A STUDY OF NEWFOUNDLAND HIGH SCHOOL STUDENTS VIEWS ON TECHNOLOGY

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A Study of
Newfoundland High School Students
Views on Technology

by

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Abstract

The STS (Science, Technology and Society) movement has become increasingly important in science education in recent years. Science education must now prepare students to live and work in a society that is likely to be even more technologically oriented than today. This implies that students must understand the concept of technology if they are to participate fully in society. Developing a clear understanding of technology is likely to be enhanced by addressing any misconceptions that students may already hold. This study is an attempt to discover how clear are the conceptions and misconceptions about technology that are held by a typical group of high school students in this province.

A representative sample consisting of 36 students who were likely to participate in a pilot version of the new STS course was selected from participating schools. Attrition resulted in a final sample size of 26. An approximately 30 minute interview was conducted with each student.

The interview included discussions of examples of science and technology, the activities associated with science and technology, the purposes of science and technology, the relationships between science, technology and society, characteristics of scientists and technologists and sources of information about science and technology. Each interview was tape-recorded and transcribed verbatim. Conceptual inventories were then constructed

from each transcript and the data were analyzed.

The results indicated that a majority of the students did not have a clear understanding of the concept of technology, and, that in many cases, they had difficulty distinguishing between science and technology. Most students could differentiate between activities associated with science and activities associated with technology, respectively. Many students held stereotypical images of scientists and technologists. A majority of the students in the sample felt it was important to be informed about science and technology and that the general population should play a role in the decision-making process for matters involving science and technology. There was some concern expressed by the students that there was not enough information available to them in school about science and technology, even though school was usually their primary source of information.

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CHAPTER 1

THE RESEARCH PROBLEM

Overview of the Chapter

This chapter introduces the problem that is the basis for this research study. As science education has become increasingly accountable for its relevance to students there has been an accompanying increase in the attention paid to science-technology-society (STS), as an aspect of science education. In order for students to benefit fully from STS curricula they must first have clear concepts of what science and technology are. Although attention has been paid to students' individual conceptions of science there has been no parallel emphasis relating to their conceptions of technology. If students are to benefit from STS programs, this aspect of their present knowledge must also be known. If educators do not know the present level of students' understanding and the misconceptions that they hold, then it is more difficult to design programs which will meet their needs. It is the purpose of this study, therefore, to study the conceptions and misconceptions of technology held by typical students who may enter the Science-Technology-Society course in Newfoundland High Schools so that this information can be used to identify the congruence between what such students already know and what they may need to know. The research questions are designed to identify students' conceptions

and misconceptions of the meaning of technology and the sources of their information about it.

Introduction To The Problem

For approximately the last two decades, one factor that has had an increasingly important impact on science education has been that of the relationships between science, technology and society. This field has come to be known simply as STS. Today, more emphasis is being placed in the curriculum on the relevance of science, even for non-scientists, and on the effects of science on society and of society on science. This trend has accompanied a parallel trend in our society in general. Our society has become focused in many ways on scientific knowledge and technological know-how. Almost any aspect of our lives can be impacted by the benefits and losses associated with the growth of science and technology.

Science education today, therefore, must be aimed at preparing the student to live and work in a society that is even more technologically oriented than at present. Yager (1984) brought out the need to define science education as including the interface between science and society. According to Yager, science education would have a more obvious legitimacy to the public in general if it prepared people to understand the importance of science and technology in daily life and for future generations. Opposing viewpoints to

this have also appeared however. For example Good, Herron, Lawson, and Renner (1985) refute Yager's definition and define science education as the discipline devoted to discovering, developing and evaluating improved methods and materials to teach science. However, the majority of writers in the field of science education tend toward Yager's view but not quite to the extent of his statements (Bybee, 1987; Bybee, Harms, Ward, & Yager 1980; Fensham, 1988; Fleming, 1989; Knamiller, 1984; and McConnell, 1982).

Bybee (1987) discusses the idea that schooling should serve individual and, ultimately, society's needs for maintenance and development. Bybee concludes that science education should enhance the personal development of all students and contribute to their lives as citizens. To do this he says we must look at an STS orientation. This would include research and development of a curriculum that includes, among other things, knowledge, skills and understandings relative to technology. Fensham (1988) states that STS is an attempt to bring science education closer to the needs of citizens in an increasingly technological society. Yager (1993) suggests that STS means using technology as a connector between science and society and that this means that the applications of science are seen as closer to the lives of students, including food, clothing, shelter, transportation, communication and careers.

Although Fleming (1989) proposes that we should teach students that technology is not something to be completely understood, if students are to be prepared to live in this future technological society then it seems reasonable that they must first have clear

concepts of science, technology, society and the relationships between these three. Fleming defined technological literacy as when a person has the power and the freedom to use that power to examine and question issues of importance in sociotechnology. Students can never achieve this power without understanding technology. This study, therefore, is an attempt to discover how clear is the concept of technology that is held by high school students in this province and what, if any, misconceptions they have about it.

Need For The Study

Although there is a very large body of literature relating to technology in the curriculum (Donnelly, 1992), little attention has been paid to measuring students' concepts of technology (Wolthers, Raat and de Vries, 1990). In this province, preparations are being made for the introduction of a new science-technology-society course at the high school level in September 1994. This course has run as a pilot project in the previous two school years. Consistent with Ausubel's suggestion that "The most important single factor influencing learning is what the learner already knows; ascertain this and teach him accordingly (Ausubel, 1968 p.iv)", it is of benefit to know what the students understand by the term technology when they enter the course.

The first goal stated in the course description for this course is that students should

be able to develop an understanding of the interrelationships among science, technology and society (Government of Newfoundland and Labrador, 1993). In turn, this requires that each student should develop an adequate concept of science and technology. The likelihood of success in achieving these learning outcomes will be greatly improved if teachers and curriculum developers have some knowledge about what students already understand about the meaning of technology. The study is intended to fill in some of that information and, in addition, discover any misconceptions about similarities and differences in the meaning of science and technology that the students hold which may impact on further development of these concepts.

Purpose And Rationale For The Study

This study attempts to discover high school students' understanding of the meaning of technology and how it differs from science. It is aimed particularly at determining the scope of students' concepts of technology and identifying any consistent misconceptions or alternate conceptions that they hold about it.

The importance of ascertaining this information towards improving the STS education of Newfoundland students can be seen in the following statement from the science-technology-society course description, "The social and economic future of Newfoundland will depend on the appropriate use of science and technology to manage our

resources and develop new economic opportunities, which in turn will depend on how well we educate our youth to utilize science and technology" (Government of Newfoundland and Labrador, 1993, p.3).

Clearly, an understanding of the meaning of technology is important, yet there has been no similar study to this in this province nor with respect to similar students elsewhere and therefore this exploratory study is warranted.

Although this study was conducted with high school students in the province of Newfoundland and Labrador, it is an area that should be of concern to educators worldwide. The level of education that young people receive in the area of science and technology can have a strong impact on the level of development that their society as a whole will have in the future, since society in general is becoming more and more dependent on science and technology. The research done here therefore may provide valuable information in that it can act as support for similar research and decisions that may be undertaken elsewhere.

Research Questions

The study addresses three research questions.

1. What are the most prominent features of the concepts of the nature of technology held by high school students?

2. What are the misconceptions that students have concerning technology?

3. What are the students main sources of information about technology?

In order to differentiate between their understanding of technology and science, students were also probed about their related understandings with respect to science.

Limitations Of The Study

The study was conducted in most of the schools piloting the proposed new provincial STS course, but because of the excessive distance involved one school was not included. Strictly speaking, the schools involved may not be representative of the larger provincial population or of schools elsewhere. Nevertheless, pilot schools for the proposed course were selected by the department of education to represent a variety of types, sizes and locations of schools. It is reasonable to assume that these students are representative of the target population in general. It is also possible that the interview technique did not ascertain all pertinent information. Although this is a widely used method for obtaining data relating to students' conceptions and misconceptions, as it allows probing of students' understandings, it can lend itself to subjectivity and bias. However steps were taken to minimize this and therefore enhance the reliability of the

results.

Delimitations

This study is limited to five schools on the island portion of the province of Newfoundland and Labrador. Technically then, all we can conclude on the basis of this is the conceptions and misconceptions held by these particular students. Strictly speaking the results may not be generalized to any other population. However the procedures used to select schools and students enhances confidence in the generalizability of the results obtained.

Summary

This chapter presented the research problem that is being addressed, that is, the need for more knowledge about students' present understandings about the concept of technology. Arguments were presented for the importance of this information and the consequent need for a study to be undertaken to determine this information. The research questions for the study were also described. Chapter two outlines research that is considered relevant to the present study.

CHAPTER 2

REVIEW OF THE LITERATURE

Overview of the Chapter

This chapter reviews literature and research that is directly related to the study undertaken here. First, an attempt is made to analyze some of the various definitions of technology that can be found in the literature as it is impossible to analyze meaningfully students' conceptions of technology without first defining what technology is. Second, similar studies that have looked at students' concepts of technology are reviewed as well as some literature related to identifying students' misconceptions in the field of science education. Finally methodological techniques used in this type of research and, in particular, the use of the semi-structured interview are considered.

Literature Review - Related Research

There is a growing body of lit. .ture and research in the area of science-technology-society. However, it emphasizes some aspects of the field much more than

others. There has been an abundance of commentary and critical analysis of the field, written from a wide variety of perspectives. However, much less has been done in terms of actual research. There is not even a consistently accepted definition of technology. For example one British study (TVEI,1988) notes ten definitions, and Donnelly (1992,p.125) comments that these are generally uninformative.

The nature of technology is discussed at some length in Science for All Americans, (American Association for the Advancement of Science, 1989). Technology is described as a social, complex enterprise that includes not only design and crafts but also finance, manufacturing, management, labor, marketing and maintenance. The relationship between science and technology is also discussed. The use of technology in science to provide tools is emphasized but it is also stated that technology is more than this, as it can also provide the motivation and direction for theory and research. New technology often requires new scientific understanding; new scientific investigations often require new technology. Social and economic forces strongly influence what technologies will be undertaken, attended to, invested in and used. A Canadian who is prominent in this field suggests that "Science is people satisfying their curiosity about the world around them .... technology is people responding to human needs by discovering, designing, and producing things or ideas for society" (Aikenhead, 1991, pp. 96-97). Finally, UNESCO (1985, p. 8) defines technology as: "... the know-how and the creative process that may utilize tools, resources and systems to solve problems, to enhance control over the natural and

man-made environment in an endeavour to improve the human condition." These examples show the wide range of factors that must be taken into account when considering the meaning of technology. Narrow and misleading definitions, such as "technology is simply applied science", must be avoided if all aspects of the concept are to be taken into consideration.

Attempts to define technology have been accompanied by proposals of how much knowledge and understanding people need to have about technology. This can be seen in Fleming's (1989) idea of technological literacy. Fleming argues that there are several requisite understandings to becoming technologically literate including developing a meaning for both technology and literacy; knowing about the nature of technological knowledge; and developing decision making skills in a technological society. A technologically literate person, he says, must be able to understand the relationship between technology and social change. Association with technology however, is not always seen as producing a positive image, as pointed out by Carelse (1988). Carelse writes " The fact that technology is associated with those who do manual work, whereas the education system is largely controlled by those who do not, has tended to give technology a lower status in education than science" (p.101). A summary of the literature concerning technological literacy is presented by Hayden (1989), who also emphasizes that technology is much more than the application of science. Based on a synthesis of hundreds of articles written on the subject Hayden defines technology as "a set of

processes by which resources are utilized to extend human potential within a given environmental context" and then goes on to define technological literacy similarly as "Having the knowledge and ability to select, properly apply, then monitor and evaluate appropriate technology given the context."

Technology is often presented as the servant of science or as applied science. Yet technology pre-dates science by millennia, as exemplified in ancient agriculture, metallurgy, glass manufacture and even brewing. Fensham (1990) summarizes the differences between science and technology by referring to the culture of science versus the culture of technology. He points out that technology is much older than science and that science and technology are sometimes related and sometimes not, as one can often be shown to have been developed without accompanying related development in the other. According to Fensham, the difference in the culture of science and the culture of technology is the difference between knowing persons and making persons. Fensham suggests that scientists take nature apart to understand it or explain it, whereas technologists put nature together to make something novel; scientists are interested in natural phenomena, while technologists are interested in artificial things; scientists tend to do analytic kinds of thinking, while technologists are more inclined to synthetic thinking; and scientists are interested in knowledge for its own sake while technologists are interested in specific knowledge for real problems. Finally Fensham notes that science involves discovering and uncovering whereas technology involves design and invention.

One of the main purposes of STS education is to see education become more socially responsible. This requires that science and technology be viewed as potentially problematic and dependent on human interests. Curricula following this view challenge students to consider the risks to society that are generated by science and technology (Cross, 1993). But what do children and adolescents consider the essential characteristics of technology to be?

Students perceptions of technology have been studied, directly and indirectly on several occasions. In a major study of Canadian high school students, (Aikenhead, Fleming, and Ryan, 1987) students' views on interactions among science, technology, and society were exposed. The sample for this study was selected mostly on the basis of course registration. The target population comprised students taking the second year offering of biology, chemistry or physics plus students in their final year of high school who were not taking any science courses. The population of graduating students numbered about 202,000. These students were enroled in 1941 schools across Canada, excluding Quebec, the Yukon and the Northwest Territories. A stratified sample of 10,800 students was selected. In May and June 1984, a questionnaire (VOSTS) was responded to by all students in the sample. VOSTS was designed to overcome the problem of different perceptions of questions on the part of the student and the assessor respectively that may occur when objectively scored instruments are used by researchers. VOSTS shifts the responsibility of handling subjectivity to the researcher. VOSTS requires the student to

write an argumentative response to a statement on an STS topic. The answers are not analyzed as right or wrong but rather the students' arguments are used to define various positions on each STS topic. Students are given one of the 46 statements that make up the VOSTS instrument and are asked to agree, disagree or say they cannot tell and then argue for their position. Part one of the study looked at students' views of the influence of science and technology on society. When statements concerning specific social ills, for example, were put to the students technoscience served as the basis for their responses. As part of the study, students' beliefs about the interaction between science, technology and society were analyzed (Fleming, 1987). It was found that, on the surface, students seemed capable of distinguishing between science and technology, but when they actually had to do so in order to respond to a related statement they failed overwhelmingly. The roles of science and technology were often confused, for example scientific research was often equated with finding cures for disease. When students' views on the roles of science and technology in decision making concerning future energy use were analyzed, 46 percent of the students espoused a purely technocratic decision-making view. Many of these students made their choice based on their belief that the solid repertoire of facts inherent in the training of scientists and technologists made this group uniquely prepared to decide future energy use. Half of the respondents (48 percent) supported a more democratic model of decision making on societal issues related to science and technology. Almost half favoured social control of science and technology, expressing their belief that funding

should only be given to scientists who can show, in advance, what the return on the investment will be. Thirty one percent believed that research should be funded because science functions to benefit society. A third part of the study looked at the characteristics and limitations of scientific knowledge and is therefore not related to this present study. The final part of the study looked at the characteristics of scientists (Aikenhead,1987). For example, when asked why scientists do science, most students listed either "satisfying curiosity" or "striving for a better world" as the primary reasons.

In a related VOSTS study (Fleming, 1988), a semi-structured interview format was used with the VOSTS statements to determine the views of undergraduate science students. It was found that the views of these students were remarkably similar to those of high school students.

Another Canadian study in this field has been carried out in British Columbia (Zoller, Ebenezer, Morely, Paras, Sandberg, West, Wolthers, and Tan, 1990). This study reported on the beliefs and positions of grade 11 students who were enrolled in an STS course. A questionnaire comprised of four VOSTS statements was administered to 101 students in randomly selected classes. The control group consisted of 276 students in randomly selected classes at the same schools who had not taken the STS course. The responses to each of the four statements were grouped into "clusters" consisting of one to four responses each of which expressed, in principle, the same view on the issue dealt with. It was found that the course in question (ST 11) clearly had an impact on the STS

viewpoints of high schools students. However, it was also found that gender difference may play a significant role in accounting for the differences in certain STS viewpoints between ST 11 and non - ST 11 students. The ST 11 students favoured the public deciding on world food production and distribution compared with the non - ST 11 students who believed that scientists and engineers should decide this issue. ST 11 students strongly believed that scientists should be held responsible for the harm that might result from their discoveries, whereas typically the non - ST 11 students' view was that the scientists should not be held responsible for this. This study concluded that ST 11 students understand that society controls technological developments and influences and responds to scientific activity.

Nash et al (1984) studied factors that may influence pupils to opt or not opt for a technology course in England. A questionnaire was issued to 862 students in fourth year options at four secondary schools. The questionnaire was administered in "exam-like" conditions. Ninety-one students in a technology course responded to a query asking why they opted to study technology. Twenty-seven (30 percent) replied that they found it interesting and a good course, 12 (13 percent) replied that it was a useful subject for future career interests and nine (10 percent) replied that it was a useful subject for life. These students were also questioned about their perceptions of the difference between science and technology. The most popular explanation offered was that "There is more design work and constructing and developing your designs in technology."

Another British study looked at pupils' perceptions of technology in the secondary school curriculum (McCarthy and Moss, 1990). The study was carried out in a single 11-18 co-educational comprehensive school with a large, active, crafts, design and technology department. A total of 40 pupils following technology courses in the last four years of the school were asked to complete a questionnaire designed to measure their attitudes towards two technology oriented courses in terms of perceptions of technology. In general, they perceived technology as being intellectually demanding and as having a high employment value. When asked their reasons for taking technology, 30 of the 40 students stated that they believed technology would be useful to them in the future.

Solomon (1988) analyzed empirical data from 284 British STS examination scripts. Candidates, aged 16 and 17 years, were asked, based on a short introduction about in-vitro fertilization, to explain the meaning of the term technology. The question was designed to avoid the usual connection between technology and machinery. Still, 165 of the students defined technology as equipment, tools or machinery. Another eight percent equated technology with science.

A large study based in Holland investigated students' attitudes towards technology (Wolthers, de Klerk, Raat, and de Vries, 1990). The instrument used, the PATT (Pupils' Attitudes Towards Technology), focused on dimensions of pupils' attitudes towards technology for both the cognitive and connative components. The cognitive dimensions are (1) technology and humans; (2) technology and science; (3) technology and skills; and

(4) technology and matter, energy and information. Two of the connative components are also of interest here, namely consequences of technology and technology in the school curriculum, respectively. The first study, conducted in the Netherlands, sampled students in the second year of secondary school. About 500 students were involved. Results showed that students mainly associated technology with machines and equipment, not with humans. They tended to see only the product aspect of technology, not the process aspect. Students were interested in technology but girls were significantly less interested than boys. Students in technical/vocational education appeared to be more interested in technology but did not appear to have a better concept of technology than students in general secondary education. A second PATT study conducted in India with a sample of 1167 16-plus students in urban and rural settings looked at male/female differences in their attitudes to technology. Results showed that differences between boys and girls were not significant on most scales. A third study was carried out in Poland and involved about 600 students in general secondary education. In this study slightly more than half the students showed an interest in technology. Boys showed significantly more interest than girls. A large majority of the students felt that technology was important for the development of their country and almost all students mentioned production as an element of technology. Over two thirds mentioned a relationship between technology and science. Another PATT study was carried out in Australia (Rennie, 1987). The questionnaire was administered to 229 year eight students in nine intact classes in the Perth metropolitan

area. The classes were selected to represent an overall balance in academic ability and socio-economic status. Most students in this study agreed that technology is important, yet their responses indicated that they did not have an understanding of technology. More than half the students appeared to be unaware of the pervasiveness of technology in everyday life. Many students, for example, did not recognize a bicycle or a radio as products of technology. More than half the students failed to appreciate that technology existed more than 100 years ago. Six percent of the students believed that technology only concerned computers and 14 percent believed that it always had to do with electricity. Forty percent of boys and 56 percent of girls felt that at school they did not hear much about technology. Students generally wanted to learn more about technology. In summary, this study concluded that a large proportion of students, including the majority of girls, show a high level of unawareness and misconceptions about technology.

These and other studies indicate the need for more in depth research into what students understand about the meaning of science and technology and, in particular, how they see it relating to themselves and the world in which they live. To do this, an attempt must be made to collect data which provide more than a superficial knowledge of students' understandings of STS issues. In this process, it is necessary also to look at any misconceptions held by the students concerning the meaning of science and technology. Although there is a very large body of research in the field of students' misconceptions of science (Pfundt and Duit, 1991), it is very much focused on scientific concepts and does

not extend to technology. Nevertheless, in terms of its focus on the identification of students' conceptions and when they are at variance with currently accepted ideas, this literature is very relevant to the present study. A variety of terms have been used to describe this area of study, including "misconceptions", "alternative conceptions", "naive conceptions", "preconceptions", and "children's science" (Confrey, 1990; Gilbert and Watts, 1983). These and other reviews of the studies that have been done in this area show the extent of attention that has been paid to this topic (Driver and Easley, 1978; Posner, Strike, Hewson and Gertzog, 1982; Driver and Erickson, 1983; Eylon and Linn, 1988; Perkins and Simmons,1988). The sources of these misconceptions have also been investigated and at least five possible sources have been suggested (Head,1986). These include the following: everyday experience and observation; confusion about analogies; the use of metaphors; peers; and innate origins. Discovering students' prior knowledge will also provide an indication of the alternative conceptions that they hold, (Hewson and Hewson, 1983).

Attempts to discover students' misconceptions of science concepts have been made locally. Griffiths and Preston (1992) investigated Grade 12 students' misconceptions of fundamental characteristics of molecules and atoms; Griffiths and Thomson (1993) looked at students' understandings of science processes, and Griffiths and Barry (1993) investigated students' misconceptions of science processes. In each case, many misconceptions were identified.

It can be concluded from the research that students' misconceptions influence the way in which they perceive information that is presented to them. The present study seeks to identify the status of students' conceptions about the meaning of technology.

Methodological Techniques

Research into students' understandings of science and technology and attitudes to science and technology has been ongoing for a number of years and has taken a variety of forms. Research methodologies in this area have included both interview and paper-and-pencil type investigations.

Several of the tests available in this area at the time were reviewed by Aikenhead (1973). These included Test on Understanding Science (TOUS), Facts About Science Test (FAS), Nature of Science Scale (NOSS), Science Process Inventory (SPI), Wisconsin Inventory of Science Processes (WISP), and Test on the Social Aspects of Science (TSAS). It was found that each seemed to have limitations, and that they generally failed in research designed to test the effects of different teaching strategies. The instruments did prove useful, however, when used in experiments concerning the content of science lessons.

Aikenhead's (1988) analysis of four methods covering a wider range of methodologies considered Likert-type response, written paragraph, semi-structured

interview and empirically developed multiple choice. He found that interviews clarified ambiguities in the students' viewpoints that were found in written work. Of the four methods, interviews were found to provide the most lucid and accurate data and provided the opportunity to investigate the sources of students' beliefs. The problem with the use of interviews was suggested to be the amount of time needed to gather and analyze the data.

Sutton (1980) reviewed techniques for probing the organization of a learner's prior knowledge. This review looked at clinical interviews and the construction of concept maps, word-association tasks, writing or selecting a definition, and identifying and using bipolar dimensions in a semantic space. Sutton concluded that any useful conceptualisation of how a learner's thoughts are organized must include some picture of its dynamics as well as its static aspects, and that the clinical interview was the method which had the best chance of displaying the learner's reasoning. He also concluded, however, that the problems with this method are the length of time required and problems interpreting the data correctly.

The use of interviews has also been examined as a method for studying students' misconceptions. Lythcott and Duschl (1990) looked at the interview as a method for answering the following question:

What are the grounds that are used to support the claims that:

1) children construct personal conceptions about natural phenomena,

2) these conceptions are often ascientific, and

3) they are remarkably resistant to change toward more scientific conceptions through traditional instruction?

Lythcott and Duschl then go on to illustrate how defensible conclusions can be reached from interviews in science education research. They also point out three of the probable difficulties that can be encountered when using interviews for this type of research: inducing a student conversation with a perceived authority figure, the danger of misrepresenting the responses, and the necessity of holding a general hypothesis about what the student knows which can be used to guide the general flow of the interview, while still being open to adapt to what emerges outside the prediction of that hypothesis. Avoiding these pitfalls is largely dependent on the skill of the interviewer. Basic interviewing skills can make a great deal of difference to the reliability, validity and completeness of the information obtained from the interview (Gorden, 1992).

Guba and Lincoln (1981) examined interviewing with reference to the degree of structure which should be incorporated into the interview. Interviews may be structured, adhering exclusively to a fixed set of questions; unstructured, without any pre-set questions; or semi-structured, where pre-set questions are used as a guideline allowing the interviewer flexibility to ask probing questions or questions to clarify ambiguities. This flexibility is what allows additional information to be obtained by this method that may not be obtained otherwise (Osborne and Gilbert, 1980). Interviewing also has the advantage

of allowing the interviewer to use non-verbal cues as a guide to when additional probing is needed.

Even with the potential difficulties outlined here, the interview was considered to be the most appropriate method for the research attempted in the present study, as other methods do not permit deep enough probing into students' ideas or the sources of these ideas.

Summary

Chapter two has provided a summary of research and literature relating to the present study. Several definitions of technology were reviewed so as to provide a clearer understanding of the concept of technology accepted by the researcher in this study. This was followed by a review of related research studies and a brief review of the methodological techniques employed in this field of research.

Chapter three presents the methodology utilized in the present study.

CHAPTER THREE

METHODOLOGY FOR THE STUDY

Overview of the Chapter

This chapter outlines the methodology used in the present study. It presents the method used to select the sample for the study and the composition of the sample. It also provides the procedure used to develop the questions used in the interviews and the research design of the data collection and analysis.

The Sample

Interviewing as a research technique is labour intensive and time consuming. This factor limits sample size. In this study the sample contained 36 students, which after attrition became 26. These students were chosen to be representative of the students who will be enrolled in the new provincial science-technology-society course. Hence, students were selected from the schools where the STS course was to be piloted the following

September. The schools were selected by the Department of Education to give a representative sample of the various sizes of high schools that exist in this province. Small, medium and large schools were selected. At the same time, attempts were made to have schools included that represent both urban and rural settings within the province, however there was not a school from a large urban setting included in the pilot. It was intended that a balanced representation of male and female teachers be used as well. One of the pilot schools selected is in Labrador as this represents a different environment in which the course will be taught but this school was omitted from the present study for logistical reasons.

The schools selected for the study included Holy Trinity High School, Torbay; Ascension Collegiate, Bay Roberts; Random Island Integrated School, Random Island; Lewisporte Regional High School, Lewisporte; La Rochelle High School, Brent's Cove; and Sop's Arm High School, Sop's Arm.

At each of these six schools, six students who intended to enrol in the STS course the following September were interviewed. These students were selected jointly by the interviewer and staff at the school in order to provide a stratified random sample. Three male and three female students were selected at each school and these students represented high, average and low achievers in science. Students were randomly selected from class lists in the schools and the selection was then modified as necessary to provide one male and one female student in each of the three groups. The procedure provides a

representative sample of students in the eventual target group for the STS course.

When the interviews were transcribed from the audio tapes it was discovered that the six apes from the school at Random Island were of very poor audio quality and could not be transcribed and used. Four other tapes could not be transcribed due to the very low volume of the students voices. This resulted in a sample size of 26, which consisted of 13 males and 13 females. The students ranged in age from 15 years and 5 months to 18 years and 4 months with an average age of 16 years and 6 months. There were nine students in the high achiever group, 10 in the middle or average group, and seven were in a group of low achievers.

Question Development

The intended structure of the interviews as semi-structured requires that a series of questions be developed as a guideline to maintain commonality of the interviews as a whole. A series of core questions was developed which focused on the main aspects of the concept of technology and a series of probing questions were also developed which could be used if and when further information was needed from the student. The questions were then analyzed using the following criteria developed from those proposed by Guba and Lincoln (1981, p.177).

1. Is this question necessary? How will the response be used? How will the response be analyzed?
2. Does the question cover the topic? Are other additional questions necessary?
3. How will this question be interpreted? Are other facts needed before the response will make any sense?
4. Do the respondents have the information to answer the question? Has the interviewer allowed for differences? How reliable would the interviewer expect the responses to be?
5. How valid does the interviewer expect the responses to be? Is the question leading? Is it formed in value neutral terms? Is the response likely to be adequate? What has been taken for granted? What are the possible frames of reference?

The final interview guide is included in Appendix A. In order to establish students' understanding of the meaning of technology, it was considered necessary to include equivalent questions relating to science to determine whether, in fact, the students understood the differences between science and technology. The results of this analysis are compared to the results of other studies attempting to identify students conceptions of scientists and technologists, such as the Draw a Scientist Test (Kahle, 1989) and the Draw a Technologist at Work Test (Moore, 1987).

Research Design

The purpose of the design was to provide a representative sample of students in the target group for the science-technology-society course. Sample size was determined mainly by consideration of the time necessary to interview, transcribe, and analyze this kind of data. A sample of about thirty students is normal in such studies (Griffiths and Preston,1992; Griffiths and Thomson,1993; Griffiths and Barry,1993; Garnett and Treagust,1992)

Once the schools were selected the interviewer arranged visits to each school. The students were selected and then interviewed on a one to one basis during regular school hours. The setting of the interview, an office or unused classroom within their school, was made as relaxed as possible both physically and verbally to encourage students to provide accurate information. It was felt that students would be more likely to provide accurate information freely if they did not feel intimidated. They were assured that the tape recording and their identity would be kept confidential. Probing questions were used when the students provided indications, verbal or nonverbal, that they wanted to elaborate but could not seem to express what they wanted to say. These techniques are recommended to assist in getting correct and relevant information from an interview (Gorden, 1992).

The interview questions were reviewed initially by several science teachers to

determine if they are relevant to the topics likely to emerge in discussions of this topic and to see if they are sufficient to cover the topic. Once the questions were finalized, the interview was field tested four times in a pilot study to allow the interviewer to determine the appropriateness of the questions in terms of wording and in terms of the general flow of the interview. These interviews were conducted with students at Holy Trinity High School who had been eliminated from the main study. The interviews were then conducted with the main sample. Each interview took approximately 30 minutes and was tape-recorded and then transcribed for analysis. At this point in the process, several interviews were eliminated from the study due to poor audio quality. Conceptual inventories, as described by Erickson (1979), were then constructed from these interviews for further analysis.

Analysis Procedures

The interviews were transcribed verbatim from the tape so that the intended response of the student could be determined as accurately as possible. Conceptual inventories were then developed from these transcripts. The conceptual inventories were reviewed by independent science teachers and, where appropriate, modified to accommodate their concerns. The conceptual inventories were then analyzed for conceptions and misconceptions. As well, the interview transcripts were analyzed and

information used directly from them. The data collected in this way included students' responses to lists of examples of science and technology and also responses to the sketches used in the interview. This information required no interpretation.

Reliability and Validity

Two methods were employed to check the reliability of the procedures used. First, several repeat questions were built into the interview. This allowed the interviewer to determine the consistency of the students' responses over the course of the interview. In addition, the set of statements that were developed from the interview transcripts were analyzed by individual science teachers and science-teachers-in-training to help ensure that the conceptual inventories were not biased by the researchers conceptions and that they are appropiate representations of the responses of the students.

The validity of the procedure was checked by the review of the questions by several science educators before any interviews were carried out and again by the pilot study. Modifications were made to the interview protocol after each of these procedures to accommodate concerns with wording and any other matters that arose.

Summary

This chapter has outlined the methodology used to collect and analyze the data for

this study. This includes the selection of the sample, the development of the interview protocol, the research design of the pilot and main studies and the analysis procedure employed to obtain the relevant data from the interview transcripts.

Chapter four presents the findings of the study.

CHAPTER 4

RESULTS AND DISCUSSION

Overview of the Chapter

This chapter presents the findings of the study. As described in the previous chapter, each interview was transcribed verbatim from the tapes and conceptual inventories were then constructed from these transcripts. The data presented in this chapter includes data from these conceptual inventories and data taken directly from the interview transcripts. Results are presented in tabular form and include information obtained from the students for each topic discussed where the idea was found in three or more students' responses. Other responses that were given by only one or two students are included in the discussions following the tables if they are particularly interesting or relate directly to other research findings. The discussion of the results however is for the most part limited to ideas that can be attributed to three or more students, ie. to more than 10 percent of the sample.

Table one contains lists of objects and events and the number of students selecting

each of these as examples of science, technology, science and technology, and those that are neither science nor technology, respectively. These examples include their responses to the lists provided to them. This table shows the number of students who classified each of the examples provided as being science, technology, neither sciecen nor technology, or both. Other examples provided by the students themselves, at the beginning of the interview, are included in the discussion following Table one. Table two lists the total number of students classifying each of a number of given processes according to whether they are related to science or technology or neither or both. Tables three and four list the students' understanding of the purpose of science and technology, respectively. Table five indicates their understanding of the relationship between science and technology. Each of these includes a list of the responses given by three or more students and the number of students who gave each response. Tables six, seven, eight and nine list students' understanding of the characteristics of scientists and technologists. Table 10 represents students' understanding of the responsibilities of these occupations. Table 11 lists examples of the overall relationship between science, technology and society, and again is in a similar format to Table three. Finally, Tables 12 and 13 refer to where students find their information about science and technology.

For each topic area, the students' conceptions are discussed in relation to their prevalence and in their agreement or disagreement with currently accepted definitions of conceptions of these topics. It should be noted that as this was a semi-structured interview

format not all students gave usable response to all questions. Also, on a few occasions students did not give audible responses to a particular question on their interview tape. This means that sums of students agreeing or disagreeing with a particular point or classifying a particular example may or may not add up to the total number of subjects in the final sample. Finally a brief analysis of the data in terms of gender differences is presented.

Results

Examples of Science and Technology

The first part of the interview asked students what they thought of when they heard the word science, and then, separately, the word technology . These two questions were followed by a list of examples, which students were asked to classify as examples of science, technology , both science and technology or neither science nor technology. The results of these lists of examples are presented in Table one in the order in which the examples were given during the interview. Some of the examples initially given by the students are noted in the discussion following the table.

Table 1

Examples of Science and Technology

Example	Science	Technology	Neither	Both
studying atoms and molecules	26	0	0	0
computer	0	24	0	2
toaster	1	20	2	3
electron microscope	10	6	0	10
telephone	4	18	1	3
hammer	5	12	9	0
new medicine/drug	14	3	0	9
television	0	25	0	1
new military equipment	0	19	0	7
DNA	24	1	0	0
artificial heart	4	6	0	15
space shuttle	2	12	0	12
steam engine	2	18	0	5
striped toothpaste	10	3	4	8

These results present some interesting conceptions and misconceptions that students have about typical examples of science and technology, respectively. The first column of Table one lists those examples that respondents thought represent science. The first example here is the only one for which there was agreement among all 26 respondents. All said that studying atoms and molecules represented science. Twenty-four of the students also responded that studying DNA is an example of science. These examples represent things that are studied in science class in school and therefore are logically and easily related to science by most of the students. A new medicine or drug was listed as an example of science by 15 respondents. This may be due to the history they associate with medicine rather than a conscious elimination of the technology involved in modern medicines or it may be that the medicine itself is a chemical and therefore considered to be part of science. Two examples given in the list to students produced prevalent responses that cause more concern. Striped toothpaste and the electron microscope were classified as examples of science alone by 10 students each. Separating either of these from technology shows a lack of understanding of the concept of technology. Striped toothpaste is possibly classified this way as again it is the substance itself to which they are referring. One student, for example, reasoned that striped toothpaste is an example of science because you "have to mix things together" to get it. An electron microscope is seen as a tool of science and therefore representative of science rather than technology. Even more troubling, but not as prevalent, is the classification of a hammer as science by

five students. This, by any widely accepted definition, is a technological instrument. The typical reasoning presented for a hammer, as stated by one student, was that "something that has been around for a long time can't be technology". The telephone and an artificial heart were classified as science by four students each. In both cases it could be argued that these represent a blending of science and technology but neither could reasonably be classified solely as science.

In the initial question posed to the students, they were asked what kinds of things came to their mind when they heard the word science. Although this initial open-response question served mainly to start the interview and introduce the lists of examples, it did produce some interesting responses. The most prevalent responses were listing of school science subjects. Thirteen students mentioned biology, ten included chemistry and eight listed physics as examples of science. Two students actually responded that they felt science was something that existed only in the classroom and they couldn't think of any examples outside of school. Other responses that were given in this initial list included chemicals (eight students), computers (five students) and the environment (four students). Column two lists the examples of technology alone. Television and computers were classified as examples of technology by 25 and 24 students, respectively. A toaster was listed as an example of technology by 20 students, new military equipment by 19 students and the steam engine and the telephone by 18 students each. A hammer was classified as an example of technology by 12 students. All of these fit with currently accepted

definitions of technology. The space shuttle was listed as technology alone by 12 of the respondents. While this is arguable that science is involved here to a larger extent than in some other cases, it fits with the products or machinery conception that prevails in many of the students' responses. Machinery itself was listed as an example of technology by 11 students, even though it was not given in the list. Other similar problems occur with an artificial heart (seven students), an electron microscope (five students), and striped toothpaste and a new medicine or drug, which were classified as technology alone by three students each.

Column three lists examples that were classified as neither science nor technology. These are all cause for concern. A hammer was listed by nine students, striped toothpaste by four, a toaster by two and a telephone by one. Each of these examples indicated that some students do not associate "everyday" items with science and technology even when they are good examples of one or both.

All examples classified by the students as being both science and technology are represented in the last column of Table one. The most prevalent example was the artificial heart (15 students). This example combines features that many of the students saw as the specifications for the division between science and technology, namely a biological link on the one hand and electronic equipment on the other. An electron microscope was classified as being an example of both science and technology by 10 students on a similar basis. The space shuttle was placed in this category by 12 students and was seen in some

cases as combining research (science) with machinery (technology). Other examples placed in this group can be explained similarly: new medicine (nine students), military equipment (seven students), steam engine (five students), and the telephone and the toaster (three students each). Striped toothpaste was placed in this category by five students who generally saw that both science and technology had to be used in order to produce it as a product. One student reasoned that science is used in making striped toothpaste because of the chemicals involved in making it and technology is involved because of the machinery in the factory where they make it.

Activities Associated With Science and Technology

The next part of the interview asked the students what they thought were the processes or activities associated with science and technology respectively. Results from this section are presented in Table two.

Each of the five processes or activities listed showed a majority of students giving a particular response. Discovering was considered to be an activity associated with science by 16 of the 26 students. Four students associated it with technology and six said that it could be involved in both. For designing, 18 of the students said it was an activity associated with technology. These responses fit with the earlier examples of science and

Table 2

Activities associated with science and technology

Process	Science	Technology	Both
Discovering	16	4	6
Designing	4	18	4
Making	3	14	9
Uncovering	21	2	3
Inventing	5	15	6

technology given by the students as most of the activities they gave as examples of science involved discovering or finding out things. Designing fits with the product oriented examples that most students gave for technology. The actual process of making something showed the most variation in responses, with 14 students associating it with technology, nine saying that it could be both and three associating it only with science. The students who classified making as being representative of both science and technology typically added that "It depends on what you're making". The actual construction or production of things has a strong link to technology for most of the students. As one student stated, "If he was making a machine it'd be technology". The process of uncovering a fact that no one had known before was seen as science by 21 of the 26 respondents, again reinforcing the "finding out about things" aspect of science. Finally, 15 of the 26 respondents saw inventing as an activity associated with technology, once again a finding which might have been due to the association of technology with products. In all five cases, the majority of students considered there to be a separation between the activities of science and the activities of technology similar to that described by Fensham (1990), namely science as involving knowing and technology as involving making. The processes that involved mental activities, discovering and uncovering a new fact, were considered to be representative of science. Those activities which involved making products, (designing, making and inventing) were considered to be representative of technology.

The Purpose of Science and Technology

The third section of the interview asked the students "What is the purpose of science?" and then "What is the purpose of technology?". The students were not provided with lists of examples here, but simply asked these items as open-ended questions. The results of this section are presented in Tables three and four, respectively.

A large number, 19 of the 26 students, responded that the purpose of science was to find out things. This again fits with the majority of responses given as examples of science. Science is seen largely as a process of discovery or finding out things. Finding medicines or cures for diseases was the purpose of science given by six of the students. Again this is an association with science that was seen earlier in the examples of science. This association equating scientific research with finding cures for diseases was also found in the VOSTS study (Fleming, 1987). Four students stated that the purpose of science was to help technology. As will be seen later, this is indicative of a problem a number of students have concerning the relationship and interdependence between science and technology. Technology is sometimes seen by the students as a result or application of science. Three students each gave the purpose of science as to help people and to make

Table 3

The Purpose of Science

Purpose	# of responses
to find out things	19
to find medicines or cures for diseases	6
to help technology	4
to help people	3
to make the world better	3

Table 4

The Purpose of Technology

Purpose	# of responses
to make life easier	12
to make things more advanced	10
inventions	3

the world better. In the VOSTS study (Fleming, 1987) 31 per-cent of the students believed that research should be funded because science functions to benefit society and "striving for a better world" was given as one of the primary reasons for doing science. This association again fits with the finding out things conception of science, but now with a specific reason for doing so. However making the world better is a function of technology rather than science and not really acceptable as a purpose for science. This again illustrates the difficulty many of the students have differentiating between science and technology.

The purpose of technology was largely divided into two sections by the respondents. Twelve of the students said that the purpose of technology is to make life easier and ten replied that its purpose is to make things more advanced. Three students gave the purpose of technology as inventions. All of these responses follow a similar pattern and reflect a view of technology as a provider of useful products. This once again fits with earlier responses linking technology with products.

A variety of other responses with low frequencies were obtained for both science and technology. Other purposes for science included to see what life is, to answer questions, to invent, to help the environment, to make us more intelligent, to make life easier, to prove things, to create things and to make progress. Other purposes given for technology included to help science, to help the world, to do things, to make things happen

faster, to find out things, to explore space, to make things work, to build things and to better society.

The Relationship Between Science and Technology

The final question directly about science and technology that was posed to the students concerned the relationship between science and technology. The responses varied widely and thus indicated some very different opinions on this matter. The statements made by the students in response to this question are summarized in Table five.

The most prevalent response in this section was the belief that without science, technology would not exist. The idea was found with 16 of the 26 respondents. This has several implications including an obvious lack of real understanding of the nature of technology. Students do not see technology as an entity unto itself, but rather as a product or application of science. They fail to see ancient technologies, such as the use of the hammer, as examples of technology because of this belief. Only four students stated that technology would exist without science. The next response shows a different aspect of the relationship. Thirteen of the respondents exhibited the belief that science would exist without technology but we wouldn't know as much about it. Also, three students indicated

Table 5

Relationship between Science and Technology

Statement	# of responses
without science, technology would not exist	16
science would exist without technology but we wouldn't know as much about it	13
science and technology are two different things	11
science and technology are two different	10
science and technology are interdependent	10
science and technology are related	8
science would exist without technology	5
technology would exist without science	4
we need technology as tools for science	3

a similar relationship by stating that we need technology to provide the tools for science. Although this is a correct, it is an incomplete view of technology. Five students simply stated that science would exist without technology. A more troubling view was indicated by two students who said that science would exist without technology but it would have no purpose. This again shows the idea that technology is when somebody actually takes the science and uses it to do something. According to this view, science itself has no real use. Eleven students indicated that science and technology are in fact two different things. However 10 other students stated that science and technology are just two different ways of referring to the same thing. Typically, the students who distinguished between science and technology did so on the basis of the kinds of things that one would do in science and in technology. As stated by one student in response to this section, "I think that technology refers to building things more while science refers to finding out about things, like finding out how an atom works, while technology is like building a computer." Ten students stated that science and technology are interdependent and eight students stated that they are related. Again the idea that science and technology are the same thing indicates a real lack of understanding of the two fields, or at least of one of them. The statement that science and technology are interdependent again returns to the problem that students are not coming to the realization that each can exist without the other. Two statements that were made by one student in each case also bring up some serious misconceptions. One student each said that if we have science, we will automatically have technology and

that without technology, science wouldn't exist. These suggestions agree with those found in the VOSTS study (Fleming, 1987) where it was found that students, on the surface, seemed capable of distinguishing between science and technology, but when they actually had to do so they failed overwhelmingly. Similarly, in the PATT study in Australia (Rennie, 1987), it was found that most students did not have a clear understanding of the meaning of technology.

Characteristics of Scientists and Technologists

At this point in the interview, students were told that the topic would change from science and technology themselves to the people who work at science and technology. The students were asked what kind of picture came to their minds when they thought about a scientist and then several further questions about the characteristics they associated with scientists. These questions included queries about the characteristics they associated with scientists in relation to skills, motivation, values, standards, gender and ability to communicate. The same series of questions was then repeated with respect to the characteristics of a technologist. Finally, in this section, the students were shown six sketches and asked to identify which most closely resembled their image of a scientist and then a technologist. The responses to the questions are presented in tables six through nine and a discussion of the responses to the sketches follow the discussion of these tables.

Table 6

Characteristics of Scientists (Physical)

Statement	# of responses
white lab coat	14
there are more males than females	13
works in a lab	11
there are equal numbers of males and females	10
talk in technical terms	9
glasses	8
work alone	5
works with chemicals	4
like scientist in "Back to the Future"	3

Table 7

Characteristics of Scientists (Non-physical)

Statement	# of responses
smart or a "brain"	17
motivated by curiosity	13
good at communicating	10
not good at communicating	7
work can be affected by their values	7
need high standards/careful	6
may or may not be good at communicating	4
are motivated by money	4
like finding out about things	3
want to get known for their work	3

Table 8

Characteristics of Technologists (Physical)

Characteristic	# of responses
there are more males than females	11
there are about equal numbers of males and females	10
pictured as male	3
talk in technical terms	3

Table 9

Characteristics of technologists (Non-physical)

Characteristic	# of responses
good at communicating	13
good at working with machinery	8
values do not affect their work	7
smart	5
good at Physics/math/science	5
need high standards/careful	5
good at working with their hands	4
better at communicating than a scientist	4
motivated by money	3
motivated to improve life	3

The characteristics associated with scientists and technologists have been divided into physical and non-physical characteristics. In each case the physical characteristics include those relating to appearance and the activities the scientists would be doing. The non-physical characteristics are the other attributes that the students associated with scientists and technologists.

The physical characteristics of scientists include many of the stereotypical views of scientists that were found earlier from the application of The Draw a Scientist Test (Kahle, 1989). The most predominant examples of stereotypes were that scientists wear a white lab coat (15 students) and that there are more male than there are female scientists (14 students). In the Draw a Scientist Test 90 percent of students in the USA and 47 percent of those in Australia drew figures wearing a lab coat and 90 percent of those in the USA and 75 percent of those in Australia drew males. Thirty-eight per-cent of the students in this study felt that there were about equal numbers of male and female scientists. Forty-two per-cent pictured a scientist as working in a lab and thirty-four per-cent thought that a scientist would talk in technical terms that most people would not be able to understand. In the Draw a Scientist Test about half the scientists were drawn with symbols of research such as a beaker. In the present study, scientists were also pictured as working alone by five respondents, and working with chemicals by four respondents. Other features associated with appearance included the wearing of glasses (eight students),

looking like the scientist in Back to the Future (three students), looking like a doctor (two students), and having a beard (two students). Again these are similar to characteristics found in the Draw a Scientist Test where approximately 80 percent of the American and Australian students drew figures wearing glasses and 40 percent of the drawings showed facial hair.

The non-physical characteristics associated with scientists varied somewhat but several were given by a majority of the students. The most predominant characteristic associated with scientists was that they had to be smart, or a "brain". This statement was given by 17 of the 26 respondents. The other two statements that showed up most often were that scientists are motivated by curiosity (13 students) and that scientists are good at communicating (10 students). Seven students however, felt that scientists are people who are not good at communicating with others. This fits with the idea that scientists work by themselves which is consistent with the information presented in Table seven. Scientists were seen as simply representative of the general population and, therefore, as people who may of may not be good at communicating by four students. Three respondents simply stated that scientists are people who liked finding out about things. Seven students also felt, appropriately, that scientists' work could be affected by their values and beliefs. This is compared to two students who stated that a scientists' work should not be affected by their values. In most cases those who saw the work being affected by values saw this as a positive effect. One student, for example, felt that scientists would have to believe in

something if they were really going to put their best effort into it. Six students indicated that scientists needed to have high standards in their work while two indicated that this was not necessary. Four students stated that scientists are motivated by money while three students said that the scientists wanted to get known for their work.

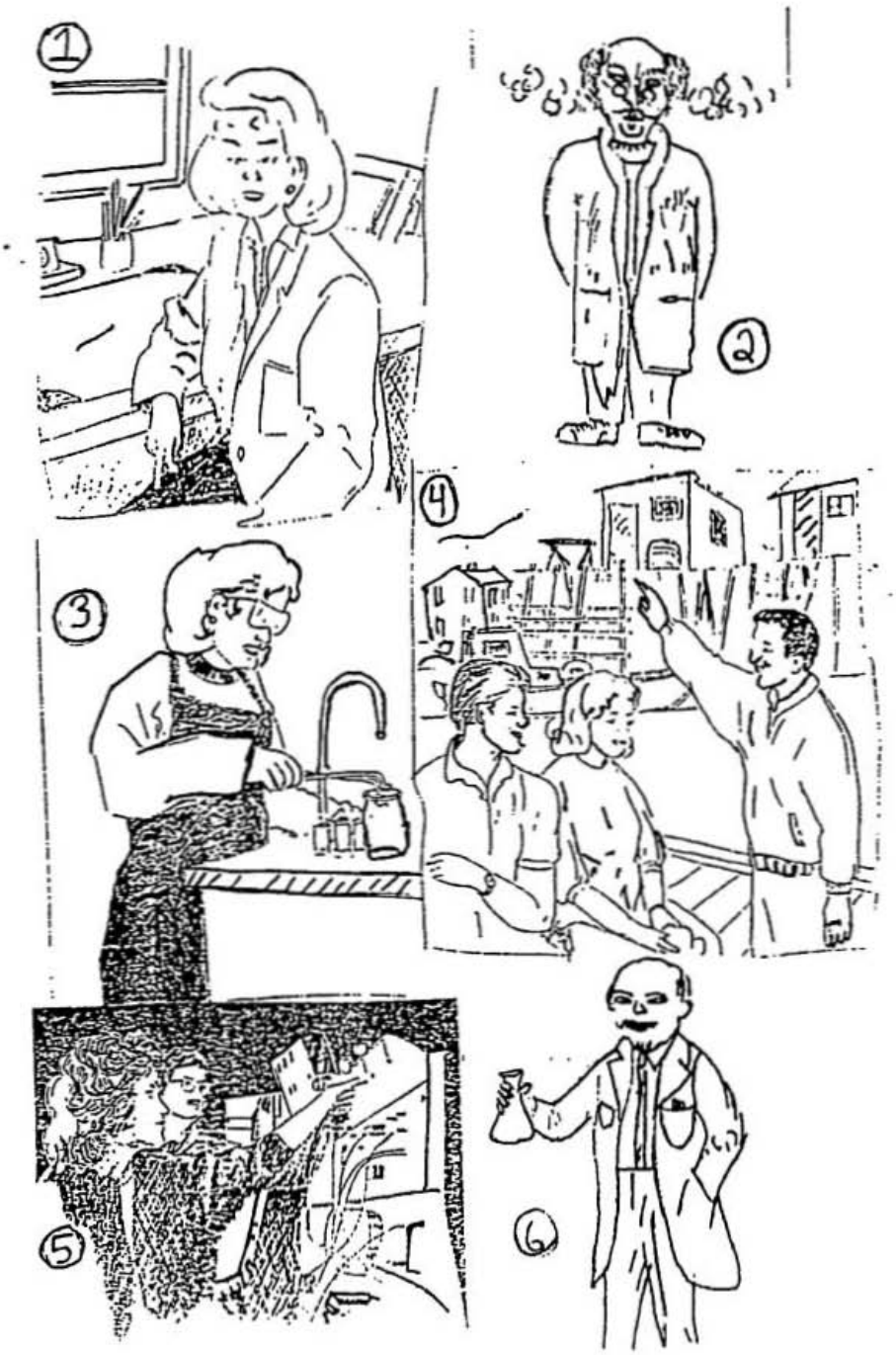
The characteristics of technologists follow a somewhat similar pattern to those of scientists but it should be noted that in general students did not have as clear an image of what a technologist is like as they did for what a scientist is like. Only two students stated this directly but, in general, students hesitated more and were less confident about their opinions of what a technologist is like than they were concerning a scientist. The most prevalent statements about technologists concerned the ratio of males to females. Eleven students stated,correctly, that there are more male than female technologists while 10 students indicated that are were about equal numbers. Three other students said that they pictured technologists as male but didn't really know if this meant there were actually more male technologists. Three students also stated that they thought technologists would talk in technical terms that most people would not understand. The most prevalent statement concerning the non-physical characteristics of technologists is that they would be good at communicating, a view expressed by 13 of the respondents. Four other students simply said that they felt technologists would be better than scientists at communicating. Eight students said that technologists would have to be good at working with machinery, which relates to responses in the first part of the interview. Similarly

four students said that technologists would have to be good at working with their hands. Technologists' work was thought to be unaffected by their values by seven students. Five students each stated that a person would have to be smart or be good at physics and/or math to be a scientist. The need for high standards in a technologists' work was also indicated by five students, which is comparable to the six students who felt this was true for scientists. The motivation of technologists was not addressed by most students but three each gave the motivation to be a technologist as money and the desire to improve life, respectively. In the Draw a Technologist at Work Test (Moore, 1987) 25 percent of the students' drawings of technologists included concepts relating to science when students were tested prior to any formal teaching about technology. Approximately half of these students showed technologists as making things, showed a technologists as having similar appearance to that of a scientist and showed technologists as male. These results are similar to those found here.

At this point the students were shown the six sketches represented in Figure one. They were first asked which sketch or sketches, if any, most closely matched the picture that they had of a scientist. When they selected these, they were then asked if any of the other sketches made them think that the person was a scientist. These questions were then repeated for a technologist. The results obtained are as follows.

Figure 1

Sketches of Scientists and Technologists



For the first selection of a drawing representing a scientist, one student chose sketch one, five chose sketch two, ten chose sketch three and 16 chose sketch six. For their second selection one student chose sketch one, five chose sketch two, eight chose sketch three, one chose sketch five and six chose sketch six.

For the first selection of a technologist one student selected sketch one, three selected sketch four, 23 selected sketch five and one selected sketch six. Second choices included seven choosing sketch one, one choosing sketch three and eight choosing sketch four.

It should be noted that several students chose two sketches as equally close to their picture of a scientist or a technologist and others did not chose any sketch at all, especially as their second choice. One student for example, stated that none of the sketches looked like a technologist. Sketches six and three were the predominant choices as representative of a scientist. These two sketches match well with the characteristics of scientists described by respondents in this study and with the results obtained in the Draw a Scientist Test (Kahle, 1989) where a majority of the students drew scientists as males wearing lab coats and also showed them surrounded by the tools of science such as beakers.

Sketch five was the choice of 23 of the 26 students as representative of a technologist. This sketch fits with the concept of technology as machinery that many of the students hold. Sketches one and four, which show little or no clue as to the occupation of the people in them, were selected by very few students. This leads to the conclusion

that scientists and technologists are associated with the tools of science and technology by most of the students and they do not readily identify "ordinary" people as scientists or technologists.

Responsibilities of Scientists and Technologists

The discussion of people working as scientists and technologists then continued with the students being asked what were the responsibilities that went along with being a scientist or a technologist. These statements are summarized in Table eight. Some students did not differentiate between scientists and technologists for this question as it was asked as a single, two-part question. However where the responses were clear, the discussion includes those differentiations.

One response was particularly dominant here, that scientists and technologists are trying to do good and/or benefit people was the response of 18 of the 26 respondents. This certainly indicated that the majority of the students have a positive image of scientists and technologists in terms of their intentions. The need for scientists and technologists to be responsible people was brought out by one student who stated "If people are scientists like, its like the people that everyone else relies on to think for them, they're the people who, like do the technical stuff that no one else can do." Seven students pointed out that

Table 10

Responsibilities of Scientists and Technologists

Statement	# of responses
mostly try to do good and benefit people	18
are responsible for the safety of their work	7
have a lot of responsibility	4
may become rich and famous for what they do	4
have to be dedicated to their work	4
help people and make money at the same time	3
a few are just trying to get rich and famous	3

scientists and technologists have to be responsible for the safety of the work they are doing, indicating that they felt there would be some danger involved. This is also reflected in four students' responses that scientists and technologists would have a lot of responsibility in their work and also four responses that they would have to be dedicated to their work. Four students indicated that scientists and technologists may in fact become rich for their work. Three students indicated, as an aside, that scientists and technologists work to help people but would yet make money at the same time. This is balanced, however, by one student's remark that scientists generally don't make a lot of money, and by another that all scientists and technologists are just trying to get rich and famous. Another student separated the two groups to say that scientists are just trying to get rich and famous but technologists are trying to help people. One other student's faith in scientists and technologists was indicated by the statement that they have to be honest because people rely on them.

Relationships Between Science, Technology and Society

The final main section of the interview probed students' ideas about the relationship between science, technology and society. Several statements about this relationship were held by a large number of the students in the sample. The statements given by the students are summarized in Table 11.

Table 11

Relationships Between Science, Technology and Society

Statement	# of responses
science and technology have a big influence on society	19
society should be able to influence science and technology	18
science and technology affect careers/jobs	17
science and technology make life easier	17
the public should be informed about science and technology	15
the government influences science and technology	15
scientists and technologists themselves should decide what risks they take	14
science and technology respond to the needs/wants of society	14
problems associated with science and technology result from how we use them	14

Statement	# of responses
science and technology affect entertainment	12
science and technology affect us everyday	9
science and technology cause more benefits than problems	8
science and technology will be more important in the future	8
other people decide how scientists' and technologists' work will be used	7
science and technology cause problems like pollution	4
the general public doesn't get much say about science and technology	3
others should decide what risks scientists and technologists take	3
scientists themselves should decide how their work will be used	3
accidents will happen in science and technology, it is the nature of the work	3

The most prevalent statement concerning the relationship between science, technology and society is that science and technology have a big influence on society. This response was given by 19 of the 26 respondents. Another point, made by 18 students, was that society should, in turn, be able to influence science and technology. Three students felt that the general public does not get much say in what science and technology gets done. Fourteen students, however, felt that science and technology do respond to the needs and wants of society.

There were several statements made about just how science and technology affect us. Seventeen students in each case indicated that science and technology make life easier, and that science and technology affect careers and/or jobs. Twelve students indicated that science and technology affect entertainment and nine students indicated that science and technology affect us everyday. Eight students thought that the effect of science and technology would become even more important in the future. These are all realistic perceptions and expectations. There were also differing viewpoints, however. For example, one student indicated that science and technology do not affect entertainment and another said that speech pathology is not a career involving science and technology. The importance of the public being informed about what goes on in science and technology was stated by 15 students. This was reinforced by statements such as " If the general public is not educated about science and technology then they cannot have a say in them" and "The general public can influence science and technology if they understand it." The

importance of knowing about science and technology is further explored in the final section of the interview. Fifteen students believed the government has some influence over science and technology, usually in financial form, but this was not always considered to be positive. One student pointed out, "Really, the government should have nothing to do with science because, like I said, all they're in it for is the economic aspect of it." The decisions concerning science and technology also brought some differing opinions. Fourteen students thought that scientists themselves should decide what risks they take while three people thought that these decisions should be made by others. Seven students thought that other people decide how scientists' and technologists' work will be used while three people indicated that scientists and technologists themselves should make this decision. The problems associated with science and technology also received some attention. In the opinion of eight respondents, science and technology cause more benefits than problems. However, four students also pointed out that science and technology cause problems such as pollution. Another student suggested that science and technology harm the environment and another that science wipes out species of animals by investigating them. Such comments show the negative perception that some students have about science and technology. Three students indicated that accidents will happen in science and technology because of the nature of the work and that these cannot always be blamed an a human being as they are beyond our control. Finally, two other interesting viewpoints made by individual students were that the government should have nothing to do with

science and that the public should not decide what risks are taken in science and technology because the public is not at risk.

In the VOSTS study (Fleming, 1987), 46 percent of the students indicated a purely technocratic decision-making posture. Many of them based this on their belief that scientists and technologists have the required training that allows them to make decisions in their fields. Almost half, however, favoured social control of science and technology, suggesting that scientists should be funded only if they can show the potential return on the investment. Zoller et al (1990) found a difference between students who had taken an STS course and those who hadn't when they were faced with this issue. Those who had the STS course favoured the public making decisions while non-STS students thought it was better done by scientists and engineers. In the present study, the majority of students felt the public should be making decisions concerning science and technology. This is promising as in most cases it led students to the conclusion that it was important for the public to be informed about science and technology so that participation in this decision-making was not only possible but done in the best interests of society as a whole.

Information About Science and Technology

The final question in the interview asked students where they obtained their information about science and technology. The responses to this question are summarized

in Table 12. In addition, they were probed as to how important it is to be informed about science and technology and if information therefore is easy to come by. These responses are in Table 13.

School was the most often provided source of information on science and technology as it was listed by 23 students. The media, usually referring to television, was also a very common source of information concerning science and technology for the respondents in this study. Twenty - two of the respondents listed the media as a source. Magazines and books were listed by five and four students respectively. It is noteworthy that home or parents was listed as a source of information by only two students. This means that the large majority of students depend on school and the media for the information they receive about science and technology. The conceptions and misconceptions that they hold appear to be formed by the information that they receive from these sources, therefore.

The final question in the interview asked how important the students felt it was to be well informed about science and technology and how easy it was to be so. Twelve of the respondents felt it was important to be informed about science and technology. Reasons for this included ideas such as a better educated public would be able to make better decisions about science and technology. There was concern about a lack of information available to them, especially in school. Seven of the students said that school has enough information about science but not enough about technology. Another three

Table 12

Sources of Information

Source	# of responses
school	23
media	22
magazines	5
books	4

Table 13

Information Availability/Importance

Statements	# of responses
it is important for people to be informed	12
school has enough science but not enough technology	7
school doesn't have enough science or technology	3

said that school did not have enough information about either science or technology. This is of particular concern when related to the information in the previous table, which showed that for most students school is a major source of information concerning science and technology. If the information provided there is not current and easily accessible it may well lead to uninformed or misinformed students. Only one student said specifically that there was enough science and technology in school already. It is of note that this same student said there is information available on television about science and technology but students just didn't pay any attention to it.

Analysis on the Basis of Gender

The sample of 26 students interviewed for this study was made up of 13 females and 13 males. The data were examined to determine any differences in the responses of the male and female students. All responses that were given by eight or more respondents were analyzed in terms of the male to female ratio for that response. In most cases it was found that there were approximately equal numbers of male and female responses. A Chi squares analysis was carried out on the data and it was found that there were no significant differences in the responses of male and female students in this study.

Summary

This chapter has presented the research findings of this study and related them to similar findings elsewhere. Chapter five summarizes these findings and outlines the educational implications and recommendations that arise from them.

CHAPTER FIVE

SUMMARY, EDUCATIONAL IMPLICATIONS, AND RECOMMENDATIONS

Overview of the Chapter

This chapter summarizes the research findings of this study and the analysis of them. It then outlines the educational implications of these findings and recommends further research in this area on the basis of these.

Summary of Results

The first part of the interview focused on examples of science and technology. In general, students correctly categorized many of the examples. There were misconceptions identified in this area however. For example, a new medicine or drug was seen as strictly science by fourteen students, and toothpaste and an electron microscope were also considered to be science by ten students each. A hammer was classified as science by five students. This is certainly an example of technology. A machinery or products idea of

technology was found with many of the students. In addition, nine of the students thought that a hammer was neither science nor technology. This indicates that so-called every day items are not seen as science or technology by some students. One student also stated that something that has been around for a long time can't be technology. These results suggest that some students have a definite problem in distinguishing between science and technology. This is similar to that found in the VOSTS study (Fleming, 1987) where it was also found that students could not clearly distinguish between science and technology.

The second part of the interview looked at the activities associated with science and technology. Most students appear to have a good understanding of this. Discovering and uncovering a fact were considered to be science by most students while designing, making, and inventing were thought to be associated with technology by most students. This reinforces the designing concept of technology found for a number of the respondents. These results also reinforce the differentiation between the cultures of science and technology (Fensham, 1990) who stated that science involves discovering and uncovering and technology involves design and invention.

The third section of the interview looked at the purposes of science and technology. Most students thought the purpose of science was to find out things. A minority, almost 25 per-cent, considered the purpose of science to be to help people or to improve conditions of life, which correspondes closely to the results from the much larger VOSTS

study (Fleming, 1987), but which is really more closely allied to the purposes of technology. Technology was seen, appropiately, as either to make life easier or to make things more advanced. Again, most students associated science with discovery and technology with products and design.

The fourth section of the interview addressed the perceived relationship between science and technology. The most prevalent response was that without science, technology would not exist. This is probably the most troubling of the misconceptions identified as it clearly shows a lack of understanding of the nature and long history of technology. Two students stated that science would have no purpose if technology did not exist. This again indicated that technology is the application of science and that science itself has no purpose. Ten students thought that science and technology were just two different ways of referring to the same thing which means that they don't understand at least one of science and technology and probably both. This again is similar to the VOSTS study (Fleming, 1987), in which students failed overwhelmingly to distinguish between science and technology.

The interview then focused on characteristics of scientists and technologists. The physical characteristics of scientists were often stereotypical, such as that a scientist wears a white lab coat, works in a lab setting and works alone. The non-physical characteristics found suggested that scientists are smart, motivated by curiosity and communicate well with other people. Overall, the majority of students maintain an image of scientists as

different from the general population. Students did not have such a fixed picture of a technologist and in general their concept of a technologist was not as well defined as their concept of a scientist. The only characteristics concerning technologists that were held by ten or more students concern male to female ratio in that there are more male than female technologist and that technologists are able to communicate well with other people. Eight students associated technologists as working with machinery. Overall technologists were seen as more a part of the general population than scientists. There were indications of a real lack of information concerning what a technologist does.

Scientists and technologists were thought to be working for the collective good and to benefit people, by most of the respondents. This positive image of scientists and technologists agrees with the generally positive image of science and technology that is found in the last part of the interview. When the students were shown sketches and asked to identify them as representative of scientists and technologists, the majority of students associated scientists and technologists with the tools of science and technology. The results of this part of the interview generally agreed with those found in the Draw a Scientist Test (Kahle, 1989) and in the Draw a Technologist at Work Test (Moore, 1987).

In the final section, the relationship between science, technology and society was examined. The most prevalent statement here was that science and technology have a big influence on society. Many students also felt that , in turn, society should be able to influence science and technology, but the extent to which this actually occurs was

questioned by some students.

A majority of students felt the public should be informed about what happens in science and technology. However, there were also some concerns that the public would have to be better educated about science and technology if they were going to make good decisions concerning them. This contrasts with earlier findings (Fleming, 1987), where in the VOSTS study almost half the students supported a purely technocratic decision-making posture. A majority of the students also felt that the government influences science and technology, particularly financially, however most students could not give specific examples of this. Other ideas stated by a substantial number of students concerned decision-making in the area of science and technology, such as that scientists themselves should decide what risks they take and that other people usually decide how the work that is done by scientists and technologists will be used. The positive outlook about science and technology also appeared again in the opinion that science and technology cause more benefits than problems. Rather that indicating serious misconceptions, most of the responses in this part of the interview reflected a need for more information about science and technology. Individual students however did have serious misconceptions such as that the public should not decide what risks are taken in science and technology because the public is not at risk.

The final question posed in the interview simply probed the students' sources of information about science and technology and how important they felt it was to be

informed. School and the media were the most often cited sources and many of the students felt it was important to be informed about science and technology. There was concern however that schools did not provide adequate information, especially about technology.

When the results were analyzed for male to female ratios no significant differences were found.

Educational Implications

The findings obtained in this study suggest several educational implications. These implications impact on both curriculum development and on the teaching of STS topics. These implications are listed below.

1. Students need to understand the concept of technology if they are to benefit from instruction relating to technologies. This study has shown that a large number of students in the sample do not have a clear understanding of the concept of technology. The first consideration then in any educational undertaking in this field must be the realization that this is the case.

2. Many of the misconceptions identified in this study result from the students' inability to distinguish between science and technology. Although this is related to the previous statement, it is necessary that students be given the opportunity to explore the relationship between science and technology in order to define each of these concepts more clearly.

3. Most students in this study seem to differentiate between the activities associated with science and those associated with technology. Teachers must realize however that this is not true for all students and recognize when a student has difficulty with this idea.

4. Some students in this study could not differentiate between the purpose of science and the purpose of technology. This is indicated particularly by students' responses that the purpose of science is to "help people" or to "make the world better". These misconceptions must be addressed using clear examples of science and technology and discussing the purposes of each.

5. This study, like reports of the application of the Draw a Scientist Test (Kahle, 1989) and the Draw a Technologist at Work Test (Moore, 1987), found that many students hold stereotypical views of scientists and technologists and the type of work that

they do. Students need to be provided with real examples of scientists and technologists if these views are to be corrected.

6. Most students in this study appear to realize the importance and depth of the impact of science and technology in their lives. This is accompanied in most cases by an awareness of the need for a well informed general population who will participate responsibly in the decision - making process involved in science and technology. This view must be encouraged in any future STS education as it is the most powerful motivation students can be provided with in their quest for knowledge about science and technology.

7. Current and relevant information concerning science and technology must be made easily available to all students. It is impossible for any of the previous implications to be addressed in the classroom if the students cannot access information. A large number of students in this study expressed the need for more information in the school setting as this was their primary resource for information concerning science and technology.

Recommendations for Further Research

The following recommendations for further research have been identified by the

findings of the present study:

1. Since this study is an initial attempt to determine the level of understanding about technology of the students in this sample, additional studies are warranted to confirm and elaborate on these findings.

2. Further research is needed into the relationship between students performance in particular tests and activities and their understanding of technology. This should eventually lead to an instrument which can be used to determine students' understanding of the concept of technology, so that this information is available to teachers. It is impossible to address misconceptions or lack of understanding if if the misconceptions held by individual students are not identified. Although this type of research has been done extensively for the field of science, it does not exist for the field of technology.

3. An analysis of the current level of STS education included in the various course taught at the junior high school level is needed in order address the sources of information that the students have prior to high school and also to identify any possible sources of misconceptions.

4. Studies need to be performed which assess the effects of various curriculum materials and teaching methods on students' understanding of technology. It is of limited use to identify problems relating to students' understanding of technology if we do not then know how to address these problems.

5. Research needs to be undertaken which investigate the relationship between students' understanding of the concept of technology and their ability to apply appropiate reasoning in decision-making processes involving technological issues.

6. A survey of current information relating to technologies should be conducted. The concern raised by the students in this sample as to a lack of available information within the school system must be addressed.

Summary

This chapter has presented a brief summary of the research findings of this study as were reported in Chapter four. It has also identified some educational implications and recommendations for further research that have arisen from these findings.

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Appendix A

Interview Guide

INTERVIEW GUIDE

1. Are you familiar with the words science and technology?

2. What does the word science mean to you? Examples?

3. What does the word technology mean to you? Examples?

4. Are these examples of science or technology: studying atoms and molecules, a computer, a toaster, an electron microscope, a telephone, a hammer, a new drug or new medicine that is discovered, a television?

5. What is the purpose of science?

6. What is the purpose of technology?

7. Are these applications of science or technology: new military equipment, studying DNA, an artificial heart, the space shuttle, the steam engine, striped toothpaste?

8. Do the terms science and technology refer to two different things or are they just two ways of referring to the same thing? If different, how do they differ?

9. Do these words mostly describe science or technology: discovering, designing, making, uncovering, inventing?

10. Is studying the structure of an atom, using lots of equipment, mostly science or mostly technology?

11. Do science and technology depend on each other? Is technology the application of science? Could one exist without the other?

12. What characteristics do you associate with scientists? Skills? Appearance? Motivation? Values? Standards? Gender? Communication?

13. What characteristics do you associate with technologists? Skills? Appearance? Motivation? Values? Standards? Gender? Communication?

14. Which of these pictures do you think best represents a scientist? A technologist?

15. What kinds of responsibilities do scientists have? Technologists? Do they work with opportunity in mind? Do they consider human needs? Do their values affect what they do?

16. Who decides how science will be used? Technology? Who decides about risk management, informing the public, what is appropriate work to do? Who has the ultimate responsibility for science and technology?

17. Do science and technology influence society? Do science and technology affect decisions that we make.

18. Does society affect science and/or technology? Do we make decisions that affect science and/or technology?

19. Overall, how important do you think science and technology will be in your life? Will science and technology make your life easier or harder? Will it affect work and/or entertainment? Do science and technology cause more problems or more benefits?

20. Where do you find out about science and technology? Is information easily available? Is it important to be informed?

Appendix B

Conceptual Inventories

Student 1

-science includes biology and chemistry
-science exists only in the classroom
-technology exists both inside and outside school
-the purpose of science is to find out new things, like new medicines
-the purpose of technology is to help science
-the purpose of technology is to use it to do things, to help science
-science and technology are two different things
-you usually find science and technology together
-science would exist without technology
-technology would exist without science
-scientists are always mixing things together
-scientists are old
-scientists need to be good at thinking
-scientists like finding out about things
-there are more male scientists than female scientists
-scientists may or may not be good at communicating
-there are more male technologists than female technologists
-technologists need to be careful about their work
-a technologist may or may not be good at communicating
-scientists and technologists are responsible for safety in their work
-most scientists and technologists are trying to do good
-a few scientists and technologists are just trying to get rich and famous
-the government has some influence over science and technology
-the general public should have a say about science and technology if it is going to harm the environment.
-someone other than themselves should decide what risks scientists and technologists take.
-we use technology everyday
-science and technology respond to the needs and wants of society
-society in general should be able to influence developments in science and technology
-science and technology will be more important in the future
-science and technology won't affect the things we do outside of work
-science and technology will make life easier
-science and technology cause more benefits than problems
-the problems caused by science and technology are caused by how we use them
-information on science and technology comes mostly from school
-it is important for everyone to know about science and technology in order to know what is going on around them.

Student 2

-science includes chemistry, biology, and what things are made of
-technology is new developments and inventions
-something that has been around for a long, long time can't be technology
-the purpose of science is to answer questions and to help technology
-the purpose of technology is to make life easier
-the reason for working on science is to help get more technology
-science and technology are two different things
-using microscopes is using technology
-technology is used to help figure out things in science
-science would exist without technology but we wouldn't know as much about it
-a scientist is pictured as having glasses and being nerd-like
-a scientist works in a lab and doesn't get out much
-a scientist is a "brain"
-a scientist must have good observational skills
-a person would be motivated to be a scientist because they were curious
-scientists need high standards in their work in order to be successful
-scientists are pictured as males but there are female scientists as well
-there will never be as many female scientists as male scientists
-scientists are not good at interacting with other people
-scientists tend to talk in technical terms
-a technologist is like an inventor
-a technologist trys to improve things
-a technologist needs to be dedicated to their work
-a technologist may be motivated by the desire for recognition
-a technologist may be motivated by the desire to improve life
-a technologist is a more regular, 9 to 5, job than a scientist
-technologists are pictured as being male
-a technologist would be better at communicating than a scientist
-a scientist has a lot of responsibility
-scientists and technologists work to benefit people mostly
-people other then the scientists and technologists themselves should decide how their work will be used.
-the bigger the discovery in science and technology, the more important it is that people have a say in the development
-scientists and technologists should have someone checking on the risks they take
-the people in charge of the work being done in science and technology should inform the public about it
-science and technology has a big influence on society and it is increasing every year

-the general public has some influence on science and technology because science and technology is trying to make life better for the general public
-science and technology will be more important in the future
-science and technology will make life easier in the future
-science and technology affects what we do for entertainment
-science and technology will cause more problems in the future, like pollution
-information on science and technology comes from the media and from school
-school doesn't provide enough information on science and technology

Student 3

-science has to do with life and nature
-technology is using a lot of machinery and how the machines affect you
-the purpose of science is to find cures for diseases and to find out how things around us affect us
-the purpose of technology is to find out how other things affect science
-science and technology are two ways of referring to the same thing
-technology has more to do with working with machines than science does
-if we have science we will also have technology
-scientists are smart and know a lot
-scientists are motivated by their interest in finding things out
-scientists work more if they like what they are doing
-scientists are mostly males
-scientists have to be able to communicate with others
-scientists talk about things that most people wouldn't understand
-a technologist has to be good at working with machinery
-scientists deserve to be well paid for what they do
-technologists don't need to have such high standards as scientists in their work
-technologists are mostly males
-technologists don't deal with people as much as scientists
-scientists and technologists have to meet deadlines
-scientists and technologists work for the good of people mostly
-the general public should have a say about science and technology if it affects them
-scientists and technologists should decide themselves what risks they take themselves
-scientists and technologists should take responsibility for their mistakes
-science and technology affects us a lot, everyday
-the general public influence science and technology by what they want and don't want
-science and technology is getting more and more important
-science and technology causes more benefits than problems
-the problems result from how we use science and technology
-information comes from school and "just around"

Student 4

-science involves the elements in chemistry, the environment, insects, and the way things grow.
-technology is how the world improves
-the purpose of science is to find out things, like the cures for diseases
-the purpose of technology is to make things, like computers, more advanced to help people
-science and technology are sort of the same thing
-technology is making things easier
-science is finding out things
-without science, technology wouldn't exist
-science could exist without technology
-picture of a scientist is a guy in a long white coat with test tubes
-a scientist needs to know a lot about chemistry
-scientists will do a better job if they believe in what they are doing
-scientists are both male and female, and the number of females is overtaking the number of males
-scientists are good at interacting with other people
-scientists use different vocabulary with other scientists that with most people
-a technologist is not as familiar a concept as a scientist
-technologists are both male and female
-technologists have to be able to communicate with other people
-technologists work with politicians
-scientists have to be responsible for safety in their labs
-scientists and technologists try to help people but at the same time make money
-the general public should have a say in science and technology
-scientists and technologists themselves should decide what risks they take
-the government should inform the public about science and technology
-science and technology makes the world a lot easier
-society in general should be able to influence science and technology
-science and technology is changing some careers
-science and technology causes more benefits than problems
-the problems that come from science and technology are mostly from how we use it
-information comes from school and a bit from parents and TV

Student 5

-science includes biology and physics
-technology includes things that are Japanese, stereos and computers
-the purpose of science is discovery and invention
-the purpose of technology is computers and really sophisticated stuff
-science and technology are two different things that are related
-science is learning new things
-technology is computers
-picture of a scientist is Albert Einstein
-a scientist wears a white lab coat and uses a microscope
-a scientist has to be smart
-a scientist is interested in finding out things
-scientists' work can be affected by their values
-scientists don't have to have high standards
-scientists are mostly male but its changing
-scientists have their own vocabulary
-picture of a technologist is Japanese
-a technologist needs to be good at physics and math
-technologists need to be able to think quick on their feet
-technologists need to be able to work with others
-technologists want to invent new things
-technologists don't have to have high standards
-technologists are mostly males
-technologists use their own vocabulary
-scientists and technologists work to benefit people
-people other than the scientists and technologists decide how their work gets used
-scientists themselves should decide what risks they take
-the media should inform the public about science and technology
-the government assists science and technology financially
-science and technology influence society a lot, it affects us everyday
-society influences science and technology because science and technology responds to the needs of society
-science and technology affects both careers and entertainment
-science and technology makes life easier, eg. the calculator
-science and technology cause problems such as the ozone but these result from how we use the science and technology
-information comes from the media mostly, some in school and some magazines
-it is important for everyone to be informed about science and technology because it is all around us

Student 6

-science is interesting
-science includes biology, the body, and space
-technology makes you think "Japanese"
-technology includes VCR's, cd players and the space shuttle
-the purpose of science is to learn new things
-the purpose of technology is to make life easier and to make things happen faster
-science and technology are interrelated
-using machines is using technology
-science could exist without technology
-technology couldn't exist without science
-picture of a scientist is Japanese and not a good athlete
-scientists are very smart
-scientists are curious
-scientists need to be interested in science
-scientists are motivated by curiosity or money
-some scientists apply values to their work but not all, eg. missiles
-scientists are free to do whatever they want in their work
-most scientists now are male
-scientists are good at communicating about their work but use big words
-picture of a technologist is Japanese
-technologists are good at working with their hands and working with machines
-technologists are fascinated by moving things
-technologists have to have high standards because people expect a lot of them
-technologists are mostly males
-technologists talk in technical terms
-scientists and technologist have to be honest because people rely on them
-a scientist's peers should decide how that scientist's discoveries are used
-the general public should decide how technology gets used
-the general public should be informed about science and technology developments
-consumers decide how technology will be used
-science and technology causes both benefits and problems
-science and technology responds to the needs of society, but society doesn't directly influence all science and technology that gets done
-science and technology make life easier
-science and technology harm the environment
-life is becoming more and more influenced by science and technology
-science and technology causes more benefits than problems
-society needs to be more responsible about how science and technology is used

-information comes mostly from magazines and tv
-school has no current information on science and technology
-its very important to keep up on science and technology to know what is going on around you

Student 7

-science includes doctors, lawyers, teachers and computers
-technology includes computers, printers, television and satellites
-the purpose of science is to discover different matters, to help people and to make medicines
-the purpose of technology is to make things to use in our everyday life
-science and technology are really the same thing
-science and technology are similar to each other
-science involves medicine
-technology involves computers and things higher up
-using a microscope is technology
-science would exist without technology but we wouldn't know as much about it
-technology wouldn't exist without science
-picture of a scientist is working in a lab and squinting
-scientists have to have good minds
-scientists are motivated because they are good at what they do and value it
-scientists don't need to have high standards
-scientists are usually thought of as male but there are females as well
-scientists need to be good at communicating with other people
-scientists would need to explain things more simply for the general public
-technologists have to be able to draw to design things
-technologists' values do not affect their work
-technologists are both male and female
-technologists have to be good at communicating
-scientists and technologists are responsible for staying on schedule
-scientists and technologists work for the good of people mostly but they may become rich and famous while doing so
-scientists themselves decide how their work will be used
-the media should inform the general public about what science and technology gets done
-the public should have a say in science and technology if it affects them
-science and technology affects our everyday lives a lot, including jobs and everyday things like lights
-society can influence what happens in science and technology
-jobs in the future will be influenced by science and technology
-science and technology gives us more possibilities for entertainment
-science and technology gives us benefits like running water
-technology causes problems like overpackaging
-problems like overpackaging could be reduced
-information comes from public television, books, magazines and some in school

Student 8

-science includes computers, VCR's, tv's, and the people who invented them
-technology is more advanced things than a VCR
-the purpose of science is to discover new things, like new vehicles
-the purpose of technology is to become more advanced
-the telephone is an example of science but vehicles and VCR's that are more advanced are technology.
-science would exist without technology
-if science didn't exist, technology would not be able to be created
-technology depends on science
-a scientist wears a coat and works in a lab
-a scientist works with machines
-a scientist has to be smart and inventive
-scientists want to get known for their work
-there are equal numbers of male and female scientists
-a scientist may or may not be good at communicating
-a technologist trys to discover new things and improve things
-a technologist has to be smart
-a technologist has to be good at working with their hands
-scientists and technologists work to benefit people and for fame and fortune
-the public decides how science and technology gets used
-scientists themselves should decide what risks they take
-the public should not decide what risks are taken in science and technology because the public is not at risk
-scientists work for the government
-science and technology have a lot of effect on our lives
-society creates the demand for new science and technology because they are the ones who use it
-in the future most jobs will involve science and technology
-science and technology will make life harder
-science and technology will improve entertainment
information comes from books, tv, and school

Student 9

-science involves space flight, chemicals and the environment
-technology involves new machines for a better future
-technology involves computers, progress and more education
-the purpose of science is to help people, help the environment and make us more intelligent
-the purpose of technology is to make life easier, find out things and explore space
-science and technology are the same thing because both benefit you
-science has to do with basic stuff like in a lab
-technology has to do with trying to do work and better machinery
-using a microscope is technology
-information about an atom is science
-without science, technology wouldn't exist
-science would still exist without technology
-picture of a scientist is a white lab coat and glasses
-scientists are strict, sharp and intelligent
-scientists are motivated by an interest in science and in helping people
-scientists need to be always on top of their job
-there are more male scientists than female but this is changing
-scientists are not very good at communicating
-scientists talk at a higher level than most people
-a technologist is a creative person
-a technologist is intelligent
-a technologist is good at working with their hands
-a technologist is motivated to see something done with science
-technologists need to be interested in their job
-there are equal numbers of male and female technologists
-technologist talk on a higher level than most people
-technologists and scientists need to be sure of their results
-scientists and technologists are good jobs
-scientists and technologists themselves decide how their work will be used
-society should decide what risks are taken in science and technology
-scientists and technologists should inform the general public about their work
-technology makes our life easier
-science broadens our minds
-science affects our daily lives, eg. high cholesterol foods
-society can affect science by supporting it
-society should be able to stop developments in science and technology that affect them
-technology can fix some of the problems in the world

-we need science to get technology
-we need to learn more about technology
-there is no information available in school on science and technology
-information is available in certain places and in magazines and on tv, eg. news

Student 10

-science involves computers, chemistry and physics
-science is not involved in anything outside of school
-technology indicates a loss of jobs
-technology makes people lazy
-the purpose of science is to see what life is, to make life easier, to find cures and to make the world a better place
-the purpose of technology is to make everything easier
-science and technology are two different ways of talking about the same thing
-technology involves making things
-science is working to try to figure out what something is
-using a microscope is technology
-studying atoms is science
-science would exist without technology but we wouldn't know as much about it
-technology wouldn't exist without science
-picture of scientists is astronauts on the moon
-picture of a scientist is the scientist on Back to the Future
-a scientist has to be good at remembering
-people become scientists to make money
-scientists will believe the results of their experiments even if it goes against what they thought would happen
-scientists are both male and female
-scientists are not very good at interacting with other people
-technologists are not a familiar concept
-people become technologists to make money
-peoples' goals and values affect what they will work at
-technologists are both male and female
-technologists are good at communicating with people
-scientists and technologists have a lot of responsibility
-scientists and technologists have to be dedicated
-scientists and technologists work to benefit people
-the general public should have a say in science and technology because they are the ones that use it
-the government should inform the public about science and technology
-science and technology accidents can't be blamed on people, it is the nature of the work
-science and technology affect us everyday
-science and technology are developed to respond to society's needs
-science and technology will be very important in the future
-all jobs are affected by science and technology

-computers make life easier but it is harder to learn how to use them
-science and technology affect entertainment as well as work
-science and technology cause both benefits and problems
-information comes from school tv and magazines
-school has enough science but not enough technology

Student 11

-science involves medicine and discovering new fields of study
-technology involves making things more advanced, like computers, new cars and sound systems
-the purpose of science is to find out new things and to help people
-technology is more involved in economics than science is
-science and technology are two different things
-science and technology are related
-science and technology are interdependent
-science is how to figure things out, it involves the brain
-studying atoms is science
-we need technology to do science, eg. microscopes
-science would exist without technology but it wouldn't be as advanced
-without science, technology wouldn't exist
-picture of a scientist is a bald fella with lab coat and glasses
-scientists have to be sharp, have good common sense and be able to relate things
-scientists are curious
-scientists are not humane, they would kill a species of animals to study it
-most scientists are male
-scientists are good at communicating with people
-a technologist wears a lab coat and works with machines
-a technologist likes fiddling around with things
-technologists don't always think about the possible bad effects of what they produce
-technologists are pictured as male but could be female as well
-technologists are good at communicating and cooperating with other people
-scientists and technologists have to stick with their work
-scientists and technologists work to benefit people mostly
-someone other than the scientists and technologists decide how their work gets used
-the general public should have a say in science and technology in order to prevent things that could harm the public
-the government should have nothing to do with science
-government is interested in only the economic aspect of science and technology
-scientists themselves should determine the risks they take
-scientists need to explain things in simple terms
-accidents will happen in science and technology from the nature of the work
-science and technology has a huge influence on society
-society influences science and technology because science and technology respond to the needs of the people
-the public or the government can't actually stop research, it will go ahead anyway

-science and technology will be important in most careers in the future
-technology makes life easier, with tools
-life is harder because you have to learn about all the technology
-science wipes out species of animals by investigating them
-information about science and technology comes from tv and from school
-current information on science and technology comes from tv
-it is important for people to know about science and technology so that they will know when to oppose it

Student 12

-science includes chemistry, biology, physics and evolution
-technology involves computers
-the purpose of science is to find out more about whatever is out there
-the purpose of technology is to advance
-science and technology are closely related
-atoms and DNA are part of science, not technology
-technology is usually man-made stuff
-discovering new things means technology
-science would exist without technology but it would have no purpose
-technology would not exist without science
-a scientist works in a lab and wears a lab coat
-scientists have to be good at thinking
-scientists want to learn things
-scientists used to be more males than females but now its evened up
-a scientist has to be very good at communicating
-scientists talk to each other with their own language
-a technologist or a technician is like a computer operator
-technologists are mostly male
-technologists are not as good as scientists at communicating
-scientists and technologists have to be dedicated to their work
-most scientists and technologists are trying to make things better
-government influences science and technology by supporting it financially
-scientists and technologists should get to decide how their work is used but their bosses actually do so
-the public should influence science and technology if it is life-threatening
-the government or a spokesperson for the scientist should inform the public about what is being done in science and technology
-science and technology have a big influence on society
-the general public doesn't get much say in science and technology
-the public should be able to influence science and technology if there are a lot of them concerned
-science and technology will affect most careers in the future
-technology makes life easier but adjusting to it can be hard
-science and technology doesn't affect entertainment now but it probably will in the future
-information comes from school and tv
-knowing about science and technology will be more important in the future
-there should be more science and technology related things done in school

Student 13

-science includes biology and bombs
-technology includes microwaves, stoves and fridges
-the purpose of science is to work towards technology
-the purpose of technology is to make everything more convenient and help society
-science and technology are two different ways of referring to the same thing
-science involves chemicals
-technology includes toasters and refrigerators
-technology is necessary in order to do science
-without technology, science wouldn't exist
-without science, technology wouldn't exist
-a scientist is like a doctor
-a scientist wears a lab coat and glasses and uses test tubes
-a scientist needs to be interested in science and curious
-a scientist's morals and values may affect their work
-scientists need to be motivated
-scientists are mostly male
-scientists are not very good at interacting with other people
-picture of a technologist is a computer whiz in a suit and tie
-technologists need to be motivated to build things
-technologists are motivated by money
-technologists are mostly male
-technologist have to be good at communicating
-scientists and technologists need to be motivated and must stick to what they are doing
-a technologist just takes plans from a scientist and puts them together
-most scientists and technologists are trying to do good, a few are just trying to get rich and famous
-a technologist is not a stressful job
-a scientist has more stress than a technologist
-scientists and technologists themselves should decide how their work gets used
-the general public should have a say about science and technology if it affects them
-the general public shouldn't influence science and technology that belongs to the military
-the government shouldn't have a say in science and technology but they do
-government are the employer for people working in science and technology
-scientists should be responsible for the safety of what they do but somebody should be checking on them
-some mistakes in science and technology are beyond human control
-science and technology have a big influence on society
-as society advances, science and technology will change to suit it

-society could affect decisions about science and technology if there were a lot of people involved
-science and technology will affect more careers in the future
-science and technology make it harder to learn things but then make it easier
-science and technology affect entertainment as well as work
-information comes from school and tv
-school provides information on both science and technology
-schools just need more computers

Student 14

-science includes biology, a lot of facts, computers, tv's and computerized checkouts at the supermarket
-technology involves the same things as science
-the purpose of science is to know how your body works and how systems around you work
-the purpose of technology is to make life easier
-science and technology are two different things that work together
-machines are technology
-science is anybody using their hands
-studying an atom is science
-without science we couldn't have technology
-science would exist without technology but it wouldn't be as good
-a scientist uses test tubes
-a scientist trys to find out if things work or not
-a scientist wears a lab coat and goggles
-a scientist needs to be good at math
-a scientist needs to have a good memory
-scientists are trying to find out things about the world and people
-scientists are responsible for safety
-scientists are both male and female
-scientists are good at communicating
-a technologist fixes machines and makes machines to make life easier
-technologists have to be smart and good at math
-a technologist likes working with machines
-there are more male technologists than female
-technologists are good at communicating
-a scientist would have a lot of responsibility
-scientists and technologists work to benefit people mostly
-other people make changes to what scientists and technologists produce
-the government influences science and technology through financing
-the media should inform the public about what goes on in science and technology
-science and technology has a really big influence on society
-science and technology is around us everywhere
-science and technology will be involved in most jobs in the future
-science and technology mean you have to put more time into preparing for work
-science and technology affect entertainment as well as work
-science and technology cause both benefits and problems
-information on science is available in school, but not on technology

-it is important to be informed about science and technology
- there should be more on technology in school , it should be equal to science

Student 15

-science includes chemistry, biology, physics and jobs like doctors
-technology includes engineering
-medicine is a science
-the purpose of science is to prove things or to see how things work
-the purpose of technology is to make things work and to help you everyday
-science and technology are two different things that are related
-technology is things that work, like a hammer, electricity or computers
-science is experimenting with different materials and chemicals
-using microscopes and machines is using technology
-without technology, science wouldn't exist as it does now
-without science we would still have technology but it would be a bit different
-a scientist works in a lab
-a scientist is out of style with grey fuzz hair and a lab coat
-a scientist works with chemicals
-scientists are curious
-scientists need standards in order to take pride in their work
-scientists today are equally male and female
-in textbooks, most of the scientists are male
-scientists are not very good at interacting with other people
-scientists work alone in a lab
-a technologist works with computers
-technologists need to be good at math, science and computers
-technologists want to create things to help people
-technologists are curious
-technologists are both male and female but the stereotype is male
-technologists work in groups and communicate more than scientists
-technologists have more stress than scientists
-scientists are trying to get rich and famous
-technologists are trying to help other people
-if the general public are not educated about science and technology then they cannot have a say in it
-the public probably bases decisions on rumours about science and technology rather than facts
-the government doesn't know any more about science and technology than the public
-the scientists and their bosses together should determine what risks are taken
-the public should be informed about all that goes on in science and technology
-science and technology have a big influence on society
-people don't realize how much science and technology affects them

-the public takes science and technology for granted
-the public has some influence on what science and technology gets done
-most careers in the future will have some science and technology in them
-science and technology make life easier
-science and technology affect all aspects of life
-science and technology cause more benefits than problems
-science and technology would cause less problems if we used them better
-information about science and technology comes from school and tv
- school needs to do more about technology

Student 16

-science involves dissecting things, physics, light and sound, and the environment
-technology mostly involves computers
-the purpose of sciénce is to find out things and to develop technology
-the purpose of technology is to make life easier for people
-technology and science are different but one sort of leads to the other
-science involves humans and life
-technology involves machines
-studying atoms is doing science
-using microscopes and machinery is using technology
-science would exist without technology but we wouldn't know as much
-technology depends on science
-a scientist is a person in a lab, wearing a white coat and surrounded by chemicals
-scientists are curious
-scientists' discoveries sometimes conflict with their beliefs
-scientists are mostly male
-scientists may or may not be good at communicating
-technologists put together machines
-technologists need to be smart and have a good memory
-technologists like to fiddle with things
-technologists' work is not affected by their values and beliefs
-high standards are not as important for technologists as for scientists
-technologists are mostly males
-technologists may or may not be good at communicating
-technologists work with other people
-scientists are responsible for the safety of their work
-most scientists and technologists work to benefit people but a few may just want to get rich and famous
-scientists and technologists themselves should decide how their work will be used
-the government should stop science and technology that is really dangerous
-science and technology influence everything around us
-science and technology respond to the needs of society
-science and technology will influence jobs in the future
-science and technology will make life easier
-science and technology cause problems like pollution but these could be reduced
-information about science and technology comes from school, tv and books
-information can be picked up all the time
-being informed about science and technology is more important for people going into science and technology than for others

Student 17

-science includes physics and cars
-technology includes advancements in machinery and computers
-the purpose of science is to find out things and to make things better
-the purpose of technology is advancement, new inventions and making life easier
-science and technology are different things but are similar in some ways
-science has to do with the way things are
-technology has to do with inventions
-a scientist uses a microscope and wears a lab coat and glasses
-scientists have to know about all the sciences
-scientists have to be adaptable
-scientists need to be curious
-scientists have to be careful about their work
-scientists are mostly male
-scientists may or may not be good at interacting with other people
-a technologist works at machinery, microchips and computers
-a technologist probably wears overalls or a hard hat
-technologists need to understand electricity
-technologists need to be good at designing stuff
-technologists' values and beliefs probably won't affect their work
-technologists have to have high standards for safety
-technologists need to be able to communicate
-scientists and technologists work to improve things
-how the products of science and technology are used is decided by someone higher up than the scientists and the technologists
-the general public should be able to affect science and technology if they think it is unsafe
-the general public should influence science and technology that directly affects them
-the government influences science and technology financially
-scientists and technologists should take responsibility for their own safety
-scientists and technologists and their employers are responsible for their products
-science and technology influence everyone's daily live a lot
-science and technology respond to the needs of society
-science and technology can make life easier if you get into it
-science and technology affect your life if they are part of your job
-science and technology harms the environment because of how we use it
-we could fix the problems of science and technology but it is too expensive
-information on science and technology comes from home, books, tv and in lab at school

Student 18

-science involves chemistry, chemicals, biology and the earth
-technology includes cars, things for the future and machinery
-the purpose of science is to find out things and to create new things
-the purpose of technology is to build new things
-science and technology are almost the same thing
-technology has more to do with advancing the world than science does
-technology refers to building things, like computers
-science refers to finding out things, like how an atom works
-science and technology depend on each other
-science would exist without technology but it would be harder to do
-technology makes it easier to do science
-technology would not exist without science
-a scientist wears a lab coat
-a scientist is smart
-a scientist tries to find new things
-a scientist needs to know about disease and chemicals
-a scientist needs to know how to use technology
-scientists are motivated to find cures or to make the world better
-scientists' values should be put aside when they work
-scientists are mostly males
-scientists have to be good at interacting with other people
-technologists work with their hands more than scientists
-technologists try to make things to make life easier for everybody
-technologists should put aside their beliefs and values when they work
-technologists have to be sure their products are safe
-there are equal numbers of male and female technologists
-technologists need to be able to communicate with other people
-scientists and technologists are responsible for the public safety of their product
-scientists and technologists make things that benefit people
-government should control the risks taken in science and technology
-scientists and technologists should determine the risks they take themselves
-if the general public is at risk then they should have a say in it
-the general public should be told about all activities in science and technology
-science and technology have a massive influence on society
-the public can stop certain things in science and technology if there are enough people involved
-science and technology will be more important in the future
-a speech pathologist is not a career in science and technology

-science and technology will affect most careers only in a small way
-science and technology affect entertainment, eg. entertainment
-science and technology make life easier and more efficient
-science and technology create more benefits than problems
-science and technology create problems for the environment because of how we use it but we could use it better
-information on science and technology comes from tv, first hand experience and a small bit in school
-school has science but not much technology
-it is important to be informed about science and technology for the future in order to know what's going on

Student 19

-science involves new technology, advancement, experiments, and new equipment
-science and technology are basically the same
-the purpose of science is to discover things
-scientists work mostly to make a name for themselves
-the purpose of technology is to make life more convenient
-science and technology are not exactly the same thing
-science involves humans
-technology has to do with inventing stuff
-using a microscope is technology
-science would exist without technology but it wouldn't be as advanced
-technology could exist without science
-science and technology depend on each other
-a scientist is a person in a lab wearing a lab coat
-scientists have to be patient
-scientists have to be able to work independently
-values and morals are not related to a scientist's work
-scientists, to be good, can't make mistakes
-scientists want to discover things that will benefit people
-there are more male than female scientists
-scientists are not very good at communicating
-scientists usually work alone
-technologists try to solve problems
-technologists' values and beliefs don't affect their work
-technologists are mostly males
-technologists are good at communicating
-scientists and technologists work for money and to make advances in technology
-a scientist should be able to decide how much risk they take themselves
-the general public should have a say in science and technology because they are affected by it
-science and technology have a lot of influence on society
-society influences science and technology because they use it
-society should be able to stop some developments in science and technology if they don't want them
-science and technology will be important in the future because of computers
-science and technology make life easier and more convenient
-science and technology cause problems such as pollution
-information about science and technology comes from school, tv, and reading
-it is important to know about science and technology

Student 20

-science involves computers, new inventions and chemicals
-technology involves computers more so than science
-technology involves new ways for making products
-the purpose of science is to find medicines and cures for diseases
-the purpose of technology is to make things more modern and easier
-science and technology are two ways of talking about the same thing
-science is necessary to make technology
-science involves medicine
-technology involves machines
-working on an atom is science
-using microscopes and equipment sounds like science
-a scientist is a weirdo, a brain, with glasses and their hair stuck up
-scientists have to have a lot of knowledge
-scientists are trying to become famous
-scientists' values and beliefs affect their work
-scientists have to be careful about what they produce
-scientists are mostly males
-scientists are good at communicating
-a technologist is like a business person, very up to date
-technologists have to know about science and machines
-technologists are trying to make the world easier to live in
-technologists are mostly males
-technologists work more with machines than they do with people
-scientists and technologists have to be responsible for the safety of what they produce
-scientists and technologists are trying to get rich and famous
-scientists and technologists need to make good products in order to be successful
-the government decides how science and technology will be used
-the people affected by science and technology should decide what risks should be taken
-science and technology have a lot of influence on society
-society should be able to stop science and technology if they don't want them
-society should be able to stop science and technology if there are enough people involved
-science and technology will be important for jobs in the future
-science and technology make life easier because everything is faster
-science and technology cause more benefits than problems
-problems caused by science and technology are because of how we use them and we could use them better
-information about science and technology comes from tv and mostly from school
-school needs to have more information on science and technology

-a new course in science and technology is a good idea

Student 21

-science includes chemistry, physics and medicine
-technology includes computers and complicated stuff
-the purpose of science is for technology, to increase our knowledge, and to discover things
-the purpose of technology is to better society
-science and technology go hand in hand, one leads to the other
-atoms are associated with science
-science and technology depend on each other
-without technology, we wouldn't need science, it would exist but it wouldn't be important
-without science we wouldn't have technology
-a scientist is a guy in a lab coat in a lab
-scientists need to be good at science and math
-scientists like discovering new things
-scientists can be affected in their work by their morals
-scientists need to have high standards
-the stereotype of a scientist is male
-there are probably equal numbers of male and female scientists
-scientists are not very good at communicating
-scientists don't spend much time with other people
-technologists deal with computers
-technologists like to discover things
-there are more male than female technologists
-technologists are better than scientists at communicating
-complicated machinery indicates technology
-scientists and technologists are responsible for what they create
-scientists and technologists are trying to come up with things to improve the way we live
-the general public probably shouldn't have much to say about complicated science and technology issues that they don't know much about
-if the public understands science and technology then they should have a say in it
-risks taken in science and technology should be decided by an objective third party
-the public should be informed about science and technology
-the government is responsible for informing the public about science and technology
-the scientist or technologist is responsible for what they create
-the general public influences what science and technology gets done
-science and technology fields are growing and providing jobs
-science and technology make life easier
-people have to adjust to science and technology but once they do life is easier
-science and technology affect entertainment as well as work

-science and technology have both benefits and problems
-the problems caused by science and technology come from misuse
-information about science and technology comes from school only
-there is information on tv but, don't pay attention to it
-there is enough science and technology in school already

Student 22

-science involves experiments, studies and technical stuff
-science includes advancing technology
-the purpose of science is to see how things work
-science involves experiments, seeing what happens and how it affects other things
-the purpose of technology is to advance things and to advance science
-science and technology are not the same thing
-science and technology affect each other
-work that hasn't been done before indicates technology
-parts of science depend on technology
-without technology, science would not be as advanced
-technology would not exist without science
-a scientist has brains and good math skills
-a scientist has glasses and a beard
-a scientist needs to be able to work with their hands
-a scientist needs to be interested in science to do a good job
-there are equal numbers of male and female scientists
-scientists usually work by themselves
-a technologist picks apart things like tv's
-technologists have to be good at math and science
-technologists will get good jobs in the future
-a technologist needs to have high standards
-technologists can be either male or female
-technologists have to be able to communicate
-technologists do not work alone
-scientists and technologists work on secret material
-scientists and technologists have safety responsibilities
-scientists and technologists get recognition if they discover something
-the public should influence science and technology if it is going to affect them
-the government should have some control over science and technology
-scientists themselves should decide how much risk they take
-science and technology has a big influence on the world
-the public can influence what science and technology gets done
-science and technology will affect every career in the future
-science and technology affect entertainment as well as work
-science and technology cause more benefits than problems
-the problems from science and technology are caused by how we use it
-information on science and technology comes from school, tv and the news
-it is important to be informed about science and technology

-schools should do more about teaching technology

Student 23

-science includes chemistry, biology and medicine
-technology includes computers
-the purpose of science is to find out what's going on
-the purpose of technology is trying to get more advanced
-science and technology are part of the same thing
-science and technology have to be used together in order to do anything with them
-technology involves machinery and complicated things
-science is more basic than technology
-atoms are part of science
-science and technology sometimes depend on each other
-science would exist without technology but wouldn't be as advanced
-technology would exist without science but wouldn't be as advanced
-scientists are usually around chemicals
-scientists have to be good at science
-scientists have to be curious
-scientists' ideas and beliefs may affect their work if they were working in the field of medicine
-scientists are both male and female
-scientists have high standards
-scientists work with other people
-technologists work on machinery
-technologists use science and electronics
-a technologist's values and beliefs don't affect their work much
-technologists have high standards
-the image of a technologist is a male
-technologists have to be able to communicate well
-scientists and technologists have a lot of stress because they do research
-scientists and technologists work mostly to benefit people
-scientists and technologists, as well as the government and companies they work for all decide how science and technology will be used
-the public should have a say in how science and technology get used
-there should be standards set for what risks can be taken in science and technology
-the public should be informed about science and technology
-government and technologists are responsible for informing the public
-science and technology influences everything around us
-society can influence what science and technology gets done
-science and technology will be very important in the future
-science and technology will affect most careers

-science and technology will make life easier
-science and technology don't affect entertainment or leisure
-science and technology cause both benefits and problems
-the problems from science and technology, like pollution, are caused by how we use it
-information about science and technology comes from tv and school
-it would help if everyone knew more about science and technology
-a better educated public would make better decisions

Student 24

-science includes physics, biology and light
-technology includes lasers
-the purpose of science is to make things better
-the purpose of technology is to make things progress or to invent something
-science includes chemicals
-technology involves machines
-science and technology are two different things
-technology means designing different things
-science is trying to answer questions
-using equipment is technology
-science and technology depend on each other
-science would exist without technology but it wouldn't be as advanced
-technology would not exist without science
-a scientist is a guy with a beard and a moustache, like the guy in Back to the Future
-values and beliefs shouldn't affect a scientist's work but they could
-scientists have to be careful in their work
-scientists don't have to be dedicated to their work
-there are female scientists
-there are equal numbers of male and female scientists
-scientists are good at interacting with other people
-values and beliefs would not affect a technologist's work
-there are equal numbers of male and female technologists
-technologists need to be good at communicating
-scientists and technologists have to keep some things confidential
-fixing or building something refers to technology
-being a scientist would be more stressful than most jobs
-scientists work to benefit people
-scientists can get rich
-the government funds scientists and technologists
-scientists themselves should decide what risks they take
-science and technology have a big influence on society
-society influences how science and technology will be used
-people could stop some aspect of science and technology from going ahead if there were enough of them
-science and technology will make life harder
-the jobs in science and technology in the future will be better than most jobs
-the problems of science and technology get noticed more than the benefits
-information about science and technology comes from school and tv

-there should be more information about technology in school

Student 25

-science includes chemistry, plants, animals and biology
-technology includes factories, lasers and x-ray machines
-the purpose of science is to make progress in the world
-technology is what you get from science
-the purpose of technology is to help the world
-science includes chemicals
-technology includes machinery in a factory
-science and technology are two different things that are closely related
-technology is mechanical
-science is made up of theories and stuff like that
-studying an atom is science
-technology involves using equipment
-science and technology depend on each other
-scientists are like the scientist in Back to the Future
-scientists like to find out and discover things
-scientists believe in what they are doing
-scientists have to try to be perfect
-picture of a scientist is of a male
-there are female scientists as well as males
-a scientist is isolated
-technologists work more with other people than do scientists
-there are both male and female technologists
-scientists and technologists are trying to benefit people
-someone else decides how scientists' and technologists' developments get used
-the general public should have a say in science and technology but actually doesn't
-the government influences science and technology through funding
-scientists themselves should decide how much risk they take
-the government is responsible for informing the public about science and technology
-science and technology have a big influence on society
-scientists are motivated by the needs of society
-the public could stop specific developments in science and technology if they tried hard enough
-most jobs in the future will have something to do with science and technology
-science and technology will make life easier
-science and technology will affect both entertainment and work
-science and technology cause problems when they are not used correctly
-information about science and technology comes from school, and the news
-school doesn't provide much information about technology

Student 26

-medicine is part of both science and techn(logy
-the purpose of science is to know more about the world
-the purpose of technology is to advance man and make a better world
-a machine in a factory is technology
-science and technology are two different ways of referring to the same thing
-technology is man made machinery
-science involves improving medicines
-trying to discover what is inside an atom is science
-using equipment in a lab is technology
-science and technology depend on each other
-science would exist without technology but it wouldn't be as extreme as it is
-we have to have science in order to get technology
-scientists wear white lab coats and glasses
-scientists have to have good science and math skills
-a scientist's beliefs may affect their work
-scientists put in long hours
-there are equal numbers of male and female scientists
-scientists need good communication skills
-scientists use a specialized vocabulary
-technologists b..ild things
-there are both male and female technologists
-technologists are better at communicating than scientists
-scientists and technologists have a lot of responsibilities
-scientists and technologists put in long hours
-generally scientists work to benefit people
-generally scientists don't make a lot of money
-sometimes a scientist can do something that can make them rich
-other people such as the government decide how scientists's discoveries get used
-the general public should have a say in science and technology but they don't
-scientists themselves should decide what risks they take
-the government decides what science and technology gets done
-the government is responsible for informing the public about what goes on in science and technology
-whoever decides that something should be done in science and technology is then responsible for it
-science and technology have a big influence on society
-the general public would have to complain a lot to affect science and technology
-most careers will be affected by science and technology

-entertainment will be affected by science and technology
-science and technology cause more benefits than problems
-science and technology do cause some problems
-information about science and technology comes from tv and radio, and a little from school
-science and technology will increase in the future so people should be informed about them

Appendix C

Sample Interview Transcript

Sample Interview Protocol

(Note - The interviewers questions are in regular print and the student's responses are in boldface.)

I'm sure you've heard the words science and technology...

Uh-uhm.

...before, you're familiar with those words. When someone says the word science what do you think of?

Uhm, I don't know, its interesting.

You like science?... What are some examples of things you'd say are science?

Uhm, stuff like Biology and things about the body and like space, I just like it, I fall asleep in English and wake up in Biology.

How about technology, what does the word technology mean to you?

Japanese. (laughter, inaudible word)

Stereos?

Yes, basically and (inaudible word).

So more machines?

Yeah, cd's and cd players and VCR's and space shuttles.

So space fits in both categories sort of? ... alright. I'm going to give you a list of things now and what I want you to do is tell me if you think this is mostly an example of science or mostly an example of technology and if you can't decide you can say neither or both, that's fair. If you were studying the structure of atoms and molecules?

Science.

Ok, if you were using a computer?

Technology.

Your toaster, that you made your toast with for breakfast?

Technology.

An electron microscope?

Technology.

Your telephone?

Technology.

A hammer?

Technology.

Everyone stops on that one for some reason, a new drug, a new medicine that's discovered?

Science.

Your television set?

Technology.

So its fairly easy to pick out which ones you think are which. Alright, lets think about what the purpose is now, like if someone in working on science, if someone is a scientist, why are they doing it? What's the purpose of working on science?

Uhm, to learn stuff that no one else knows.

Like what kinds of things?

I don't know, like the way stuff works and why things are the way they are and stuff like that.

So they're curious and they're trying to find out things?

Yeah.

How about technology, what's the purpose of technology?

To make life easier and to make things happen faster and better.

Ok, so to help us out we use technology.

Yeah.

I'm going to give you some applications now, some things that are using one or the other, or the same as before you can say neither or both, and do you think the purpose of these is mostly science or technology? Making new military equipment, like making a new tank?

Uhm, technology.

Studying the structure of DNA? Probably what you're doing in Biology?

Science.

Making a new artificial heart?

Whoa! Ah, both.

The space shuttle?

Both.

You already said that one. You got my list there. The invention of the steam engine?

Technology.

Striped toothpaste?

Technology. Sounds technological.

What's technological about it?

Uhm, the new pump bottle. (laughter)

Ok, how they get the stripes out of the pump. Ok, you seem to think that, science and technology, that sometimes you can say that things are both science and technology, do you think that science and technology refer to two really different things or are they just sort of different ways of referring to the same thing?

I think they intermix, but like sometimes to study science you see technology, and to make technology you got to use science.

Ok, so they aren't the same thing but they are..

Intermixed.

If you were studying the structure of an atom and using an electron microscope and figuring out and learning new facts about what's inside an atom, what would you mostly be using, science or technology?

I'd say technology.

In what way?

Well you'd use machines, you'd use scientific theory but then you'd have to use technology to carry it out.

And the machines would be technology?

Technology, yeah.

Ok, if you were doing each of these processes, in this list I'm going to give you now, do you think you'd more likely be working on science or technology. If you were discovering something?

Uhm, ah, technology I'd say.

If you were designing something?

Science. Science.

If you were making something?

Technology.

If you were uncovering something.

Like with a shovel? (laughter)

Uncovering a new fact or piece of knowledge no one knew before.

Ah, science.

If you were inventing something?

Science.

Could you have science without technology or could you have technology without science? Do they depend on each other?

Yeah, I think they do

You have to have...

No, I think science could exist without technology, but I don't think you could have technology without science.

So if you couldn't have technology without science, do you think this could be a definition of technology, if I said technology is the application of science?

Yeah, that's about it.

Ok, is that all technology is, like is that a good definition of it or just part of it?

Yeah, I think that's mostly it like say you can't make a cd player unless you know how it works and to know how it works you gotta apply scientific theories.

So that's a pretty good definition of technology?

Uh-huh.

And so you, and so it couldn't exist without science but science could exist without technology.

Yeah.

Alright, lets stop thinking about the words themselves for a couple of minutes and think about the people who work with science and technology. If you think of a scientist, what kind of a person do you think about?

Uhm, very smart so Japanese, I don't know, someone who's curious, someone who's not a very good athlete. (laughter)

How about physical appearance, is there a picture that comes to your mind.

I don't know, usually a... , no I think anybody.

So there's not one set look of what scientists are like. What kinds of skills do you think they'd have to have? What particular skills?

I'd say just interest in what they're doing, that's basically all they'd need.

Ok, so the rest of it you could get then.

Yeah.

What do you think motivates somebody to be a scientist?

Curiosity or the money.

So it would be a good job then?

Uh-hum.

Do you think scientists have values that affect their work? Do you think their values ever influence what they do?

Uhm, it might, but the fact that we have missiles says it all.

You think some scientists have values that affect what they do?

Yeah, I think some make it for the sake of making it and others really think about what they're doing.

Ok, so there's a difference there. How about standards, do they have to maintain any kind of standards in their work?

No, I think they're pretty much free to do whatever they want to do.

How about gender, do you think scientists are mostly male or mostly female or is it half and half?

I don't know, I'd say they're mostly male now, but just as easily could be a woman.

So they're catching up?

Yeah.

How about how good they are at talking to other people? Do you think scientists are particularly good at communication or interaction with other people or not likely to be?

Uhm, I find that when you're talking to, like at the science fair and stuff like that, that they're usually really enthusiastic and they know what they're talking about and so they really get their message across.

Do you think that there's any difference in the way they talk to somebody else who's in science and the way they'd talk to somebody who isn't?

Yeah, cause if they're talking to someone else who's in science, you can't understand a word that they're saying.

They use a whole different vocabulary.

Yeah, different language.

How about a technologist, when I say the word technologist, what kind of picture comes to your mind?

Japanese.

Any particular appearance or anything?

Someone with a big pair of those things on, you know...

Safety goggles?

...or magnifying.

Magnifying glasses. How about skills, what kinds of skills would you need to be a technologist? What would you have to be good at?

I don't know, just like mechanics I s'pose, working with machines and someone good with their hands.

How about motivation? Why would somebody want to be a technologist?

I'd say interest too, fascinated by moving things.

Fiddling with things. How about values, would their values affect what they do?

I'd say its the same thing as a scientist, you know there's some just trying to build a better rattrap or a better machine.

Probably better rattrap most of the time. How about standards, do they have to maintain standards in their work?

Yeah, I think so. More than a scientist. Like a scientist can do 20 years of research and get it put in a book and put on a shelf but someone like a technologist, like making a robot or something got to live up to what other people expect of them, like where its more integrated into society.

Ok.

Like they've got to keep constant with what people expect of them.

There's someone going to be checking on what they do?

Yeah.

How about gender? Do you think of technologists as male or female or both?

Male mostly, I think.

Male mostly, any idea why?

No, not really, I think I just...

You picture them that way?

Mostly male, like there's no reason that...

How about communication or interaction? Would they be like scientists, would they have a different vocabulary with other people working there or...

I think that they would be more likely to be talking technical, like in shows that I've seen, it seems they have more technical terms than a scientist really, like to explain stuff really basically, like the basic theory, the basic properties and stuff and the technologist always seems to get more technical, more involved in what's going on.

Ok, I've got some pictures here.

Inkblots?

Oh no, they're a lot easier to recognize than that. Ok, there's six pictures there and they're numbered one to six, you just have to look at them and what I want you to do is tell me which one of those you think probably best fits your picture of a scientist.

This one.

Number three. Is there either other one there that could be a scientist?

Uhm, that one, six.

Ok, number six, how about a technologist, which one most...

Five.

Ok, number five, would be a technologist. Why?

It looks like she's working with a machine.

Wires and stuff. Anything else there that could be a technologist

Uhm, well they all could be but that one seems most likely.

Most likely, ok. If someone is a scientist, what kinds of responsibilities do they have?

Uhm, I'm not sure, uhm. I think they'd just have responsibility, , well for one thing honesty, they can't invent facts.

About what they find.

People turn to scientists to find out the truth about things and that.

Do you think they have a responsibility to work for the good of people and not for their own opportunities?

Yeah, I think they should. Like if people are scientists like, its like the people that everyone else relies on to think for them. They're the people who, like they do the technical stuff no one else can do and then...

We depend on them.

Yeah, other people reap the benefits of it.

In that respect, do you think their values affect what kind of science they do?

Yeah, probably, they'd do what they thought was best. Some of them might be more self concerned that other people.

How about a technologist, what kinds of responsibilities does a technologist have?

I'd say they are pretty much the same there as a scientist. They do what they think is best for everyone else, their personal idea at least.

Maybe some of them more so than others.

Yeah.

Once a scientist has come up with something new, assuming he's being honest and all that, and he's found something new, who decides how it will get used, does he decide or is that somebody else?

I'd say someone else, like his peers, his colleagues or whoever is responsible, whoever owns it really.

Whoever pays for it?

Yeah.

It could be the government or whoever funds it.

Yeah.

Do you think the general population should have any role to play in the decision?

No, I mean if they could build a better engine tomorrow that went 50 miles on a drop of gas, some arab could buy it and carry it off to the desert.

Who do you think is responsible for example for risk management. Who decides what risks should be taken in science and what shouldn't?

I think that's the scientists job.

Ok, who's responsible for telling us about it, like if there's risk or about what they find or...

Uhm, I'm not sure, I don't know.

Do you think someone should be?

Someone should be, yeah, tell us what's going on. Like I don't really think now, like you read stuff in magazines but you don't hear much, like its not general or people don't know what research scientists are doing. Like if you really want to know you can find out but its not easily available.

Its not easily available, ok. How about for technology? Who decides how technology will get used once somebody's come up with it?

I think that's the general public, consumers, cause mostly they're the ones that'll be using it. Like, say if its something major like the space programs and that, though, then the government controls a lot of it.

So its on demand.

Yeah, supply and demand.

Ok, supply and demand, for technology. How do you think science and technology influences society as a whole. What kind of effect does it have on it?

I think it, ah, I'm not sure if it makes us better or worse but it certainly makes us more complex. Ah, I suppose you'd say it improves our lives but for every benefit you get, you get problems along with it.

Do you think it affects the kind of decisions we make about what we want to do?

Yeah, I think so, I think it, ah, I don't know, ah, what do I want to say.

Ok, let's look at the reverse of that, science and technology affect us, how much influence do you think the general population has on science and technology?

I think, well, I think, like when its a concept, like a general idea, like the cure for cancer, I think if the motivation for it is the general population then eventually some scientists are going to sit down and try to find it.

So on the whole, what we really want done is what people will probably work on.

Yeah.

Can we actually make decisions that would directly affect science and technology?

No, I don't think so, I think its a fluke if anything gets done, that some scientist might pick up on, like this would be a good idea for research or something, but, it might benefit us or not.

How about for technology?

Yeah, like I said, like I'm thinking of technology, like products and stuff that people buy. That definitely would be controlled by people and what they want.

How about, if you think of a technological development, like maybe a new highway being built, maybe they decided to build a new ferry terminal or something down here and they decide to build a big new road right through (community name) here. If it was going to go right through your backyard, would you have any say in the matter?

I don't think so, I'd like to but...

If it was going through 20 peoples backyards do you think they'd have any say in the matter?

I'd say they'd kick up a pretty big stink but I'd say the road would get through anyway.

So they would say something but it would probably go through.

There's not much you can do.

Overall, how important do you think science and technology is going to be in your life once you get out of school?

Very important. I'm planning on going to university and doing medicine or Biology or something like that.

So its probably going to become a career for you.

Yeah.

Do you think science and technology is going to make your life easier or harder, overall?

Easier I think, over the next few years I think. I think you're going to see technology probably improve things and make it easier, like there's all these products out in the last 30 years or so, developing all these things to make life easier, and they're really screwing up the environment and that, you know, and you're going to get people being more conscious.

I see what you mean. Ok, so you think its going to affect you in the work that you do because of the career you're heading for. How about the environment and things outside of work, will it have any influence there?

I think we're going to see, people are going to get a lot more technical in my lifetime. Now, my parents, if their clock gets unplugged they got to get me to fix it. Its a digital clock, like the 12 sign on the VCR.

Keeps flashing. You're one of the teenagers we keep hearing about on the radio. He's the only one in the house who can fix the VCR. Overall, do you think science and technology causes more problems or more benefits for people? You say it causes both.

Overall I'd say its mostly benefits, probably people don't realize like the good old days when they had to walk out to the outhouse.

So the problems are overcome, sort of, by the benefits.

Yeah, there's a lot of problems but the benefits...

Outweigh them?

Yeah.

Could we overcome the problems better than we do?

Yeah, I think if we had more responsibility, like with the technology, if we really tested stuff before we just threw it into the market.

So its more in the way we handle the technology than in the technology itself that the problems are?

We get an idea and we run with it, we don't just check it out.

I guess maybe because you particularly like science, but you seem to know a fair bit about science and technology and that's a good sign. Where do you think you find out, or where do you think you've found out most of what you know about science and technology?

Well I guess mostly from science magazines.

Ok.

Discover magazine, and TV really helps, like on Newton's Apple and Wonderstruck you can pick up a lot of interesting little titbits. I think if you're interested in anything then once you pick up a fact then you retain it.

That's true, because you like that area, how about in school?

No, I think school is pretty much stagnant. You don't get much new stuff.

You think its important for us to keep up on science and technology?

I think its important so I don't end up in 20 years having to get my son to program

the VCR.

You think its important even for people who aren't going into a career in science and technology?

Yeah I think that, just to keep up, just to know what's going on around you. Like you see some people and they've never heard about the greenhouse effect and they think that's some new project in Mount Pearl growing cucumbers.

And they tore it down.

Yeah, there's no greenhouse effect any more, they tore it down.

Ok, I see what you mean, Ok, I think that's all I need to ask you.
Thank you.