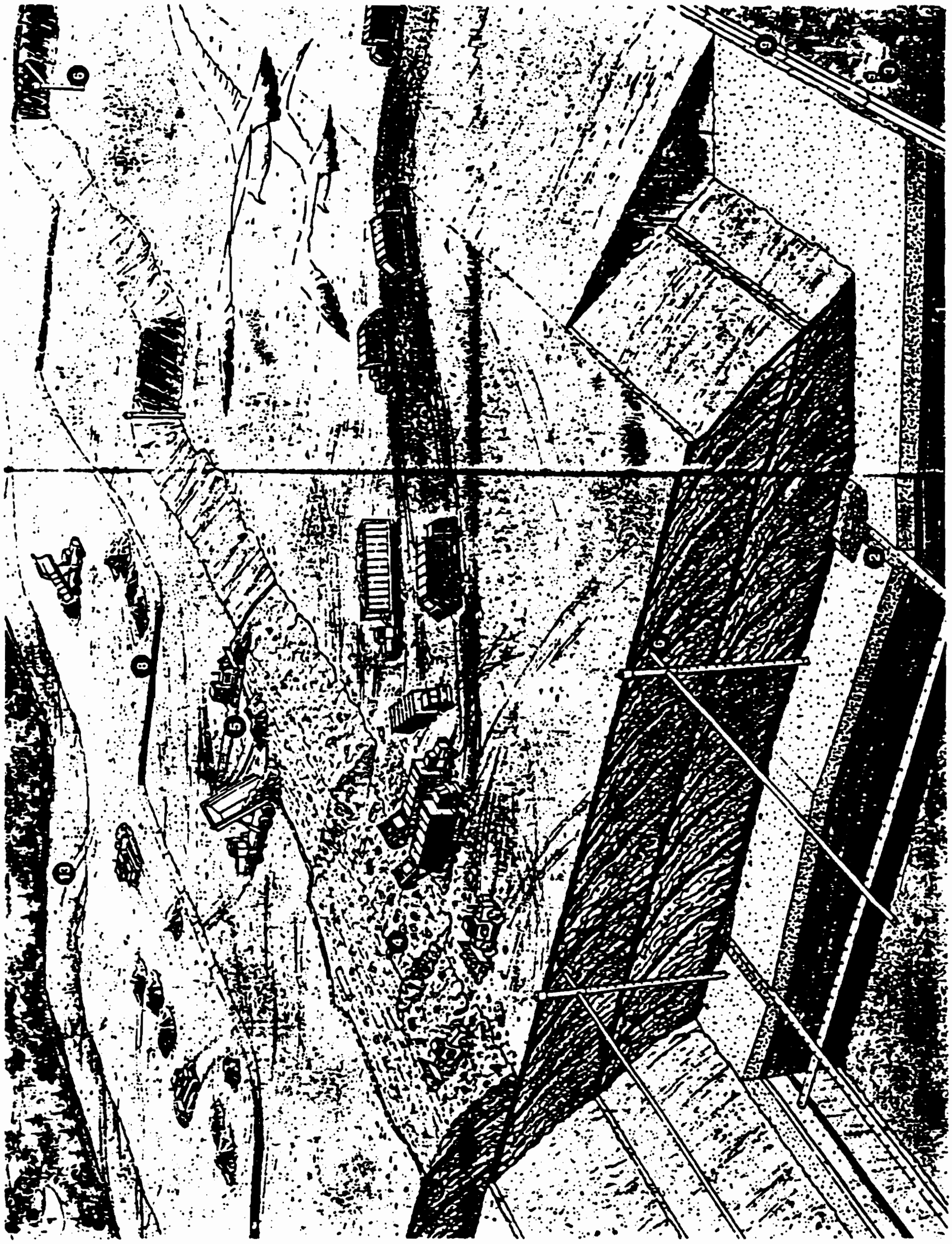


Illustration I

and summer.(Carolyn Wagoner) It was originally scheduled to open in October but is now supposed to open in December. It was thought that the old landfill would not have enough room for more trash, but Jeff Cromer, landfill manager, said that there should be enough space to last until December.(Turner, Sat. Sept. 11, 1993)

The transporting of solid waste by railroad is fitting for Southwest Virginia. Historically, we have always had strong ties to the railroad. Now, Norfolk & Southern will transport our trash. The Wasteline Express, as it is called, will originate from the transfer station in Roanoke, Virginia. There, waste will be loaded into specially designed rail cars and then covered with lock down lids. At the end of the day, all wastes that have been collected and loaded into the rail cars, will be transported by the Wasteline Express to the landfill. This was developed through the efforts of the Resource Authority to provide the most efficient, effective, and environmentally safe method to transport the Roanoke Valley's solid waste.(The Wasteline Express ,1993).

Residents of the Roanoke Valley were given a first hand view of exactly how the Wasteline Express will operate in a festive inaugural celebration held Wednesday, December 1st. It was a sold out event by November 19, 1993.(Turner, Fri. Nov. 19, 1993). Approximately 300 people who have been involved in the project were invited to make the 66-mile round trip from the transfer station in Roanoke to the landfill on the far side of Fort Lewis Mountain.(Turner, Thurs. Dec. 2, 1993).

Not only are there many social aspects to consider but there is the economic side of the story. Landfill projects tend to be very expensive and municipalities must decide if they are willing and able to pay for modern facilities. For the new landfill in Roanoke, the total cost for the project is approximately $42 million and is being funded by the sale of revenue bonds. Once the project is operational, funds from waste disposal tipping fees will be used to pay the debt and operate the system.(Questions and Answers ,1993). The tipping fees increased from $25 a ton to $55 a ton. As an incentive to recycle, the Roanoke City School System will be given a cash rebate for every bag of recyclables versus having to pay for the regular waste.

The environment is also a big player in the process of opening a new landfill. It is because of stricter governmental regulations designed to protect the environment that the landfill is designed as it is. The landfill must take many precautions to prevent contamination of nearby water sources and natural areas and to safeguard against contammination of groundwater. The new Roanoke landfill will be lined with clay and then plastic to prevent contamination. All landfills must be covered daily to prevent scavenger animals from consuming the garbage and making themselves sick unknowingly.

Opening a new landfill is a very complicated process. There are many considerations from selecting a site to how to transport the waste. And there are definitely no easy answers. Often, landfill projects are met with oppostion from all sides. Thanks to research and technology, we are now able to design landfills that are not detrimental to the surrounding community and are not environmentally harmful. Hopefully, this trend will continue for many more generations.

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APPENDIX F

Interview Questions and Questionnaires

Questions for John

1. What did you see as your role in this study?

2. How did your role change over the course of the study?

3. How was this unit conducted differently from the other units you teach during the year?

4. What (if any) strengths do you see in teaching this way?

5. What (if any) drawbacks do you see in teaching this way?

6. What differences in the ways girls and boys work together in this unit as compared to other units taught in biology?

7. What (if any) professional growth did you think you had during this study?

8. How would you feel about doing a collaborative unit with people outside the school again?

9. There are two camps -- STS and basic science. What would you say to each side?

10. What would be your "last word?"

Questions for Mara

1. What did you see as your role in this study?

2. How did your role change over the course of the study?

3. Would you consider doing a collaborative unit like this again?

4. What (if any) strengths do you see in teaching this way?

5. What (if any) drawbacks do you see in teaching this way?

6. What (if any) professional growth did you think you had during this study?

7. You were concerned about "the role of the scientist" in the classroom. How do you feel about that now?

8. What originally did you hope the students would get out of this study? Do you think they achieved that?

9. What would be your "last word?"

Student Interview Questions

1. What differences do you see in the ways girls and boys work together in this unit versus other biology units?

2. What skills (if any) do you think you developed to help you with decision-making?

3. What in this unit has made you change the way you think about landfills?

4. What (if anything) did you learn that will carry over with you outside of school?

5. What was your impression about this unit when we first started? Did that change? Why?

6. Many times on the tape I hear people finishing other people's sentences. How do you feel about that?

7. What is your earliest recollection of being introduced to science?

8. There is a lot of table discussion that has to do with topics other than what the assignment was. Where do you think this fits in with collaborative learning?

9. What suggestions do you have for me next year when I go back in the classroom and teach an STS project?

Questionaire - Phase I

Culminating Questions on Landfill Restoration

Name__________________________

1. What sources did you find most helpful in gathering your information? Please be specific...names of people, journals, newspapers, etc.)

2. How did you locate your initial source when you first began searching?
   b. Did this initial source provide adequate information?
   c. Trace the progression of contacts you used to acquire your information. Use a flow diagram, if possible.

3. What did you find most frustrating in doing this project?

4. What information about landfills did you learn that you found most interesting? Explain why this was interesting to you.

5. Do you find yourself more aware of newspaper articles and TV news reports that relate to landfills, Explore Park, or other environmental issues now that you've done this project?

6. What advice would you give the students who will continue working on this project next year as to the best way to gather data about this project?

7. What would you tell them NOT to do?

8. Have you changed the way you buy articles or dispose of garbage as a result of something you've learned from this project? If so, what?

9. If you haven't changed your buying or disposal habits, why not?

10. If you were to change your buying or disposal habits, what might it be?

11. **Opinions please! Don't be afraid to be innovative or original. All ideas are accepted.**

    a. What do you think you, as rising adults, can do to reduce the amount of materials entering landfills?

    b. What do you think could be done as a municipality that would reduce the amount of materials entering landfills?

Questionaire - Phase II

STS PROJECT QUESTIONNAIRE

1. Have you worked in collaborative groups before? YES___ NO ___
2. If YES, what subject? What activity did you do?
3. How many science courses have you had in high school that were:
   _______teacher directed? ________students helped determine part of the content?
4. What is your opinion about science course that are teacher directed and textbook oriented?
5. What is your opinion about investigating science through a local issue?
6. Do you like to work in collaborative groups? _____YES _____NO
7. If you answered YES, why? If you answered NO, why not?
8. How does working in groups affect your learning?
9. Was there a leader in your group?
10. How did your group divide the tasks among its members?
11. Explain how your group decided on its experiment.
12. How did your group handle disagreements?
13. What is your opinion about students taking more responsibility for their learning by designing their own study?
14. Why did you choose to attend the Governor's School?
15. What are your interests or hobbies outside of school?
16. List the organizations or clubs in which you are a member.
17. What type of work or career would you like to do as an adult?
18. What is the name of your home school?

APPENDIX G

Culminating Presentation and Activities

Letter of Invitation

March 25, 1994

I am pleased you are going to join us at the Roanoke Valley Governor's School on Thursday, March 31. The meeting is from 8:30 - 10:00 a.m.

The students have been studying the issues surrounding the closing of the Roanoke Regional Landfill and the opening of the new landfill at Smith Mountain Gap. They have done considerable reading and have visited both landfills. The students have been working collaboratively with Ms. Mara Sabre and myself on vegetation choices for use on the Roanoke Regional Landfill once it is closed. Thursday morning they will be presenting their findings and recommendations to representatives of Explore Park, the Roanoke Board of Supervisors, the Roanoke Valley Resource Authority, and Virginia Tech. The Governor's School is located at 2102 Grandin Road, SW in Roanoke.

I appreciate your interest in the educational aspect of solid waste management. I look forward to seeing you Thursday morning. If you need additional information, please call me at (703) 552-9783.

Sincerely yours,

Beatrice L. Taylor

Where Does All the Trash Go? Landfill Issues in the Roanoke Valley

A cooperative learning project conducted by biology students
at the
Roanoke Valley Governor's School for Science and Technology

in conjunction with
Virginia Tech, Virginia's Explore Park
and
the Roanoke Valley Resource Authority

ADVISORS

John Kowalski
Roanoke Valley Governor's School for Science and Technology

Bea Taylor and Mara Sabre
Virginia Tech

Virginia Laubinger
Explore Park

Carolyn Wagner
Roanoke Valley Resource Authority Board

STATEMENT OF THE PROBLEM

How much trash do each of us produce? What happens to the trash after it is taken away from our homes and businesses? What is the economic cost of trash to individuals and society? What effect does it have on the environment? Can trash be a political issue? Until recently most individuals did not concern themselves with these questions. Why is this situation changing? Why are communities asked to recycle? Why is the cost of trash removal increasing at a much higher rate than the rate of inflation? These and other questions are the focus of this interdisciplinary unit which will examine the current landfill situation in the Roanoke Valley.

WHERE DOES ALL THE TRASH GO? LANDFILL ISSUES IN THE ROANOKE VALLEY

MAJOR ACTIVITIES
October, 1993 - April, 1994

Student preparation of landfill concept maps - "What do we know" directed by Bea Taylor (Va. Tech.)

Field trip to old landfill, transfer station, and new landfill coordinated by the Roanoke Valley Resource Authority

Relationships between Explore Park and the landfill - lecture/discussion by Ginny Laubinger (Explore Park)

Student reports based on Smithsonian Magazine article "I learned that it just keeps getting deeper"

Student comentaries based on articles from the Roanoke Times

Student outlines for a talk about waste management, landfills, and recycling

Student group preparation of a paper concerning one of three topics:

- Closing, monitering, and reclaiming a filled landfill
- Opening and monitering a new landfill
- Alternatives to landfills

Lecture concerning landfill issues by Dr. John Cairnes (Va. Tech.)

Lecture concerning landfill restoration by Mara Sabre (Va. Tech.)

Student development of group experiments to determine appropriate plants to use for landfill restoration coordinated by Mara Sabre and Bea Taylor

Student preparation of concept maps - "What have we learned"

Student completion of plant experiments and preparation of final reports

Student presentation of plant experiments and preparation of final conclusions

The Effect of Soil Compaction on the Shoot and Root Biomass, Height, and Germination of Bachelor's Button, Black-Eyed Susan, Kentucky Fescue 31 Grass, Abruzzi Rye Grass, and a Mix of All Four Plants.

PURPOSE: To determine the effect of compacted and uncompacted landfill soil on the shoot and root biomass, height, and germination of Bachelor's Button (*Centaurea cyanus*), Black-eyed Susan (*Rudbeckia hirta*), Kentucky Fescue 31 Grass (*Festuca arundinacea*), Abruzzi Rye Grass (*Agrostis alba*), and a mix of all four plants.

CONCLUSIONS:

1. Soil compaction does not affect the shoot and root biomass, germination, or height of the plants tested.

2. For the plants that we investigated, compacted soil is not a major disadvantage in the revegetating of closed landfills.

3. Bachelor's Button and Kentucky Fescue 31 Grass would be the best plants of the ones that were tested to be used on compacted landfill soil.

THE EFFECTS OF VARYING AMOUNTS OF SODIUM BICARBONATE IN HYDROPONIC SOLUTION ON THE SURVIVAL OF PLANTS

PURPOSE: To determine the effects on shoot and root growth of varying percentages of sodium bicarbonate by mass in solution as introduced to the roots of *Centaurea cyanus*, *Coreopsis lanceolata*, and *Brassica rapa* grown hydroponically.

DESIGN:

--Tank 1 (no aeration)
--Tank 2 (aeration)
--Tank 3 (aeration, varying amounts of sodium bicarbonate, the carbon dioxide source)

*Varying amounts of sodium bicarbonate used were 1% and 10%.

RESULTS/CONCLUSIONS:

*Plants are able to survive in an environment of only 1% by mass sodium bicarbonate, but they wilt and die in 10% by mass sodium bicarbonate.

*Lack of aeration in tanks results in plant stress and eventual wilting.

*All species tested worked well in hydroponic set-up.

*Differences in plant species did not affect growth results.

The Effect of Species Aggression on the Survival and Growth of Landfill Plants

Purpose: To determine the effect that intermixing Plains Coreopsis, Purple Coneflower, and Birdsfoot Trefoil in the same growing space would have on plant height and survival.

Results:

The number of living plants had reached its peak in each of the containers by day 36.

Those containers with intermixed species contained only 49% of the number of plants which would have been expected had the plants in mixed species groups survived as well as those grown in individual species groups.

Conclusions:

Plains Coreopsis had the greatest number of living plants, with 51 of the 60 seeds planted having germinated.

It was observed that intermixing species did have an effect on the survival of plants.

The Effect of Loosely-Compacted Landfill Soil and Tightly-Compacted Landfill Soil on the Germination, Height, and Biomass of Various Species of Lolium and Festuca arundinacea

PURPOSE:
The project was designed to determine the effect of commercial, loosely-compacted landfill, and tightly-compacted landfill soil on the biomass, germination, height, and depth of shoots & roots of various species of Lolium and Festuca arundinacea.

<u>RESULTS</u>:

- **Student t-test**
  - **Germination - statistical difference within ARG**
    -no statistical difference within KF31
  - **Height of Plant - no statistical difference within ARG and KF31**
  - **Length of Roots - no statistical difference with ARG and KF31**
  - **Biomass - no statistical difference within ARG and KF31**

CONCLUSIONS:

- No difference (except w/ germination) btw. tightly-compacted landfill soil vs. loosely-compacted landfill soil
- Recommendations
  - Germination - Annual Rye (Commercial)
  - Length of Roots - Kentucky Fescue (Commercial)
  - Height of Plant - Annual Rye (Tight)
  - Biomass - Annual Rye (Loose)

What are the effects of temperature and soil-type on the height, mass, and sprouting rate of Birdsfoot, Purple Coneflower, and Lance-Leafed Coreopsis?

Purpose

To determine the effects that different temperatures and two different soil types have on three plant species. These effects are measured by examining height, biomass, and sprouting rate of the plants.

Results/Conclusions

Plants grown in landfill dirt had steady sprout rates and grew to remarkable heights in relation to other experiments.

Landfill soil plants were taller and had a larger shoot biomass compared to potting soil plants; landfill plants also showed fewer signs of stress that potting soil plants.

Potting soil plants had deeper root depths than landfill soil plants; potting soil plants also had a quicker sprout rate.

Growth chamber plants (especially landfill soil plants) had larger sprout biomasses and taller heights than the room temperature plants.

THE EFFECT OF A 25° SLOPE ON THE GROWTH AND SURVIVORSHIP OF *COREOPSIS TINCTORIA*, *RUDBEKIA HIRTA*, AND *ECHINACEA PURPUREA*

The purpose of this project was to determine the effect a 25° degree slope would have on the growth and survivorship of plains coreopsis (*Coreopsis tinctoria*), black-eyed susans (*Rudbekia Hirta*) and coneflower (*Echinacea purpurea*) grown in landfill soil.

<u>Major Conclusions</u>

-*Echinacea purpurea* and *Coreopsis tinctoria* fared better on the flat.

-*Rudbekia hirta* fared better on the slope.

-Slope has no definite effect on the survivorship of the three plant species.

-There was a fairly good survival rate regardless of the species.

The Effect of Soil Compaction on the Shoot and Root Biomass, Height, and Germination of Bachelor's Button, Black-Eyed Susan, Kentucky Fescue 31 Grass, Abruzzi Rye Grass, and a Mix of All Four Plants.

Introduction: The purpose of this experiment was to determine the effect of compacted and uncompacted landfill soil on the shoot and root biomass, height, and germination of Bachelor's Button, Black-eyed Susan, Kentucky Fescue 31, Abruzzi Rye Grass, and a mix of all four plants. The experiment was performed in order to gain knowledge that would be useful in the field of landfill restoration. By understanding how soil compaction affects particular plants, environmental scientists can decide if compacting landfill soils is a disadvantage to restoration of the land. Knowledge can also be obtained involving the type of plants that should be used when revegetating an area that has been a landfill.

Experimental Design: The independent variable of the experiment was soil compaction. The first level was 1290.6 grams of uncompacted landfill soil in each of five containers. The second level was 1290.6 grams of compacted landfill soil in each of five containers. The dependent variables were the shoot and root biomasses, the height, and the germination of Bachelor's Button, Black-eyed Susan, Abruzzi Rye Grass,Kentucky Fescue 31, and a mix of all four plants. The dependent variables were respectively measured by grams, centimeters, and number of plants. Repeated trials were not used due to space limitations. A control group was formed by planting Bachelor's Button, Black-eyed Susan, Corrieopsis, and Kentucky Fescue 31 in uncompacted potting soil.

Procedure: On November 1, 1993, landfill dirt was sieved, and two and three liter bottles were collected. Labels were taken off the bottles and black, plastic bases were cut off the at the bottom to make platforms that the bottles would stand up on. Holes were cut in bottles for drainage, and two liter bottles were labeled to contain uncompacted and compacted versions of Bachelor's Button, Black-eyed Susan, Abruzzi Rye Grass, and Kentucky Fescue 31. Labels for a mix of all four plants, uncompacted and compacted, were placed on two separate three liter bottles. (There were eight two liter bottles, one compacted and one uncompacted for each plant type. There were two three liter bottles, one for compacted and one for uncompacted mix of all four plants.). The bottles were then cut off at the top so that they were nine inches tall.

Ninety seeds of each type of plant were counted so that each kind could be distributed as follows: Thirty seeds placed into two separate two liter bottles, one for compacted and one for uncompacted. Fifteen seeds placed into two separate three liter bottles, one compacted and one uncompacted. Thus, the three liter bottles had sixty seeds total, fifteen of each plant type.

Soil was then weighed for uncompacted investigations. 1290.6 grams of soil was put into each of the five bottles labeled *uncompacted.* Also, 174.9 grams of gravel were placed in the bottom of the two liter bottles for drainage. 350 grams of gravel were placed in the three liter bottles.

On November 2, 1993, soil was weighed for compacted investigations. 174.6 grams of gravel was placed in the bottoms of the two liter bottles, and 350 grams of gravel was placed in the bottoms of the three liter bottles. A total of 1290.8 grams of landfill dirt was then placed in each of the four two liter containers in the following manner: 322.7 grams of soil was placed in each of the bottles and then a beaker with the same diameter as the bottles was dropped ten times from the top of the bottles. This was repeated three more times in each of the bottles. For the three liter bottles the procedure was as follows: 500 grams of soil was placed in the bottles and a beaker was dropped ten times from the top of the bottles. This procedure was repeated three more times for each bottle, totaling an amount of 2000 grams of soil in both of the three liter bottles. 600 milliliters of water was placed in each of the two liter bottles and 900 milliliters of water was placed in both of the three liter bottles.

On November 3, 1993, the seeds were put into the correct labeled bottles, and ten tablespoons of soil was sprinkled on top of the seeds. In the compacted bottles, a beaker was again dropped on the soil for ten times. All bottles were placed under incandescent lights and covered with translucent garbage bags.

Several days later after germination had begun, the bags were removed and plants were counted. Plants were counted and recorded every Monday and Thursday, and plant shoots were measured using centimeters and recorded every Monday.

The controls were planted later in the experimentation. A hundred seeds of each Bachelor's Button, Black-eyed Susan, and Kentucky Fescue 31 were planted in regular potting soil. They were planted in clear containers and watered regularly. These plants were counted as soon as they germinated.

During winter break and intersession, plants were watered regularly. After winter break and intersession, plants were again counted and recorded. Final observations were made. Final heights were measured and recorded as well.

Biomass of the plants was then measured and recorded after the plants dried. The Coke bottles were carefully cut lengthwise using scissors, and the entire plant and soil was removed by hand. The soil was then gently removed from the roots using scalpels, probes, and hands. Clods of soil were removed in the most efficient manner possible. Plants that did not separate from the soil easily were dampened. The plants were lest overnight to dry. The plant-root mass was then measured to a hundredth of a gram. The entire plant-root system was placed in a beaker which had been massed. The mass of the plant-root system was determined by subtracting the beaker mass from the plant-root and beaker mass. Using a pocket knife, the green stem was cut from the whiter root system. The roots were placed in the beaker and the mass was then taken and recorded. With the data gathered, the root and shoot biomasses could be determined using subtraction.

No repeated trials were made due to space limitations. There were two levels of the independent variable. The first level was 1290.6 grams of uncompacted landfill soil in each of five containers. The second level was 1290.6 grams of compacted landfill soil in each of five containers.

Results:

Table 1.1, relating to the germination of the plants in compacted soil, shows that at the end of the experimentation, seven Bachelor's Button plants grew out of the initial thirty seeds. Graph 1.1 indicates that Bachelor's Button had a 23.3% germination in the compacted soil. Graph 3.1 shows that the tallest of these seven plants had a final height of 5cm.

Table 1.1, relating to the germination of the plants in compacted soil, shows that at the end of the experimentation, only two Black-eyed Susan plants grew out of the initial thirty seeds. Graph 1.1 indicates that Black-eyed Susan had a 6.6% germination in the compacted soil. Graph 3.1 shows that the tallest of these two plants had a final height of 0.5cm.

Abruzzi Rye Grass did not germinate in the compacted soil, therefore Table 1.1, Graph 1.1, and Graph 3.1 indicate zero results.

Table 1.1, relating to the germination of the plants in compacted soil, shows that at the end of the experimentation, eighteen Kentucky Fescue 31 plants grew out of the initial thirty seeds. Graph 1.1 indicates that Kentucky Fescue 31 had a 60% germination in the compacted soil. Graph 3.1 shows that the tallest of these eighteen plants had a final height of 30cm.

Table 1.1, relating to the germination of the plants in compacted soil, shows that at the end of the experimentation, ten plants grew out of the initial sixty seeds in the container holding fifteen seeds of each plant tested. Graph 1.1 indicates the mix had a 33.3% germination in the compacted soil. Graph 3.1 shows that the tallest of these ten plants had a final height of 38cm.

Table 2.1, relating to the germination of the plants in uncompacted soil, shows that at the end of the experimentation, two Bachelor's Button plants grew out of the initial thirty seeds. Graph 2.1 indicates that Bachelor's Button had a 6.6% germination in the uncompacted soil. Graph 4.1 shows that the tallest of these two plants had a final height of 2cm.

Black-eyed Susan did not germinate in the uncompacted soil, therefore Table 2.1, Graph 2.1, and Graph 4.1 indicate zero results.

Table 2.1, relating to the germination of the plants in uncompacted soil, shows that at the end of the experimentation, six Abruzzi Rye Grass plants grew out of the initial thirty seeds. Graph 2.1 indicates that Abruzzi Rye Grass had a 20% germination in the uncompacted soil. Graph 4.1 shows that the tallest of these six plants had a final height of 40cm.

Table 2.1, relating to the germination of the plants in uncompacted soil, shows that at the end of the experimentation, thirty-six plants grew out of the initial sixty seeds in the container holding fifteen seeds of each plant tested. Graph 2.1 indicates the mix had a 60% germination in the uncompacted soil. Graph 4.1 shows that the tallest of these thirty-six plants had a final height of 60cm.

Table 3.1, relating to the final biomass of the plants in each type of soil, shows that in the uncompacted soil, the Bachelor's Button had a final biomass of 0.03g, with 0.03g shoot biomass and 0g root biomass. In the uncompacted soil, the Black-eyed Susan did not germinate, therefore, there was no final biomass. In the uncompacted soil, the Abruzzi Rye Grass had a final biomass of 2.96g, with 0.86g shoot biomass and 2.10g root biomass. In the uncompacted soil, the Kentucky Fescue 31 had a final biomass of 0.75g, with 0.39g shoot biomass and 0.36g root biomass. In the uncompacted soil, the mix had a final biomass of 1.95g, with 0.02g shoot biomass and 1.93g root biomass.

Table 3.1 show that in the compacted soil, the Bachelor's Button had a final biomass of 0.14g, with 0.12g shoot biomass and 0.02g root biomass. In the compacted soil, the Black-eyed Susan had a final biomass of 0g. In the compacted soil, the Abruzzi Rye Grass did not germinate, therefore, there was no final biomass. In the compacted soil, the Kentucky Fescue 31 had a final biomass of 0.61g, with 0.32g shoot biomass and 0.29g root biomass. In the compacted soil, the mix had a final biomass of 2.19g, with 0.69g shoot biomass and 1.5g root biomass.

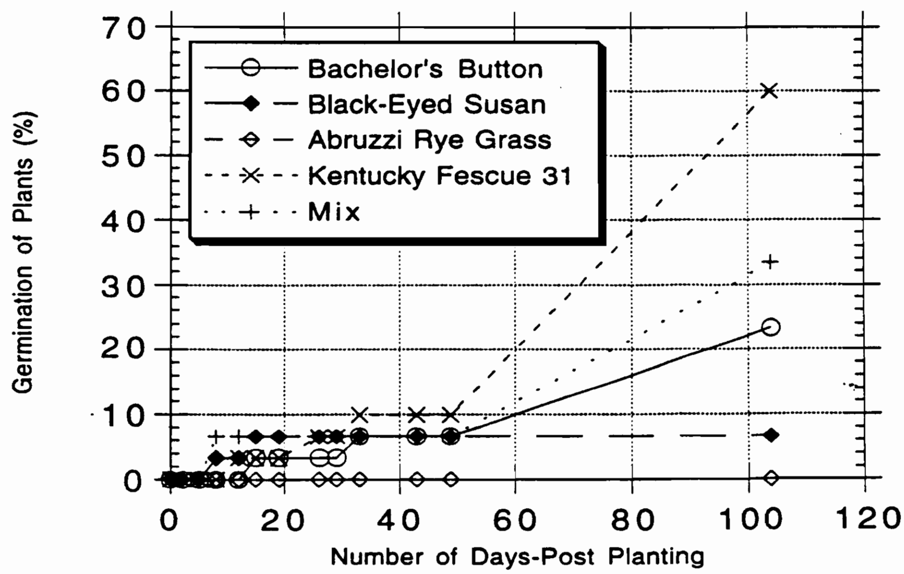
Table 3.1 indicates that in the control soil, the Bachelor's Button had a final biomass of 0.11g, with 0.08g shoot biomass and 0.03g root biomass. In the control soil, the Black-eyed Susan had a final biomass of 0.91g, with 0.43g shoot biomass and 0.48g root biomass. In the control soil, the Kentucky Fescue 31 had a final biomass of 0.69g, with 0.33g shoot biomass and 0.36g root biomass. Both the Abruzzi Rye Grass and the mix were not tested in the control soil, therefore, there was no final biomass. Graphs 5.1, 6.1, and 7.1 show the same final biomass results in bar-graph form. Graph 5.1 illustrates the biomass in the compacted soil. Graph 6.1 illustrates the biomass in the uncompacted soil. Graph 7.1 illustrates the biomass in the control soil.

	A	B	C	D	E	F	G
1							
2–5	**Table 1.1: The Germination of Bachelor's Button, Black-eyed Susan, Abruzzi Rye Grass, Kentucky Fescue 31 Grass, and a Mix of All Four Plants in Compacted Soil**						
6							
7			Bachelor's Button	Black-eyed Susan	Abruzzi Rye Grass	Kentucky Fescue 31	Mix
8	# of Seeds Planted		30	30	30	30	60
10	Germination (#):						
12	Date Tested						
13	11/5/93		0	0	0	0	0
14	11/8/93		0	0	0	0	2
15	11/11/93		0	0	0	0	2
16	11/15/93		0	1	0	1	2
17	11/18/93		1	1	0	1	2
18	11/22/93		1	2	0	1	2
19	11/29/93		1	2	0	2	2
20	12/2/93		1	2	0	2	2
21	12/6/93		2	2	0	3	2
22	12/16/93		2	2	0	3	2
23	12/22/93		2	2	0	3	2
24	2/15/94		7	2	0	18	10
26	Height of Tallest Plant(cm):						
28	Date Tested						
29	11/8/93		0	0	0	0	7.5
30	11/15/93		0	0.2	0	5.3	17
31	11/22/93		0.3	0.3	0	9	24
32	11/29/93		0.5	0.3	0	9.2	24.1
33	2/15/94		5	0.5	0	30	38

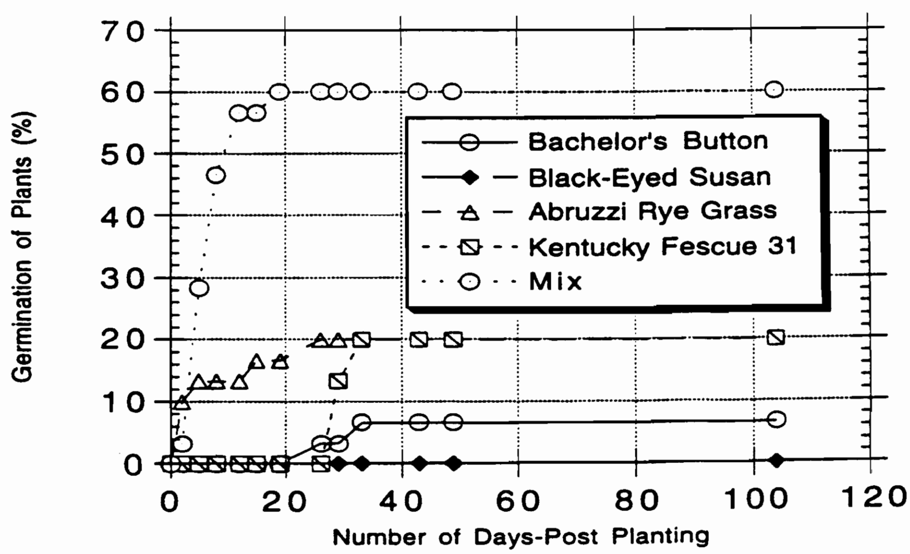
Table 3.1: Comparison of the Final Biomass of Bachelor's Button, Black-Eyed Susan, Abruzzi Rye Grass, Kentucky Fescue 31 Grass, and a Mix of All Four Plants in Uncompacted, Compacted, and Control Soils

	Bachelor's Button	Black-Eyed Susan	Abruzzi Rye Grass	Kentucky Fescue 31	Mix
Soil Type:					
Uncompacted					
Number of Plants (#)	2	0	6	6	36
Total Biomass (g)	0.03	0	2.96	0.75	1.95
Shoot Biomass (g)	0.03	0	0.86	0.39	0.02
Root Biomass (g)	0	0	2.1	0.36	1.93
Compacted					
Number of Plants (#)	7	2	0	18	10
Total Biomass (g)	0.14	0	0	0.61	2.19
Shoot Biomass (g)	0.12	0	0	0.32	0.69
Root Biomass (g)	0.02	0	0	0.29	1.5
Control					
Number of Plants (#)	11	5	no control	63	no control
Total Biomass (g)	0.11	0.91	no control	0.69	no control
Shoot Biomass (g)	0.08	0.43	no control	0.33	no control
Root Biomass (g)	0.03	0.46	no control	0.36	no control

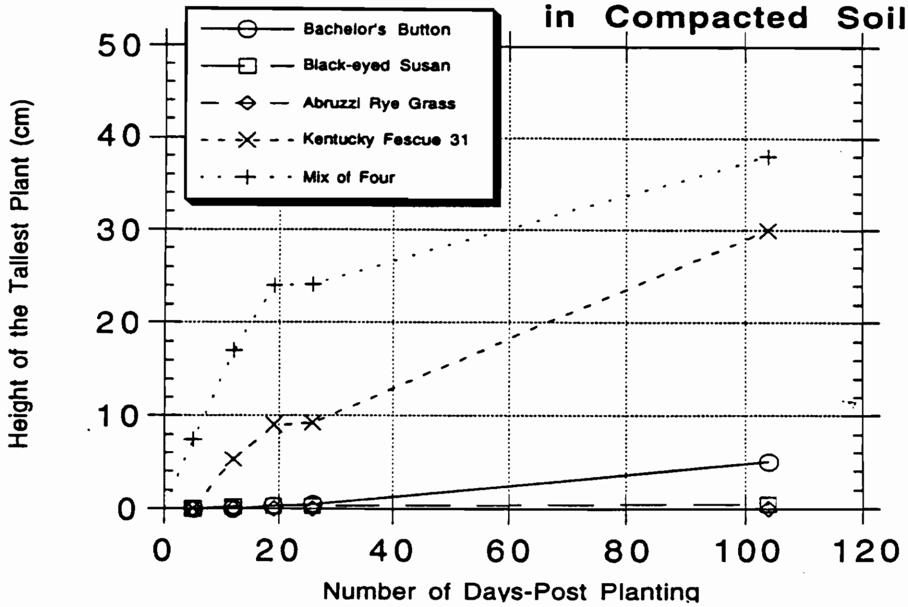
Graph 1.1: Germination of the Plants in Compacted Soil



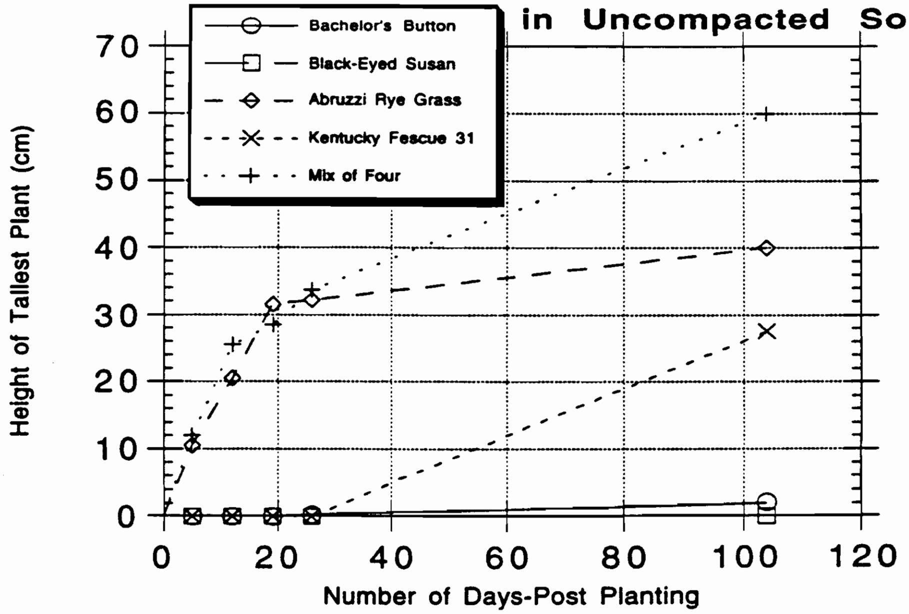
Graph 2.1: Germination of the Plants in Uncompacted Soil



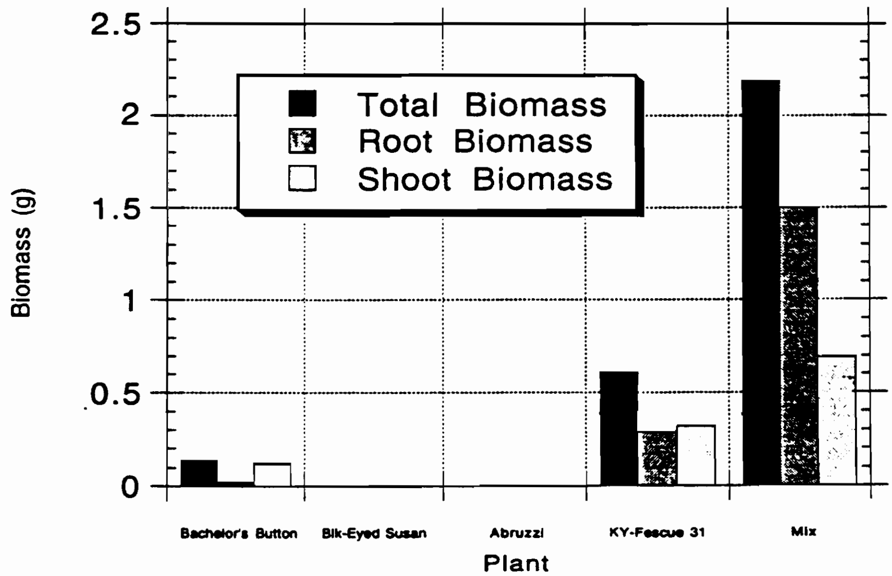
Graph 3.1: Height of the Tallest Germinated Plant in Compacted Soil



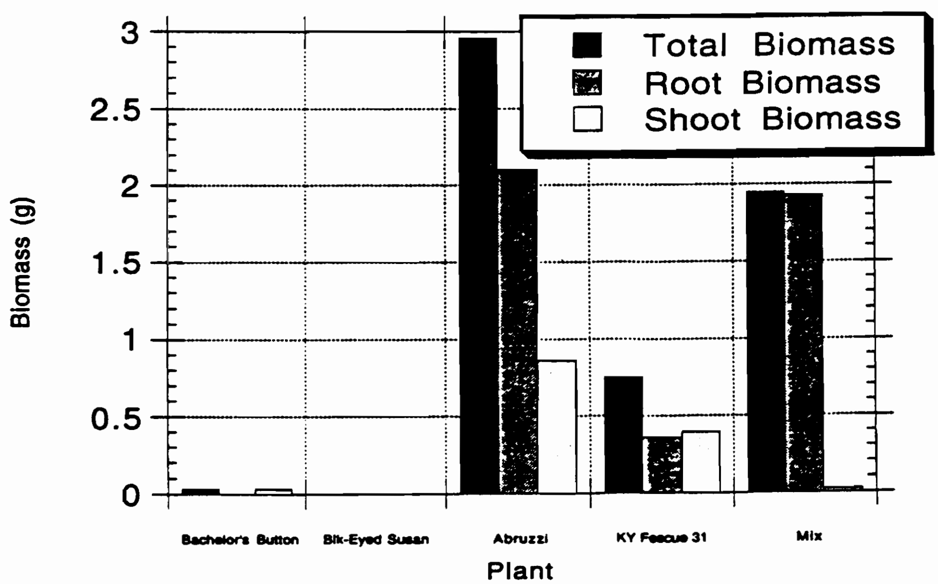
Graph 4.1: Height of the Tallest Germinated Plant in Uncompacted Soil



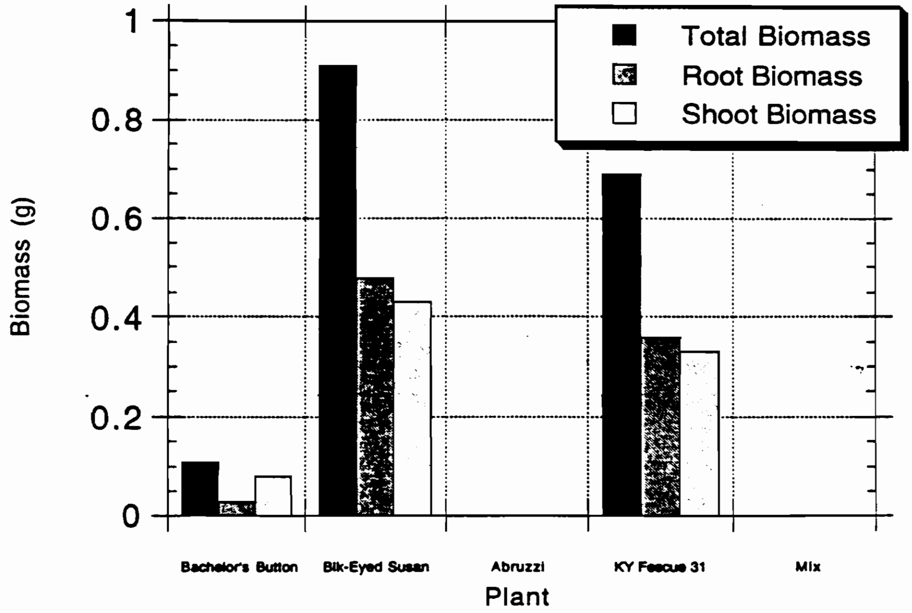
Graph 5.1: Biomass of Plants in Compacted Soil



Graph 6.1: Biomass of the Plants in Uncompacted Soil



Graph 7.1: Biomass of the Plants in Control Soil



Conclusions: The purpose of this experiment was to determine the effect of compacted and uncompacted soils on the shoot and root biomass, germination, and height on Bachelor's Button, Black-eyed Susan, Abruzzi Rye Grass, and Kentucky Fescue 31. Based on the results of this experiment, it was concluded that soil compaction does not affect the shoot and root biomass, germination, and height of the plants tested. The Abruzzi Rye Grass did not grow in the compacted soil, but grew fairly well in the uncompacted soil. Since repeated trials were not used, it could not be concluded that this difference resulted from soil compaction rather it was due to experimental error. Therefore, compacting of soil is not a major disadvantage to the revegetating of landfills after closure. During this experiment there were several problems that were encountered. The first was deciding how to keep the bottles standing on their own. The problem was solved by cutting the black bases of the bottles off into flat platforms. There was also trouble deciding how much soil to put in the compacted versus uncompacted and the two liter versus three liter. The amount of soil was kept constant in the uncompacted and compacted two liter bottles. The uncompacted three liter bottle was also constant with the two liter bottles, but the compacted three liter bottle, due to experimental error, received a greater amount of soil. Failure to punch holes in one of the bottles caused improper drainage when first planting, but holes were punched in the bottle after the problem was located. Another problem was that some of the plants did not germinate because of water deficiency and cracking of soil. The amount of water used was increased to prevent soil dehydration. Instead of measuring many plants and calculating a mean, only the tallest plant was measured for height analysis. This should be corrected for future experimentation as well as more trials should be performed. Other improvements include the following: plants should be grown in larger containers in order to provide space for increased root depth and a more sparse orientation of seeds, more exact methods of measuring and counting the plants should be utilized, better records and measurements of biomass should be taken, more plants should be grown, plants should be watered in a more organized fashion, extra soil should be applied when cracks occur, and a better method of sieving and compacting the soil needs to be developed.

Thank You Letter - April 4

April 4, 1994

Dear

Thank you for participating in the meeting at the Roanoke Valley Governor's School. The discussion of the findings and recommendations for the revegetation of the Roanoke Regional Landfill between students and guests was an important culmination of this project. We hope you found the students' experiments and suggestions to be beneficial. The students worked hard on this project, and we thank you for recognizing their efforts.

We appreciate the interest the Roanoke Valley Resource Authority has shown in participating in this Science, Technology and Society project. We anticipate doing future collaborative projects in which students will use RVRA as a resource.

Sincerely yours,

Beatrice L. Taylor
Virginia Tech

Dr. John Kowalski
Roanoke Valley Governor's School

Mara Sabre
Virginia Tech

Reflections from the Governor's School Students
on their final presentations

*I picked up the students' reflections after Mara, John, and I had written your letters. We thought you might like to read exerpts from what the students feel about the project and your being there.

"I was not aware that all of the local/area "experts" were participating in the final aspects with the class; however, I feel that their prescence [sic] added a lot to the outcome. Even a high school project can make an effect on the world around it. I was impressed by the insight and the contributions the adults added. I really enjoyed the entire process."-K.M.

"It was really neat to have many different people here that play entirely different distinct roles relating to landfills. This gave an even better opportunity for many different views and an opportunity to learn or think about many other aspects of the landfill situation."
-D. W.

"It was amazing to me to see how a group of high school students working for the good of a community can change for the better their environment. I think that some valuable information was discovered and I hope that the people in charge will take use of this information. I really enjoyed learning about everyone else's experiments and results and getting advice from the "experts" and other people who have a direct impact on the cause of our experiments." - D. M.

"I think that the informal talk with one community official gave the group a chance to explain its project in more detail and examine several other aspects of landfill restoration that were not considered (Ex. cost, maintenance, time). It was nice to know that after five months of experimentation, our projects can make an impact on our community on the dealing with landfills and also provide the basis for future groups who plan to study the crisis of landfills." -Y. J.

"I did not realize *that* many spectators were coming to watch our presentations. It got me a little nervous at the beginning, but I eventually got over it once we started talking to the spectators and getting to know them. I think it was a very good idea that each table was assigned to one visitor because they expressed their ideas with us and, thus, we could begin an interesting conversation. I, as well as other students, were very amazed at the fact that the visitors took our extensive project very seriously (what I mean by this is that they were considering publication and the media about conveying the results and conclusions that we found to others.") -D. C.

"We did not know that so many important people were attending this event. Thoughout the morning, I saw that all our guests were very attentive to what was being said. I would have never thought that they would have taken us so seriously. I concluded this because of all the positive feedback we received on the experiments that were conducted. They encouraged us to disclose our finding to our peers and the community. They suggested to go on television and publish our findings. I found all of these suggestions to (be) overwhelming. These guests really did care about the environment and felt that we had valid information. All of this talk really made me feel important. I felt that I had really contributed to a good cause." -N. C.

"Yesterday's program was a great experience. It was the reward for all the hard work that went into the landfill experiments. To have our work reviewed and praised by a wide range of officials was really exciting. To know that our experiments could help begin to confront problems with landfills from all different areas was also very uplifting. I also think a comprehensive summary of everything we worked on should be completed so we could attempt to get it published." -J. T.

"I truly hope that our work will help improve our valley. The comments from yesterday's guests were encouraging and made me believe that we may help out the Roanoke Valley with the knowledge we have gained. I also realized yesterday that I know more about landfills that I could possibly care to, but I guess that's part of accomplishing the task that was set before us---making a difference." -B. L.

"I was happy to see that there (are) professionals other than Mara and Bea who think about landfill issues and care enough to spend time in a high school classroom discussing them. I agree with Dr. Cairns, however, that our work needs (and deserves) more exposure. Why not try contacting the national media or Ranger Rick? - B. G.

"The visitors gave the students wonderful suggestions for improvements of our experiments. The visitors also allowed us to see their points of view concerning the landfill." -C. H.

"Throughout this project, I had not been able to realize the full importance of it...but I never realized our data was going to actually be useful. But now I am able to say, "Why not?" It was good to have professionals let you know the good that will come out of all of our work. Throughout the months of work on this project, we all, at points, felt we were wasting our time. But I feel that we did well and learned a lot about landfills, and it's good to know that our work is of value." -R. D.

APPENDIX H

Background Information

QUESTIONS
&
ANSWERS

ROANOKE VALLEY RESOURCE AUTHORITY

What is the Roanoke Valley Resource Authority?

The Roanoke Valley Resource Authority was established to design, construct and operate a new waste disposal system for the Roanoke Valley. The Resource Authority is a combined effort of Roanoke Valley governments, governed by a Board of Directors with seven (7) appointed members representing each member jurisdiction. Through the efforts of this cooperative venture, the Roanoke Valley will play a leadership role in the development of an environmentally controlled waste disposal project that will involve the first totally rail haul waste disposal system in the nation.

Explain the waste disposal process.

Waste will be picked up from residences and businesses using normal procedures currently in use. Waste will be transported to the transfer station where it will be transferred to rail cars, which will be sealed with locked tops for the trip to the Smith Gap Landfill Tipper Building. After arrival at the Tipper Building, rail cars will be emptied, and waste will be inspected and loaded into hauling trucks, which will transport the waste to the landfilling area to be buried.

What is a transfer station and where is the Roanoke Transfer Station located?

The Transfer station will house the administrative offices for the Roanoke Valley Resource Authority and will also serve as the building where all trash is delivered and transferred to rail cars for transportation to the landfill. The transfer station has been designed to resemble a Norfolk & Southern Railroad building from the 1900's and will be an attractive addition to the neighborhood. The transfer station will be located in Roanoke City at 1000 Hollins Road.

Where is the Smith Gap Landfill?

The.Smith Gap Landfill is located on Bradshaw Road, approximately 12 miles from the intersection of Rt. 311 and Bradshaw Road. The entrance to the landfill will be private and well landscaped. The Tipper Building is located at the landfill and will be the location that the rail cars will deliver the trash to for hauling to the landfilling area.

How many acres are owned by the Roanoke Valley Resource Authority at the Roanoke Transfer Station and at the Smith Gap Landfill? How long will the landfill last?

The Resource Authority owns 22 acres at the transfer station and 1,200 acres at the landfill, with approximately 350 acres being used for landfill. The life expectancy of the landfill is approximately 60 to 70 years.

Will any trash be hauled into the landfill by truck?

No trash will be hauled to the landfill by truck, except trash that is considered "special waste" and required to be landfilled under special supervision.

What happens if the railroad goes on strike and what will happen to the trash at the transfer station if this were to happen?

The Resource Authority has a long term contract with the railroad. In the event of a strike, the railroad will be responsible for operating the train by non union labor or by taking the trash by truck to another landfill.

What time of day will the trash train be operational?

The trash train will be ready for departure from the transfer station by 7 p.m. each evening. When the filled train arrives at the landfill, it will be uncoupled and placed in position for emptying the next day. Empty railcars already at the landfill will be transported back to the transfer station that evening for loading the next day. All railroad operations are to be completed by 12 midnight.

Will hazardous waste be disposed of at the landfill?

No hazardous waste will be allowed in the Smith Gap Landfill. Waste will be inspected at the transfer station to insure that no hazardous waste makes its way to the landfill.

How can Roanoke Valley residents be assured that trash will not be brought in from other areas?

The Roanoke Valley Resource Authority is presently made up of three members, the City of Roanoke, Roanoke County and the Town of Vinton. Only trash from member municipalities can be disposed of at the Smith Gap Landfill. Only municipalities voted in by the unanimous vote of all Roanoke Valley Resource Authority members will be given membership, thereby eliminating delivery of waste from outside non-member municipalities.

Will the transfer station or the landfill be detrimental to the surrounding area?

The Roanoke Transfer Station and the Smith Gap Tipper Building have been designed to be an asset to their neighborhoods and the Resource Authority has made a substantial investment to insure that both facilities will enhance the area where they are located. The Smith Gap Landfill has been sited strategically in the surrounding mountains and will not be visible to most residents. Strict environmental standards are being adhered to in the design and construction of all the waste disposal facilities, which will insure the safety and protection of the environment. It is very important to the Resource Authority that both facilities will be "good neighbors".

What is being done to protect property values?

A property protection policy has been established by the Resource Authority, which provides that anyone who owns property within 5,000 feet of the border of the landfill or 1,000 feet of the transfer station will have their property value protected. If an owner can prove a loss in property value due to the location of either the transfer station or the landfill, he or she will be reimbursed for that loss. For more information contact the Roanoke Valley Resource Authority, 772-2130.

What is being done to protect the water supply in the landfill area?

A groundwater protection program for residents near the landfill has been established by the Roanoke Valley Resource Authority, which protects residents who own property within 1,000 feet of the landfill border. Residents in this area may sign an agreement with the Authority and allow water samples to be taken from their well before the landfill opens. The samples will be tested at the Authority's expense. The well must pass all health standards, including chemical and bacterial tests. Testing must then be allowed on a quarterly basis. If the well shows contamination, water will be provided, unless the Authority can prove that the contamination did not come from the landfill. More information is available from the Roanoke Valley Resource Authority, 772-2130.

What is the cost of this project and how will it be funded?

The total cost of the project is approximately $33 million and is being funded by the sale of revenue bonds. Once the project is operational, funds from waste disposal dumping fees will be used to pay the debt and operate the system.

When will the new waste disposal facilities be operational?

The proposed date for operations to begin is October, 1993.

What makes the new waste disposal system different?

The waste disposal system is unique in many ways. The Roanoke Transfer Station and the Smith Gap Tipper Building will use modern, innovative waste disposal equipment; the landfill is accessible only by rail for waste disposal, thereby eliminating trucks travelling long distances on rural roads; the facilities will meet strict state and federal environmental standards; the landfill has been sited to insure low visibility; the lifespan of the facilities will last long into the future and acreage not being used for landfilling will be available for possible recreational usage. The new waste disposal system is different, because Valley governments realize the importance of meeting strict environmental standards and are working hard, in a unified effort, to see that the new waste disposal system is environmentally sound and will set a good example for other communities in the nation.

For more information, contact:
Roanoke Valley Resource Authority
3433 Brambleton Avenue
Roanoke, Virginia 24018

Printed on Recycled Paper

Information on Governor's School

A Student's Guide to the Most Commonly Asked Questions About the Governor's School

WHAT'S THE GOVERNOR'S SCHOOL?

It's a regional public school for motivated students in grades ten through twelve who want to learn all they can about science, mathematics, computer applications, and technologies. Certain students in Roanoke City Schools who will be in ninth grade can also apply.

WHO SHOULD THINK ABOUT BECOMING A GOVERNOR'S SCHOOL STUDENT?

If you've done well in science and math, like it, and really want to learn and do more, then this is for you. If you are flexible and willing to do things in new and creative ways, this is for you. If you have completed algebra 1, geometry, and keyboarding, this is for you.

CAN I COME TO VISIT DURING SCHOOL TO SEE WHAT IT'S LIKE?

Absolutely! We encourage it! Best of all, we won't make a spectacle of you or embarrass
visit by calling our counselor (981-2116) or you can let your home school counselor know that y
Most visits last a half day. You can visit classes, meet and talk to students, and spend some priva
asking questions.

WHAT KIND OF COURSES WOULD I TAKE?

Each student takes a full math and science course each year. During January, a student takes an elective (that's all!) from a menu of courses like marine biology, remote sensing, behavioral research, or product design. New students also take Computer Applications and Technologies during their first year.

HOW IS THE GOVERNOR'S SCHOOL DIFFERENT FROM MY HOME SCHOOL?

Probably in lots of ways. Most students find the schedule to be different (we don't have 50 minute classes with every class meeting every day). Other differences include the pace (it's faster), group work (it's common), evaluation (lots of different ways to show that you know and can do stuff), relationships with faculty members (they really know you), the classes (everybody is there to learn), the equipment (lots of computers and scientific equipment to learn about and use), and a much more relaxed atmosphere (everybody here is here because he or she <u>wants</u> to be)!

HOW DO I APPLY?

Get an application from your local school guidance office. Fill it out completely. There will be some handwritten essays as part of it. Practice them first! Make sure that they represent your best ideas and that they show your best writing skills. Ask your counselor to help you get your transcripts and records copied for the application. Submit it at your home school when they ask for it. Don't miss a deadline. It's probably in early March, but contact your guidance coordinator to know for sure. Make sure that your parents come to one of several information meetings available during evenings in February. The schedule will be at your home school. Plan to visit the school. You should see it and experience it before you apply.

WHEN ARE APPLICATIONS DUE?

It depends on your local school division. Some are in late February, some in early March.
Contact your guidance office to find out for sure.

WILL MY GRADES GO DOWN?

Experience has shown that students who have gotten A's and B's in the past will continue to do so at the Governor's School. There is no significant difference in grades from the Governor's School and grades from home schools.

IS THERE MORE HOMEWORK?

Sometimes. But the biggest differences will be found in the fact that homework assignments are not repetitive (like all the questions at the end of chapter 4!), are often long range (more than one night to do it), and they tend to stretch your mind rather than being the same old stuff.

WHAT IF I DON'T KNOW ANYBODY?

It's not uncommon at all. Our students come from a lot of different high schools. Just ask one of our students how they found things. They'll probably tell you that the close friendships and relationships among our students develop very fast and remain strong. Everybody's in the same boat. Everybody's very friendly. You'll feel a part of the place very quickly. We guarantee it!

WHAT IF I DON'T KNOW ALL ABOUT COMPUTERS?

No sweat. It's very important that you know how to type or "keyboard." Beyond that, if you feel like you can't do much or haven't had a lot of experience, but are willing to learn...you're set. We will help you to gain an amazing number of new computer skills very quickly. Your mom and dad will be thrilled...and your grandmother will probably write her friends about her grandson or granddaughter the "computer whiz"!

WHAT ARE THE BASIC REQUIREMENTS TO GET IN?

You must have successfully completed algebra 1, geometry, and keyboarding. That means an A or a B. Your reading ability must be very good. Your scores must also indicate that you can understand and analyze what you've read. Your record must show that you are motivated and serious about learning and that you don't give up when the chips are down. Your record must also show that you have a real interest in science and math and that you've taken the most challenging courses available to you.

WHO MAKES THE DECISIONS ON ADMISSIONS?

Each school district has its own selection committee. They choose the students from their own district. After that happens, the applications are reviewed by a regional committee which has representation from each of the participating school districts. The Governor's School has only a limited number of slots for students.

DO I HAVE TO REAPPLY EVERY YEAR?

If you do not get accepted on your first try you may certainly reapply each year. Once you become a Governor's School student you do not have to reapply each year unless you are from Salem High School. Students must maintain an overall B average to continue in the school.

IS THERE A LOT OF COMPETITION AMONG THE STUDENTS?

Amazingly no. Despite the fact that the students here are all quite capable, we do not see a great deal of competition. It's probably because the courses are set up so that students strive to achieve a set of standards, skills or "competencies." We never, never, use a "curve" that causes some students to get lower grades and some to get higher grades.

WHAT IS THE DAILY SCHEDULE LIKE?

We don't have set periods of fifty minutes each with every student going to every class every day. There are short and long instructional times, needed when you do labs. Twice a week there is time to get help on your own or in groups.

DO I GET MY OWN LOCKER?

Usually. With very few exceptions each person gets a locker to himself /herself.

HOW DO I GET THERE?

Transportation is the responsibility of the home school district. Some provide buses or other means of transportation and some do not. You should check with your home school to see if there are special arrangements for you.

WHAT PERCENT OF THE STUDENTS GO ON TO COLLEGE?

One-hundred percent of our students go to colleges or universities. Most with advanced standing and/or scholarship money.

HOW CAN I GET MORE INFORMATION?

Stop by your local guidance office or call us anytime at 981-2116.

APPENDIX I

Letters and Consent Forms

PROPOSAL
1993-1994

Title: Involving High School Biology Students and Middle School Life Science Students in Landfill Restoration Through Problem-solving Investigations

Researcher: Beatrice L. Taylor, Dept. EDCI

The purpose of this study is to observe how high school biology students and middle school life science students, when given the life context problem of restoring a closed landfill, proceed to formulate a solution.

Working with high school biology teachers from Patrick Henry High School and the Governor's School, both of which are located in Roanoke, a unit would be collaboratively developed in which the students would be made aware of the closing of the Roanoke Regional landfill. They would need to develop a proposed restoration plan so that the landfill could be integrated into Virginia's Explore Park. This first phase of gathering information and becoming informed about the problem, which was approved by the Human Subjects Committee, was completed during the spring of 1993. The second phase of the study will be done in the fall of 1993. During this phase, students would begin designing experiments with seeds thought to be appropriate for use at the landfill. Students would do their control tests at their school sites. These tests might include erosion control, germination time, plant aggression, and rooting depth.

ASSESSMENT OF PROJECT

The researcher will keep written field notes of classroom tasks and interactions between student and student, and student and teacher. Observations of interactions and interviews will be recorded by means of audio and/or video tapes. Interviews with students will be structured in the form of informal conversations. These conversations will be used to determine what thought processes the students used to construct the problem and formulate possible solutions.

Interviews and planning sessions with the teacher will be audio taped. The tapes will be transcribed for analysis. During transcription, names will be changed to provide anonymity to the participants. The study will use qualitative methods to analyze the procedures used by the students to solve a community problem which has an environmental impact. A written summary will be completed which will assess the attainment of project goals.

TEACHER CONSENT FORM
1993-1994

Being a part of a community involves the identification of community problems and negotiating solutions that contribute to the public good. The proposed closing of the Roanoke Regional Landfill and its integration into Virginia's Explore Park constitutes such a community problem. What are we going to do with the landfill? How does the public wish to use this land? What measures need to be taken to insure that the landfill becomes a compatible part of the local ecosystem? I invite you to participate in a study involving problem-solving investigations, interviews and audio and video taping that will help us research these problems. We will also attempt to determine what plant growth might be best for use on the landfill, design experiments to determine plant feasibility, and then share with the community our findings and suggestions.

The contents of the field notes, notes taken from audio recording and any other information gathered will be available to those working directly with the project. Video recordings and pictures may be used for educational purposes in educational or professional presentations. They may also be used to educate the public to the importance of landfill restoration. From this project I hope to learn more a bout how young adults when confronted with a life context problem, choose to solve it.

This research project has been approved, as required, by the Institutional Review Board for projects involving human subjects at Virginia Polytechnic Institute and State University. <u>You are free to withdraw from this study at any time without penalty or prejudice</u> by contacting Bea Taylor (703-552-9783), Dr. George Glasson, Va. Tech, 300 War Memorial Gym, Blacksburg, Va. 24061(703-231-5269), or Dr. Janet Johnson, Chair of the Institutional Review Board (703-231-6077). If you have any further questions, please contact Bea Taylor, Education (703-552-9783) 2405 Capistrano St., Blacksburg, Va. 24060 .

Your signature below indicates that you have read the information and have agreed to participate in this study. You will be offered a copy of this form to keep.

______________________________ ______________________

Your Signature Date

Letter to Parents - Governor's School

Dear Parent/Guardian:

I am a doctoral student in Education at Virginia Tech. As part of my research in science education, I wish to study how students, when presented with life context problems, proceed to solve them. The problem presented to the students is to determine the type of restoration desired for the Roanoke Regional Landfill. This restoration should include both ecological considerations and interests of the community. The landfill will become integrated with Virginia's Explore Park, and a spur from the Blue Ridge Parkway will be built across it to connect the parkway with the park.

This is an invitation for the students in Dr. Kowalski's Biology class to help me better understand how they, as young adults, proceed to solve a problem that our growing technological population has helped to create, namely one of excess garbage. You can assist in my understanding this process of problem-solving by granting permission for your child to participate in this study.

Specifically, I will be working in collaboration with Dr. Kowalski and the students to investigate ways of gathering information about landfills, their composition, guidelines for closing, and the biological and chemical changes that occur within a landfill. Once information has been gathered, the students will decide what type of plant cover might be most successful at the landfill. After seed determination has been made, students will generate activities using these seeds. These experiments will be done at their school site.

Once data has been collected, students will have the opportunity to share their findings and recommendations for restoration of the landfill. This may be in the form of community meetings and/or public displays. I will be observing and assisting the students in their investigation of landfill restoration.

There may be both audio and video recordings of the students. Contents of the field notes, notes taken from audio recordings and any other information gathered will be available to those working directly with the project. The data will be used to investigate ways students proceed to find answers when given a context life problem. Video recordings and pictures may be used in educational or professional presentations to educate the public to the importance of landfill restoration.

Your child's participation in this study is voluntary. <u>He or she is free to withdraw at anytime without penalty or prejudice</u> by contacting Bea Taylor, 2405 Capistrano St., Blacksburg, Va. 24060 (703-552-9783), Dr. Kowalski (703-981-2116), Dr. George Glasson, Va. Tech, 300 War Memorial Gym, Blacksburg, Va. 24061 (703-231-5269), or Dr. Janet Johnson, Chair of the Institutional Review Board (703-231-6077).

Please indicate your decision to participate by completing the attached form and returning it to Dr. Kowalski in the Biology Department at the Governor's School by ____________________________. I do appreciate your help.

Sincerely yours,

Bea Taylor

Bea Taylor

September, 1993

Letter to Parents - Patrick Henry High School

Dear Parent/Guardians:

I am a doctoral student in Education at Virginia Tech. As part of my research in science education, I wish to study how students, when presented with life context problems, proceed to solve them. The problem presented to the students is determining the type of restoration desired for the Roanoke Regional Landfill. This restoration should include both ecological considerations and interests of the community. A spur from the Blue Ridge Parkway will be built across the landfill to connect the parkway with Virginia's Explore park.

This is an invitation for the students in Mr. McMichael's Biology class to help me better understand how they, as young adults, proceed to solve a problem that our growing technological population has helped to create, namely that of excess garbage. You can help me better understand this process of problem-solving by granting permission for your child to participate in this study.

Specifically, I will be working in collaboration with Mr. McMichael and the students to investigate ways of gathering information about landfills, their composition, guidelines for closing, and the biological and chemical changes that occur within a landfill. Once information has been gathered, the students will decide what type of plant cover might be most successful at the landfill. After seed determination has been made, the students will generate activities using these seeds. These experiments will be done at their school site.

Once data has been collected, students will have the opportunity to share their findings and recommendations for restoration of the landfill. This may be done in the form of community meetings and/or public displays. I will be observing and assisting the students in their search for this data.

There may be both audio and video recordings of the students. Contents of the field notes, notes taken from audio recordings and any other information gathered will be available to those working directly with the project. The data will be used to investigate ways students proceed to find answers when given a context life problem. Video recordings and pictures may be used for educational or professional presentations to educate the public to the importance of landfill restoration.

Your child's participation in this study is voluntary. He or she is free to withdraw at anytime without penalty or prejudice by contacting Bea Taylor, 2405 Capistrano St., Blacksburg, Va. 24060 (703-552-9783), Ed McMichael (703-981-2255), Dr. George Glasson, Va. Tech., 300 War Memorial Gym, Blacksburg, Va. 24061 (703-231-5269), or Dr. Janet Johnson, Chair of the Institutional Review Board (703-231-6077).

Please indicate your decision to participate by completing the attached form and returning it to Ed McMichael in the Biology Department at Patrick Henry High School by ______________________. I do appreciate your help.

Sincerely yours,

Bea Taylor

Bea Taylor

STUDENT CONSENT FORM
Patrick Henry High School
1993-1994

Being a part of a community involves the identification of community problems and negotiating solutions that contribute to the public good. The proposed closing of the Roanoke Regional Landfill and its integration into Virginia's Explore Park constitutes such a community problem. What are we going to do with the landfill? How does the public wish to use this land? What measures need to be taken to insure that the landfill becomes a compatible part of the local ecosystem? I invite you to participate in a study involving problem-solving investigations, interviews and video taping through which we will try to research these problems. Students will also query the best plant growth for use on the landfill, design experiments to determine plant feasibility, and then share with the community their findings and suggestions.

The contents of the field notes, notes taken from audio recording and any other information gathered will be available to those working directly with the project. Video recordings and pictures may be used for educational purposes in educational or professional presentations. They may also be used to educate the public to the importance of landfill restoration. From this project I hope to learn more about how young adults, when confronted with a life context problem, choose to solve it.

This research project has been approved, as required, by the Institutional Review Board for projects involving human subjects at Virginia Polytechnic Institute and State University. <u>You are free to withdraw from this study at any time without penalty or prejudice</u> by contacting your teacher, Ed McMichael (981-2255), Bea Taylor (703-552-9783) 2405 Capistrano St., Blacksburg, Va. 24060 , Dr. George Glasson, Va. Tech, 300 War Memorial Gym, Blacksburg, Va. 24061 (703-231-5269), or Dr. Janet Johnson, Chair of the Institutional Review Board (703-231-6077). If you have any further questions, please contact Bea Taylor, Education (703-552-9783).

Your signature below indicates that you have read the information above along with the letter to your parent or guardian and have agreed to participate in this study. You will be offered a copy of this form to keep.

_______________________________	____________________
Your Signature	Date

CURRICULUM VITA

BEATRICE DIETERING TAYLOR

4413 Woods Edge Court
Chantilly, VA 22021
(703) 378-8810

EDUCATIONAL EXPERIENCE

Virginia Tech (June 1991 - present)

Major:	Curriculum and Instruction
Cognate:	Biology
Advisor:	Dr. George E. Glasson
Dissertation:	Topic: A study of high school biology students engaged in a Science-Technology-Society (STS) landfill restoration project
Degree:	Projected completion Doctor of Philosophy in Education - November 1994

Virginia Tech (December 1993)

Major:	Curriculum and Instruction
Advisor:	Dr. George E. Glasson
Degree:	Advanced Graduate Studies

George Mason University, VA (September 1970 - June 1972)

Major:	Education
Degree:	Master of Arts

Auburn University, AL (September 1965 - June 1966)

Major:	Elementary Education
Degree:	Bachelor of Science

PROFESSIONAL EXPERIENCE

Research Projects

Taylor, B.D. October 1993
Involving high school biology students in landfill restoration. Dissertation prospectus.

Teaching

August 1994 - present
Classroom Teacher, Ormond Stone Intermediate School, Centerville, VA.
Responsibilities: Taught eighth grade applied physical science program.

August 1993 and August 1992
Taught segment of university wide GTA training workshop at Virginia Tech, "Training the Future Professorate" - conducted, videotaped, and critiqued graduate student performance in micro-teaching episodes.

September 1988 - June 1991:
Classroom Teacher, Lanier Intermediate School, Fairfax, VA.
Responsibilities: Taught seventh grade life science program; coordinated and ordered live materials for teachers; team-taught with self-contained resource teacher; sponsored science club; taught 7-8 grade speech and theater class.

July 1989 - July 1990
Director, Camp Hemlock, George Mason University, Clifton, VA
Responsibilities: Developed curriculum and activities; hired personnel; managed medicines; bought all materials; handled advertisement and registration; supervised staff.

September 1986 - June 1987
Science Enrichment Teacher, Oak View Elementary, Fairfax, VA
Responsibilities: Developed curriculum for grades 4-6 for science enrichment activities once a week; bought equipment; set up a "sharing time" for grades 1-3 once a month; set up an animal sharing center for teachers and students; advised teachers on care of live specimen; set up outdoor activities.

September 1975 - June 1988
Classroom Teacher, Oak View Elementary, Fairfax, VA
Responsibilities: Taught first, second, and third grades; set up extensive volunteer program within classroom; faculty advisory council.

September 1969 - June 1975
Classroom Teacher, Parkwood School, Vienna, VA
Responsibilities: Taught four-year olds; taught numbers, colors, shapes, finger plays, songs, stories.

September 1966- June 1968
Classroom Teacher, Northside Elementary, Opelika, AL
Responsibilities: Taught second grade; mentored a student teacher

Supervision

August 1992 - May 1993
Supervisor--Student Teaching, Montgomery County graduate student teaching model
Responsibilities: Supervised elementary and middle school student teachers' clinical experiences in public schools. Observed student teachers in public

school classroom. Advised students in performance, curriculum, and teaching strategies and materials in graduate programs resulting in a Masters Degree. Evaluated student teaching performance. Acted as a liaison between the university and the public schools.

August 1991 - May 1992
Supervisor--Student Teaching, Roanoke City student teaching model
Responsibilities: Supervised elementary student teachers' experiences in public schools. Conducted seminars at Virginia Tech. Observed student teachers in public school classrooms. Advised students in performance, curriculum, and teaching strategies in graduate and undergraduate programs. Evaluated student teaching performance. Acted as a liaison between the university and the public schools.

CONFERENCE PRESENTATIONS

Taylor, B. L., Sabre, M., & Kowalski, J. (1994, May). *Perspectives on collaboration in an STS landfill restoration project: Scientist, classroom teacher, and researcher.* Paper presented at the annual meeting of the Virginia Academy of Science, Harrisonburg, VA.

Taylor, B. L. (1994, January). *Investigation of students in landfill restoration.* Presented at the annual meeting of the Association for the Education of Teachers in Science, El Paso, TX.

Taylor, B. L. (1993, May). *Involving high school biology students in landfill restoration.* Presented at the annual meeting of the Virginia Academy of Science, Norfolk, VA.

Taylor, B. L. (1991, November). *It's sunny, let's go outside!* Presented at the annual meeting of the National Association of Biology Teachers, Nashville, TN.

Taylor, B. L. (1991, April). *It's sunny, let's go outside!* Presented at the annual meeting of the Virginia Middle School Conference, Norfolk, VA.

Taylor, B. L. (1991, March). *It's sunny, let's go outside!* Presented at the annual meeting of the Virginia Association of Science Teachers, Lynchburg, VA.

WORKSHOP PRESENTATIONS

Taylor, B. L. (1991, March). Demonstration of seventh grade science activities. Fairfax High School Pyramid teachers, Fairfax, VA.

Taylor, B. L. (1991, March). Outdoor activities. Inservice for elementary teachers, Area IV, Fairfax, VA.

Taylor, B. L. (1988, October). Outdoor activities. Inservice for elementary teachers, George Mason Outdoor Education Center, Clifton, VA.

PUBLICATIONS

Taylor, B. L. (1993, February). Miss Suzie. Adventure Magazine. Nashville: Southern Baptist Sunday School Board.

Taylor, B. L. (1993, May). Hummingbirds. Adventure Magazine. Nashville: Southern Baptist Sunday School Board.

Taylor, B. L. (1993, July). Mystery of the disappearing flowers. Adventure Magazine. Nashville: Southern Baptist Sunday School Board.

Taylor, B. L. (1993, August). Bug zapper. Adventure Magazine. Nashville: Southern Baptist Sunday School Board.

Taylor, B. L. (1992, April). Night sounds. Adventure Magazine. Nashville: Southern Baptist Sunday School Board.

Taylor, B. L. (1992, April). Ellen's rescue. Adventure Magazine. Nashville: Southern Baptist Sunday School Board.

Taylor, B. L. (1992, April). Yolanda's mystery pet. Adventure Magazine. Nashville: Southern Baptist Sunday School Board.

Taylor, B. L. (1992, April). Manuel's science project. Adventure Magazine. Nashville: Southern Baptist Sunday School Board.

Taylor, B. L. (1991, May). He did it twice and it ruined him. NSTA Reports! Washington, D. C.: National Science Teachers Association.

Taylor, B. L. (1976, December). Where's heaven? Living with Children. Nashville: Southern Baptist Sunday School Board.

PROFESSIONAL SERVICE

May 1994 - 1995

Chairman, Education Section, Virginia Academy of Science

June 1994

Instructional Materials Evaluator

Refined indicators and developed worksheets for the VQUEST criteria for selection of instructions which will be used in forthcoming textbook adoptions.

April 1993

Reviewer, Disney Educational Productions

Reviewed science concepts and vocabulary for three Disney films being planned for released to schools on the Wonders of Life project.

April 1993 and April 1994

Reviewer, Presidential Awards for Excellence in Science Teaching
Reviewed entries from elementary teachers in Virginia who were competing for the Presidential Award.

April 1992

Session Moderator, The Commonwealth Outstanding Dissertation and Faculty Research Conference.

Summer 1989 - 1990

Volunteer, Arts and Science pavilion, Fairfax Fair.

September 1989 -June 1991

Faculty Advisory Council (Lanier Intermediate, Fairfax, VA.).
Superintendent's Advisory Council (Lanier Intermediate, Fairfax, VA.).
Science Club sponsor

September 1990 - June 1991

Science Representative to Fairfax H. S. Pyramid.

Prior to 1989 - Oak View Elementary

Chairman, Social committee
Pod Chairman
Science-PTA Liaison

AWARDS AND RECOGNITION

Outstanding Student Presentation, Virginia Academy of Science, 1994
Instructional Fee Scholarship, Virginia Tech 1991 - present
Phi Kappa Phi, 1966
Kappa Delta Pi, 1966

PROFESSIONAL ASSOCIATIONS

American Educational Research Association
Association for Education of Teachers of Science
Fairfax Education Association
National Association for Research in Science Teaching
National Association of Biology Teachers
National Education Association
National Science Teachers Association
Northern Virginia Association of Science Teachers
Virginia Academy of Science
Virginia Association of Science Teachers
Virginia Science Leaders Association

CERTIFICATIONS

K - 8
Administration, Elementary & Middle School