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THE UNIVERSITY OF ALBERTA

REMOTE SENSING WITH ACADEMICALLY-TALENTED GRADE SIX STUDENTS

by

GRANT EDWARD SMITH

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF EDUCATION

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DEDICATION

To my wife Nat,

son Doran, and

daughter Bronwyn.

ABSTRACT

The purpose of this study was to investigate and assess a potential role for remote sensing within the context of an integrated science-social studies curriculum at the elementary school level.

The author developed, implemented and evaluated a remote sensing unit in which scientific and technological aspects of remote sensing were applied to a science-related social issue, namely, the eruption of the Mt. St. Helens volcano.

The development of the unit incorporated the major concepts of the Alberta (1981) elementary science and social studies curricula and was guided by principles associated with the science, technology, society movement in education. The implementation stage spanned a period of twelve weeks and involved a sample of ten academically-talented grade six students. Lastly, the evaluation component utilized qualitative and quantitative data to analyze aspects of the unit's cognitive and affective impact on the students. The cognitive aspects of the evaluation focused on the extent to which the students were able to acquire, structure and apply knowledge related to remote sensing. The affective aspect of the unit addressed the extent to which the remote sensing

unit enhanced student understanding and awareness of the interrelationships among science, technology and society.

The findings of the study were based upon: (1) qualitative data provided by the students, classroom teacher, researcher and personnel associated with the Alberta Remote Sensing Center; and (2) quantitative data generated by the following instruments: The Remote Sensing Content Test, The ConSAT Task Analysis and the Test on the Social Aspects of Science. The findings suggest that:

1. Elementary students were capable of acquiring and structuring knowledge related to remote sensing.

2. The remote sensing unit appeared to influence, in a positive direction, the development of student understanding with respect to the interrelationships among science, technology and society.

3. The application of remote sensing to an appropriate context facilitated the integration of major concepts associated with the elementary science curriculum. In addition, remotely sensed data products enhanced the

decision-making process of an appropriate social enquiry. These dual functions of remote sensing served to manifest its role as an interfacing medium between the subject areas of science and social studies.

4. Student participants viewed the remote sensing unit as a stimulating experience. There appeared to be a positive correlation between the students' level of motivation and their perceptions of their degree of learning.

5. The remote sensing unit manifests a potential to facilitate the attainment of the unit's knowledge, value and skill objectives.

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CHAPTER I

THE PURPOSE: ITS BACKGROUND, NATURE, AND SIGNIFICANCE

INTRODUCTION

Satellites using the technology of remote sensing to study the earth represent a significant technological advance of the 1970's. Data from these platforms in space assist the survey and management of our earth's resources and enhances informed decision-making with respect to global problems that affect the quality of life.

Combining remotely sensed satellite data with that obtained from aircraft can serve to extend man's limited spectral, spatial and temporal perceptions of his environment.

BACKGROUND OF THE STUDY

A number of secondary educators (Krockover & Odden, 1977; Ring, 1979; Smith, 1980) have reported various pedagogical applications of remote sensing technology. Smith (1980) has found that satellite imagery is "capable of furthering a pupil's interpretation and understanding of geographical phenomena" (p. 48). An additional observation by Ring (1979) claims that "Integrating space-age remote sensing skills into the curriculum provides very modern training for careers in managing future environments" (p. 37). Several remote sensing activities have been developed (Krockover & Odden, 1977) which incorporate "an interdisciplinary approach vital to the sciences today" (p. 42).

Combining the educational implications of remote sensing with an increasing concern about the "technological literacy" of society led to the rationale for this study.

PURPOSE

The purpose of this study was to investigate and assess a potential role for remote sensing within the context of an integrated curriculum at the elementary school level.

The author developed, implemented and evaluated a teaching unit in which scientific and technological aspects of remote sensing were related to a specific science-related social issue, namely, the eruption of the Mt. St. Helens volcano. The unit was developed within the conceptual parameters of the Alberta (1980) elementary science and social studies curricula.

RESEARCH QUESTIONS

The study addressed the following research questions:

1. Is the concept of remote sensing appropriate for elementary students?
   1.1 Can elementary students acquire and structure knowledge related to remote sensing?
   1.2 Does student awareness and understanding of scientific, technical and practical aspects of remote sensing enhance the development of their understanding of the relationships among science, technology and society?

2. Can the technology of remote sensing serve as an interfacing medium in the context of an integrated scientific and social inquiry?

3. What effect does remote sensing have on student motivation?

DEFINITIONS

The following are definitions of terms used extensively in this study:

Remote Sensing:

Remote sensing entails the use of electromagnetic energy to detect and measure the characteristics of distant targets.

Landsat:

Landsat refers to the Landsat satellites that provide multispectral data on a repetitive basis of the earth's surface.

Sun-synchronous:

Sun-synchronous refers to the correlation of Landsat orbits with the changing position of the sun. A sun-synchronous orbit facilitates world-wide data collection at the same solar time.

C-1 Color Composite Landsat Image:

A C-1 Landsat image is produced by superimposing filtered multispectral data from three wave bands: Band 4 (green), Band 5 (red) and Band 7 (near infrared).

Visible Spectrum:

The visible spectrum is that portion of the electromagnetic spectrum, delineated by the human eye, which is comprised of a continuous series of colors ranging from red to violet.

Image:

The term image refers to the recorded representation of an object/scene and is generally used when radiation emitted or reflected from an object/scene is not directly recorded on film.

Multiband System:

A multiband system simultaneously observes the same object/scene in more than one waveband. Also referred to as a multispectral system.

Multidate:

Multidate imagery refers to imagery of the same object/scene acquired on different dates.

Multistage:

Multistage imagery is acquired at different altitudes and scales of the same area, for example, a space image, a high flight photograph and a low flight photograph.

OVERVIEW OF THE STUDY

Following this introductory Chapter, Chapter II provides the reader with a review of the literature concerning the pedagogical applications of remote sensing technology. The focus of Chapter III is on the design of the study and includes the sample parameters as well as detailed descriptions of the sources of qualitative and quantitative data. Chapter IV includes a procedural model for the design and implementation of an integrated (science and social studies) unit. In addition, the objectives and teaching strategies associated with the remote sensing unit are provided. Finally, the daily activities and the participants' perceptions of these activities are reported.

Following Chapter IV are the qualitative and quantitative findings which are reported in Chapters V and VI respectively. Lastly, Chapter VII provides a summary of the findings as well as a discussion of their relationship to the specific research questions posed in Chapter I.

DATA SOURCES

Qualitative and quantitative data provided a basis for drawing inferences concerning the affective and cognitive effects of the unit.

The qualitative data reflecting the participants' perceptions are reported in Chapter IV and analyzed in Chapter V. Participants in the study included the students, the classroom teacher, the researcher and personnel from the provincially run Alberta Remote Sensing Center. The students' daily log book entries along with their oral and written reports, debates and class discussions contributed towards the qualitative data base. In addition, the regular classroom teacher joined the class as a participant-observer and recorded her perceptions of the student-teacher interaction as well as the level of student motivation, interest and understanding.

In the dual capacity of teacher/researcher, the author endeavored to tape-record and transcribe individual student interviews, class discussions and student dialogue during class activities. Log entries reflecting the author's perceptions as a teacher and as a researcher were recorded on a daily basis. The final component of the qualitative data base consisted of those observations related by personnel associated with the Alberta Remote Sensing Center during the course of a class field trip to the Center.

The quantitative data were derived from three instruments: The Remote Sensing Content Test; the ConSAT Task Analysis; and the Test on the Social Aspects of Science (Korth, 1968). A detailed description of these instruments is provided in Chapter III.

LIMITATIONS

Generalizations based on the results of this study are limited by the nature of the sample and the extent to which the student-teacher (researcher) relationship affected the reliability and validity of student performance.

In addition, the study is limited to the results obtained over a period of approximately three months. Magnification or diminishment of differences may occur if the time period was altered.

SIGNIFICANCE OF THE STUDY

This study represents the initial attempt to assess the potential and feasibility of scientific, technical and practical aspects of remote sensing in the elementary classroom. Secondly, it provides a way of introducing the concept of remote sensing. Finally, the study reflects an integrated approach to prescribed curricula. The increasing effect of science and technology on the lives of all of us necessitates a careful examination of the relationships between the subjects of science and social studies. "Far too little attention has been paid to this topic, and teachers who are interested in the reciprocal learnings of these two fields should be encouraged to pursue this topic and share their findings with others." (Kenworthy, 1981, p. 236). The integration of technological awareness, understanding and application with school curricula merits the serious attention of educators concerned about tomorrow's adults.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

The pedagogical application of remote sensing technology is an exceptionally new phenomenon. The purpose of this literature review is threefold, namely: (1) to examine existing research on the educational applications of remote sensing technology that pertain to this study; (2) to provide a rationale for the pedagogical application of remote sensing within the general context of existing curricula; and (3) to consider the generalizability of findings from single case studies.

EDUCATIONAL RESEARCH UTILIZING REMOTE SENSING TECHNOLOGY

The evolution of remote sensing technology is reflected in the educational research during the past two decades. Studies done by Duek (1969), Blaut & Stea (1971), Carswell (1978) and many others have explored children's ability to read and interpret black and white aerial photographs. There is general agreement that accelerated instruction in map skills can be enhanced through the use of black and white aerial photography. In addition, the research points to two key variables that are commonly related to pupil success, namely: the curriculum design (sequence and structure) and the degree of teacher preparation (possession of adequate knowledge and skills).

Several studies by Kirman (1977; 1981(a); 1981(b); 1982) have focused on the ability of elementary school children to interpret black and white and false-color Landsat satellite imagery. Since satellite imagery is integral to this study it is appropriate that educational research in this area be closely examined.

In a study of Grade 3, 4 and 5 children, Kirman (1977) found that young children were able to learn about and derive information from infrared false-color satellite imagery. An additional study (Kirman, 1981) utilizing Band 5 black and white Landsat imagery, confirmed the ability of Grade 3 children to interpret selected elements of a Landsat image. The most recent study (Kirman, 1982) dealt with the ability of Grade 6 students to interpret multispectral (Bands 4, 5, 6 and 7) satellite imagery. The findings imply that a student's capacity for interpreting such imagery is related to the student's general ability and the degree of emphasis placed on the material by the teacher.

In all four studies (cited earlier), Kirman identified the need for (1) the development of a suitable pedagogical approach for the introduction of Landsat imagery into the classroom and (2) the identification and implementation of practical classroom applications of this new learning resource.

Additional research regarding the reaction of secondary students (Smith, 1980) to Landsat imagery focused on:

(1) the ability of secondary students to recognize features on Landsat imagery.

(2) the utility of Landsat imagery to enhance the students' understanding of geographical phenomenon.

(3) the extent to which students found Landsat imagery to be a stimulating resource.

A summary of the findings indicate that Landsat imagery, when compared to conventional maps as well as ground and aerial photography, enhanced the detail and accuracy of student interpretations. Specifically, color Landsat imagery improved students' ability to independently discern physical and cultural features as well as identify large landforms. Lastly, almost seventy percent of the students preferred to use Landsat imagery rather than conventional aerial photography and traditional map formats.

The incorporation of Landsat imagery into Landscapes of Alberta (1979) and the Junior Atlas of Alberta (1979), (both published by Alberta Education and made available to elementary schools across the province) is significant in that vast numbers of children have been or will be exposed to the use of satellite imagery. To what extent are teachers adequately prepared to utilize such imagery? Armstrong (1980) developed a computer assisted instructional program for pre-service teacher education in the use of remote sensing technology and Landsat imagery, however, only a limited number of undergraduates in Elementary Education have been exposed to the program.

The limited educational research in remote sensing technology contrasts sharply with the rapid advance of scientific research in this area. Man's curiosity about phenomena that exist beyond his direct sensory experience is manifest in his restless quest for new horizons. While remote sensing may have the potential for extending our children's horizons, a great deal of research is required in order to determine whether or not existing and future curricular emphasis is warranted.

A CURRICULAR CONTEXT FOR REMOTE SENSING

If one seeks to examine the utility of a potential learning resource, one must identify and justify a context in which its potential may be manifest.

The technology of remote sensing utilizes scientific principles which can, in turn, be applied to the study of our environment. Studying the environment invariably raises science-related social issues. It is this interaction among science, technology and society that is the essence of the following rationale for a contextual frame of reference.

Science, technology and society education considers motivation as being central to the cumulative learning process. Learning is a demonstration of one's ability to select and organize information. This information is then used as a basis for the formulation of interrelationships, principles and generalizations. Above all, science, technology and society education emphasizes that the children in today's schools will be the adults of the twenty-first century and our curricula ought to be "commensurate with the kind of world in which they will live" (Kenworthy, 1981, p. 63).

The supporters of science, technology and society education (Aikenhead, 1980; Ziman, 1980; Hurd, 1975 and others) contend that science curricula ought to be approached from a social context with the recognition that valuing plays a significant role in the decision-making process. The role of values and value clarification in scientific decision-making fosters an interpretive approach to science and its technological applications.

Teaching science in a social context challenges the student to:

1. Tentatively identify the possible roles that science might have in the process of assessing social issues.
2. Relate scientific knowledge that is appropriate to the social issue.
3. Consider the limitations imposed by the interaction of science with other aspects of society, such as politics and religion.
4. Recognize that science is but one of many factors that influence decisions on social issues.
5. Practice divergent thinking and value clarification in the decision-making process as it relates to the particular science-based issue (Aikenhead, 1980, p. 47-48).

The majority of science, technology and society supporters favor the "trend towards a very broad general education centered on social problems. It is conceived as a means of enlarging and enriching the upbringing of students of science and technology, and sensitizing them to the social dilemmas, political conflicts, human values and moral imperatives of the real world" (Ziman, 1980, p. 130).

It becomes apparent, within this broad context, that the complexity of global problems is larger than those addressed by specific disciplines. A danger inherent in discipline specialization is that it "can eventually fragment, and thus diminish understanding of social reality. Social reality is experienced as a totality and not as a series of unrelated parts and events" (Anthony, 1974, p. 130). The science, technology and society movement shares a deep concern to demonstrate the interrelationship between the growth of scientific knowledge and the growing problems of our world.

The preceding rationale suggests an integrated science and social studies context for remote sensing technology. Integrating the seemingly disparate subject areas of science and social studies should be the "central issue for interdisciplinary curriculum designers" (Mayville, 1978, p. 62). Ziman (1980) further supports the rationale for integrating science and social studies by stating that "The most natural approach to society from science is through its application. That is to say, the conventional curriculum is extended from teaching valid science towards explaining its social relevance" (p. 111). The integration of science and social studies will result in a closer approximation of reality. That is, a reality reflecting the world outside the school as an integrated whole - rather than a conglomerate of discrete subject areas (Kirman & Nay, 1975).

This study examined the feasibility of remote sensing as an interfacing medium between science and society. The scientific and social implications of remote sensing technology were integrated into a teaching unit that reflected the objectives of current science and social studies curricula. Details of the implementation of the remote sensing unit are provided in Chapter IV.

Social change will always lag behind scientific progress. Educational systems, by their very nature, react more slowly to technological advances and are consequently left behind and often ill-equipped to deal with technological reality. "One would hope that changing social values might make it easier to integrate scientific change, or perhaps lessen the demand for scientific innovation" (Holz, 1973, p. 361).

GENERALIZATION OF FINDINGS FROM SINGLE CASE STUDIES

The ultimate goal of this study was to generate some form of generalizable knowledge concerning the pedagogical application and implications of remote sensing.

Various evaluative strategies were employed in order to facilitate an understanding and explanation of the treatment's effect. By combining qualitative and quantitative methods of evaluation, the author was in "a position to effect a <u>rapproachement</u> between the two methods" (Rist, 1980, p. 10).

The findings generated by these methods may lead the reader to draw inferences that connect to "a population believed or assumed to be sufficiently similar that the study findings (will) apply there as well" (Kennedy, 1978, p. 5). These inferences, however, should not be based solely on the treatment effect but rather on those generalizable interrelationships between the treatment, the context and the participants.

CHAPTER III

DESIGN OF THE STUDY

In order to assess the potential of remote sensing technology in the elementary school, the author developed and implemented a specific teaching unit. Details of the unit will be elaborated upon in Chapter IV. It suffices to mention at this point that the unit's overall objective was to develop the concept of remote sensing and to relate this concept within a science/societal context.

THE SAMPLE

The sample for this study consisted of ten grade six students identified as being "gifted and talented" by a suburban school district. The rationale for this sample parameter was based on three considerations:

1. If grade six students with above average ability cannot attain the objectives of the program, then replication of the study using average or below average students in grade six would seem unwarranted.
2. The specific sample selected met as a group for one full day each week and during that time was not subject to extraneous scheduling demands.

3. Instructors of gifted children are normally encouraged to provide extended curricular experiences beyond the prescribed curricula. This study served to manifest the potential for such experiences.

SAMPLE ATTRIBUTES

The following procedures and criteria were previously employed by district personnel to identify potential members of the enrichment program:

(1) A teacher referral form (Appendix A) was provided for the purpose of rating behavioral characteristics of superior students. The completed form was then forwarded to the district's psychologist.

(2) The standardized test scores on the <u>Canadian Test of Basic Skills</u> (CTBS) and the <u>Canadian Cognitive Ability Test</u> (C-CAT) reflected performances of at least two years above peer norms.

(3) The results of the WISC-R intelligence test, administered by the district's psychologist reflected a minimum fullscale intelligence quoti[illegible] 130.

The sample in question (ten Grade 6 students with intelligence quotients ranging from 130 to 158) reflected the high intellectual qualifications that are prerequisite to admission into the program. The seven boys and three girls in the sample met as a group each Monday. Six of the ten students were bussed in from four feeder schools to the host school for the weekly five hour enrichment program. The kindergarten to Grade 8 host school contributed four Grade 6 students to the enrichment program. Eight of the ten students in the sample were previously associated with the enrichment program in Grades 4 and 5, while the remaining two students commenced the program in Grade 6.

It is significant to note that this researcher was invited to meet the enrichment class three months prior to commencing the study. As a result of this initial contact, the author was able to establish a degree of credibility and compatibility with the students while explaining the purpose of the study. The students, in turn, were given the opportunity to <u>independently</u> consider their involvement in the study.

Two weeks later, the researcher was notified by the classroom teacher of the students' decision to participate. This selection process was significant in that it provided an opportunity for the students and researcher to mutually assess one another. The resulting decision to engage in the study reflected the initial commitment on the part of both student and researcher.

METHODOLOGY

After receiving an initial commitment from the students and the classroom teacher to be a part of the study, formal approval for the study was granted by the superintendent of the district and the school principal.

The parents of each child received a letter outlining the program and purpose of the study. In addition, the letter encouraged parents to contact the researcher if further clarification was required and to attend any of the classes during the course of the remote sensing unit. The consent forms, included in the letter, were signed by the parents and returned by the students.

The author proceeded to implement and evaluate the unit over a nine week period. The instructional sequence, however, was interrupted on three separate occasions (due to the Spring Break, Easter Monday and Victoria Day holidays) which in effect lengthened the study to twelve weeks. The thirty hours spent in the field have been categorized as follows:

(1) Testing - 4 hours

(2) Interviewing - 7 hours

(3) Instructional time and group activities - 16 hours

(4) Field trip to the Alberta Remote Sensing Center - 3 hours

EVALUATION

The remaining portion of this chapter provides a description of the qualitative and quantitative strategies that were employed in order to assess aspects of the unit's cognitive and affective impact on the students. The dual purpose of the evaluation was firstly, to generate data relevant to the research questions posed in Chapter I and secondly, to assess the extent to which the unit's knowledge, skill and value objectives (listed in Chapter IV) were attained.

QUALITATIVE DATA SOURCES

The qualitative data base was comprised of four components. Firstly, daily log books kept by the students, the regular classroom teacher and the researcher provided a medium through which the participants could record their observations and perceptions during the course of the unit. The students were encouraged to record how they felt about the lessons and to describe what aspects they may or may not have enjoyed. The classroom teacher, on the other hand, focused on the student-teacher, student-student interaction as well as on the ways in which the students collectively and individually manifest their degree of motivation, interest and understanding. The researcher's analysis focused on how the students responded to the content, activities and materials associated with the unit. An additional focus of the researcher was on the dynamics of the interpersonal relationships between himself and the students themselves.

In addition to the daily log entries, a second qualitative source of data was generated from the transcripts of interviews, class discussions and related activities (reports, debates and assignments). The transcripts served to highlight numerous nuances which may have otherwise gone undetected by a researcher preoccupied with intensive interviewing and teaching. These nuances, in turn, served to complement and reinforce inferences made with respect to the quality of student experience and performance.

The third and fourth sources of qualitative data were external to the research design. The third source, namely the perceptions of personnel associated with the Alberta Remote Sensing Center, provided data concerning the students' remote sensing knowledge. The fourth and final source of qualitative data were the findings obtained from a survey questionnaire. The questionnaire was designed and administered by the classroom teacher in order to assess the 1981-1982 enrichment program. Two of the questions, "What did you enjoy most about Enrichment?" and "What activity did you learn the most from?" generated student responses which had implications for this study.

QUANTITATIVE DATA SOURCES

Quantitative data was generated by three instruments: The Remote Sensing Content Test; the ConSAT Task Analysis and the Test on the Social Aspects of Science. A description of each instrument follows:

A. Remote Sensing Content Test

The Remote Sensing Content Test (Appendix B) was developed by this researcher and validated by staff of the Alberta Remote Sensing Center and faculty of the University of Alberta. The purpose of this instrument was threefold. Firstly, to assess initially the students' background knowledge with respect to remote sensing. Secondly, to measure the extent of content mastery (Research question 1.1), and finally to identify areas of strong and weak conceptual learning. The 18 questions that comprised the test related to the scientific and technological aspects of remote sensing as well as to its social application.

B. ConSAT Task

1) Preamble

The ConSAT (Concept Structuring Analysis Technique) Task developed by Champagne, et al (1980a, 1980b) is a relatively quick and simple procedure designed to facilitate the assessment of students' conceptual understanding. The task requires students to arrange a set of discipline related terms into a schematic representation. The schema, in turn, provides: (1) a structural representation of the child's contextual organizing principles for interpreting the text (unit content) and (2) a basis for elaboration or drawing inferences from the text (Anderson, et al, 1977, p. 368).

The ConSAT Task is an attempt to operationalize: (1) the philosophical notion of discipline structure and (2) the psychological notion of knowledge structure, and to relate these notions to the instructional process (Champagne, et al, 1980b).

The twofold purpose of the ConSAT in this study was to: (1) find out how students structure a given set of concepts on remote sensing (Research question 1.1) and (2) assess the potential of the ConSAT task as a means of summative evaluation.

2) Implementation

In previous studies with junior high school students (Champagne, et al, 1980a, 1980b) identical ConSAT tasks were administered before and after a science instructional module. Based on the negligible conceptual background (as revealed by the pretest on Remote Sensing Content) of the students comprising the sample for this study, the administration of a pre ConSAT task was deemed inappropriate. Consequently, the ConSAT was administered at the end of the instructional module (Day 9).

The ConSAT task followed the Remote Sensing Content posttest. As a preliminary exercise, each student was given a 5" x 8" card on which they copied the following six words: salmon, freshwater, trout, fish, saltwater and marlin. Adopting the role of "teacher", the students were asked to develop a sequential structure that would reflect how they would go about relating these ideas to a young child. The exercise resulted in a variety of schematic representations which formed the basis of a class discussion. During the discussion, value judgments were avoided in support of the notion that knowledge can be structured in a variety of ways.

Having provided a mental set for the ConSAT task, each student was given an envelope containing 36 items on separate strips of paper that were deemed relevant to the remote sensing unit. A list of these items appears in Appendix I.

The students were then asked to organize these items into a structured representation on a 12" x 18" sheet of card stock. Blank paper strips were provided on which students could write additional words which they felt ought to be included. After completing their organizational structures, students taped the items on to the card stock. The students worked independently and completed the task within a one to one and one-half hour interval. A sample ConSAT structure is found in Appendix J.

Later that day, individual interviews focused on the ConSAT task and provided an opportunity for each student to discuss and reveal certain structural aspects of their remote sensing knowledge. Such data was utilized by the author to identify common and disparate perceptions of the structure of knowledge related to remote sensing among students and between students and the researcher.

C. TSAS Instrument

The Test on the Social Aspects of Science TSAS (Korth, 1968) consists of 52 items (Appendix C) that deal with the interactions among science, technology and society, the political and social responsibilities of scientists and the social nature of the scientific enterprise (Aikenhead, 1979, p. 119).

Students record their responses on a five-point scale consisting of the following:

A. if you strongly AGREE with the statement
B. if you AGREE but have some reservations
C. if you don't understand the meaning
D. if you DISAGREE but have some reservations
E. if you strongly DISAGREE with the statement

"Correct" responses (see Appendix C - TSAS Answer Key) are based on the content validity of the instrument. The response "strongly agree" (A) or "agree" (B) or the response "disagree" (D) or "strongly disagree" (E) was considered correct if it corresponded to the test's Key. The response "don't understand the meaning" (C) was always marked incorrect.

The pre and post data generated by the TSAS instrument provided a quantitative base for assessing whether or not the remote sensing unit enhanced the development of understanding of relationships among science, technology and society (Research question 1.2).

SUMMARY

The design of the study incorporated a variety of qualitative and quantitative strategies in order to assess the unit's cognitive and affective impact on the students. The data generated by these techniques provided a basis for drawing inferences concerning the research questions of interest and the specific objectives of the teaching unit.

While recognizing that the results of the study would be dependent on the composite character of the unit, the students and the teacher, it was, nevertheless, felt that such results could provide a basis for program adjustment and justification.

CHAPTER IV

UNIT DESIGN AND IMPLEMENTATION

PROCEDURAL MODEL

The unit in question was designed to reflect the procedural model proposed by Kirman and Nay (1975) entitled "Joint Planning for Integrating Social Studies and Science". The model suggests the following steps which are designed to facilitate an interface between social studies and science:

(1) Draw curricular comparisons between the subject areas of science and social studies.

(2) Select a topic compatible with both subject areas.

(3) Define the topic and describe the methodology of integration, i.e. will sub-topics be integrated, supportive or treated separately?

This author proceeded to implement the model by initially comparing the 1981 Elementary Science Curriculum Guide with the corresponding 1981 Elementary Social Studies Curriculum Guide for the Province of Alberta.

The following table represents a comparison of the essential concepts/objectives of these subject areas:

COMPARISON OF CONCEPTS/OBJECTIVES OF ELEMENTARY SCIENCE AND SOCIAL STUDIES IN ALBERTA (1981)

Elementary science focuses on:	Elementary social studies focuses on:
The three major concepts of (1) Matter and Energy, (2) Living Things and the Environment and (3) Earth, Space and Time. The curriculum emphasizes the inquiry approach to learning and teaching - the essence of which is the development of process skills.	The integration of History, Geography and the social sciences in order to facilitate social inquiry into contemporary social issues, as well as the promotion of effective citizenship through specific value, knowledge and skill objectives.

The emphasis on inquiry learning and teaching is evident in both science and social studies curricula. In addition, each curriculum guide identifies specific value, knowledge and skill objectives to be attained.

The selection of a topic is the second phase of the Kirman-Nay model. The topic of a particular study should be an expression of a problem that is compatible with both curricular areas and reflect the role of science in resolving social issues. The three major concepts of the elementary science program, namely:

(1) Matter and Energy,

(2) Living Things and the Environment

(3) Earth, Space and Time

invoke a variety of science-related social issues. The significance of remote sensing technology is that it encompasses all three of the specified science concepts.

Briefly stated, remote sensing technology entails the utilization of electromagnetic radiation (energy) to study the surface features (matter) of our planet (earth). The information provided by the Landsat satellite (space and time) can be utilized to examine man's relationship with his environment (living things and the environment).

The third step in the development of the model requires the curriculum developer to define the scope of the problem and outline the methodology of integration. One method of defining the scope of the problem is to ask appropriate research questions. The integrative methodology would utilize the similar processes of inquiry common to both subject areas. For example, the processes of discovering, valuing and exploring would link with an established knowledge base to facilitate the inquiry process.

UNIT DESIGN

The central theme of the unit was the development of an understanding of interrelationships between science and society through the use of remote sensing technology. The specific focus of the unit was on the May, 1980 eruption of the Mt. St. Helens volcano and the relationship of selected remotely sensed imagery to illustrate the social and scientific impact of this catastrophic event.

OBJECTIVES AND TEACHING STRATEGIES

The unit encompassed the following objectives which have been categorized as follows:

A. Knowledge Objectives - Students should develop an awareness and understanding of the following:

Science - the process of volcanism (geology).
- the scientific principles of remote sensing.
- the role of science in the development of remote sensing.
- the scientific applications of remote sensing technology in studying the environment with a specific focus on volcanic studies.

Social Studies - the history of the region as it relates to the Mt. St. Helens volcano.
- the human and physical geography of the Mt. St. Helens area.
- the psychology and behavior of indi-

viduals and groups associated with the Mt. St. Helens eruption.

- the social applications of remote sensing technology in studying natural disasters.

B. <u>Skill Objectives</u> - Students should be able to:

- identify and define the problem/central issue.
- pose relevant research questions and formulate appropriate hypotheses.
- collect, evaluate, analyze and synthesize data.
- resolve the issue (i.e. What role can/does/should remote sensing play in natural disasters?) and recognize and apply consequences of their decisions.

C. <u>Value/Attitude Objectives</u> - Students should be able to:

- develop competency in decision-making with the recognition that decisions can be made on the basis of a number of alternatives.
- recognize that decision-making involves values and sometimes these values conflict.
- appreciate the broader implications of chosen solutions, i.e. moral reasoning.

- foster an awareness of the effects of science on society and vice versa.
- understand that valuing is a way of learning.
- extend the practice of describing facts to their application in terms of meeting human needs.

D. Experiential Objectives

A further objective of the unit was to provide students with both a horizontal and vertical type of enrichment experience. A horizontal experience would provide the opportunity for students to increase their depth of knowledge (expanding sideways). A vertical experience, on the other hand, would be typified by the opportunity to acquire new knowledge.

A variety of curriculum materials were combined with teaching strategies emphasizing divergent thinking and creativity. Students engaged in a problem-solving situation that reflected their reality of a relevant issue. Independent study was encouraged since it is "particularly suited to many gifted and talented children because of the so-called 'reverse ratio' of teaching and learning - they learn a great deal with comparatively little teaching" (Epstein, 1979, p. 69).

The unit was evaluated in terms of the stated objectives and its overall cognitive and affective impact on the students.

UNIT PLAN

Aim: To introduce the concept of remote sensing and to relate its technological and scientific implications within a relevant social context.

Key Idea: To enhance the development of interrelationships among science, technology and society.

Procedure:

1. Identify knowledge, skill and value objectives which reflect a social study of science and technology and which are compatible with those existing in current social studies and science curricula.
2. Explore and differentiate the roles of science and technology in society.
3. Study the concept of remote sensing as an exemplar of a technology that has both social and scientific implications.
4. Apply the concept of remote sensing to a science-

related social issue, namely, the eruption of the Mt. St. Helens volcano.

5. Integrate the scientific, technological and social implications of the central issue, in this case, the Mt. St. Helens eruption.
6. Evaluation in terms of the unit's objectives and student perceptions.

Related Skill Areas:

Vocabulary - the development and application of an appropriate remote sensing vocabulary.

Mapping - orientation to satellite imagery as well as the identification and classification of natural and cultural features when viewed from space.

Research - practice in utilizing the processes of inquiry, for example, the identification of appropriate research questions, the gathering of evidence and the reporting of findings.

UNIT CONTENT AND IMPLEMENTATION SEQUENCE

The unit spanned an interval of twelve weeks and included six half and three full instructional days. The stages of the unit's evolution are detailed below and include descriptive comments reflecting the participants' perceptions of the daily events. A bibliography listing the materials utilized in the unit is provided in Appendix F.

Day 1

The researcher administered the Test on the Social Aspects of Science (TSAS) - see Appendix C. Student responses were the focus of indepth personal interviews that were taped and later transcribed. The rationale for using the instrument was to assess the students' incoming pre-conceptions of science, technology and society and the interrelationships, if any, among them. Subsequent to the interviews, students were assigned the following for next class (two weeks hence in this case):

1. The students were to develop their own definitions for science, technology and society and to illustrate each definition in a complete sentence.
2. The students were to read a newspaper article on a science-related social issue (ten different articles provided by the researcher) and analyze the article's significance in terms of the relationships among science, technology and society.
3. Thirdly, the students were asked to read the Canada Center for Remote Sensing Handbook (13

pages) and subsequently design a title page for their log books.

Participants' Perceptions (Day 1)

The prospect of beginning the unit prompted students to note that they were "excited"; "interested"; and "glad". In addition, the unit was something that they were looking forward "to learning about". Student log entries described the TSAS instrument as "not hard because there is no right or wrong answer"; "somewhat fun and interesting". The majority of students noted that the instrument provided an opportunity to express their "opinion on science, technology and society".

The interviews that followed the TSAS instrument focused on those items with which the student strongly agreed or disagreed. In addition, these interviews provided the opportunity for one-on-one interaction (student-researcher) and served to reveal student perceptions about science, technology and society. The following quotations from the students' comments serve to illustrate some of these perceptions.

Science:

"Science is biology and what the world is made up of".

Scientists "make new things and help other people".

"I know a scientist and he just tries to work on his own - he keeps all his stuff private".

"A scientist doesn't really want to be popular so much as he really wants to get the job done".

The role of the scientist is "to find and discover".

Society:

"People are getting lazier and they are just trying to develop something that will take over any kind of work".

People will find that "their lives are so much run".

Many people in "society don't ask questions or question their beliefs - they just automatically accept it and I don't believe in that".

Technology:

"For me the only thing new is computers".

Technological innovations should be "put in the right hands - people that would use them properly".

"Everything is all technology and none of it is really from your mind".

"Most of the inventions were made by mistake".

Students tended to share a somewhat pessimistic view of future society and frequently associated nuclear energy and computers with technology. In addition, they perceived scientists as being highly task oriented and somewhat detached from the mainstream of society. Scientific relevance was less tangible and subordinate to technological relevance.

Day 2

One instrument was administered on this day, namely: the Remote Sensing Content Test (Appendix B). An 'opener' was designed to stimulate student interest about the interrelationships among science, technology and society. The essential component of this 'opener' was the film entitled Science and Society produced by McGraw-Hill. The ensuing discussion attempted to differentiate the meanings of science, technology and society and to compare and contrast the concepts advanced in the film with the students' own definitions developed earlier.

The concept of remote sensing was introduced as an example of a technology that can be used to study the environment. Students were asked to prepare a one page written report (to be presented orally) on one aspect of remote sensing. Students were free to choose a topic of interest from a variety of material (Appendix F) provided by the researcher.

Participants' Perceptions (Day 2)

The Remote Sensing Content pretest prompted one student to comment "Gee, I don't know very much", however most students felt they would be able to answer more questions on the posttest.

The students' initial definitions of science, technology and society reflected a diversity of ideas; for example:

Science is - "the study of living things"
- "the study of the world around us"

Technology is - "the advancement of science"
- "how to make machines"

Society is - "the environment and the people around us"
- "where you live - your community".

With reference to the Science and Society film, the classroom teacher noted that during the "excellent" film, "the students were most attentive" although she perceived the film to be "beyond the intellectual level of most grade sixes". A similar concern was raised by a student who commented that "The film was a little bit hard to understand, but I liked it anyway".

Several students related that today's lesson enhanced their "understanding of science, technology and society". They went on to describe the lesson as being "good"; "enjoyable"; and "neat".

In general, students related the concept of society to themselves - "the people around me/us". Concerns were expressed as to the appropriateness of the Science and Society film.

Day 3

Students presented their reports orally in a seminar arrangement. The presentations were taped and later transcribed. Students were encouraged to ask clarifying questions about one another's reports. The NASA film entitled Remote Possibilities was subsequently screened and students were asked to relate aspects of their reports to the film. Later, Landsat satellite orbital characteristics were briefly discussed and students were assigned the task of identifying and locating specific orbital path and image center numbers for sites in West-Central Alberta (see Appendix D).

Participants' Perceptions (Day 3)

The researcher was very impressed with the quality and presentation of the reports. Some of the topics selected by the students included "The Electromagnetic Spectrum", "The Difference Between Thermal and Reflected Infrared", "The Landsat Satellite", as well as applications of remote sensing in assessing grizzly bear habitat and in the control of forest fires.

During the film Remote Possibilities, the classroom teacher observed students "relating to one another as areas of information dealing with their own subject (report) came up - smiles, nods, etc.". Students asked clarifying questions during the lesson, for example, "Do you mean?"; "Is that why?".

One student found today "interesting because I got to read my report and learned about Landsat". Another student commented that "Even though I missed most of the class (had a conflicting appointment), I got a good understanding of the Fleming System and the infrared scanners of the Landsat". The homework sheet (Appendix D) "looked like fun" to one student and another described the day's events by stating "All of it was excellent".

One activity which generated a lot of interest and participation was the creation of the visible spectrum by means of a prism. Students attempted a variety of prism configurations in order to obtain the best spectral representation.

In general, there was more student initiated interaction - possibly due to their increasing familiarity with the content and the researcher.

Day 4

Various remote sensing concepts were emphasized, such as 'multistage', 'multiband' and 'multidate'. In addition, the ultraviolet, visible and infrared (reflected and thermal) regions of the electromagnetic spectrum were examined and contrasted. A series of fifty-eight slides entitled "Introduction to Remote Sensing" (developed by this author - see Appendix E) assisted in the development of these concepts. The "Introduction to Remote Sensing" phase of the unit attempted to develop student skills in the following areas:

1. Appreciation and understanding of the scope of remote sensing.

   1.1 Awareness of multispectral scanner systems (including the Landsat satellite system).

   1.2 Acquisition of technically related vocabulary.

2. Understanding the character of the electromagnetic spectrum.

2.1 Distinguishing between the visible and invisible regions of the spectrum, with emphasis on the ultraviolet, reflected and thermal infrared regions.

2.2 Emphasis on unique reflective features, such as deciduous and coniferous forests as well as sedimented versus clear water.

3. Recognition of natural and cultural features on satellite imagery.

3.1 Associating environmental features with tonation, texture and spatial resolution.

4. Application of Landsat data to a variety of environmental studies.

As part of a group activity, students were asked to superimpose transparencies of topographic maps onto false-color (C-1) Landsat imagery of the same scale and region (1:250 000). Students were then asked to locate a variety of cultural and natural features and subsequently affix identifying labels on the imagery.

As a homework assignment for the following week, students were to identify twenty cultural and natural features on a Landsat (C-1) image of the West-Central region of Alberta (scale: 1:000 000). Each student was given an Alberta Road Map on which to delineate the Landsat frame parameters. The road map was intended to guide the student's orientation to the data frame.

Participants' Perceptions (Day 4)

The slide presentation entitled "Introduction to Remote Sensing" (Appendix E) generated many questions with the students being encouraged to speculate and hypothesize answers.

The mapping exercise prompted this student comment "I had to point out areas on the (Landsat) map. It was great! The best so far" and after listing the concepts learned to date, one student noted (in his journal) that he was "getting VERY interested in remote sensing" (student's own emphasis).

Students encountered little difficulty as they moved from Landsat imagery at a scale of 1:250 000 to a 1:1 000 000 scale image. In addition, they easily differentiated cultural and physical features on both the road map and satellite image. The fact that the road map's scale (1:1 500 000) was smaller than the image scale (1:1 000 000) presented little difficulty.

Day 5 - all day session (5 hours)

A. Morning Session (3 hours)

1. The orbital characteristics of the Landsat satellite were demonstrated utilizing a Landsat model and a large globe. Orbital characteristics emphasized were:

    a) sun synchronous
    b) repetitive coverage
    c) near -polar orbit
    d) near global coverage

2. A modified version of the slide tape minicourse entitled "Landsat: An Earth Resources Satellite System" by Shirley M. Davis was then presented. Students made appropriate notations on the mini-course worksheets that served to illustrate the following concepts:

    a) scanner systems (Return Beam Videcon and Multispectral Scanner)
    b) orbital characteristics of the Landsat satellite
    c) structural features of the satellite
    d) the mechanics of the reception and transmission of data
    e) the various applications of Landsat data.

3. The students corrected the assignment of Day 3 - namely, locating various image centers and orbital paths of selected West-Central Alberta towns

(Appendix D).

4. The class then viewed the NASA film entitled "The Fractured Look" which examined geological applications of remotely sensed data. The film emphasized how Landsat satellite imagery can be used to study earthquakes and volcanos.

5. The last half hour of the morning session enabled students to:

   a) organize their note/log books
   b) complete the assignment of Day 4 - i.e., the identification of twenty natural and cultural features from a Landsat image
   c) enter their comments and observations into their daily journals.

B. Afternoon Session (2 hours)

1. Satellite imagery (slides and hardcopy) of the Mt. St. Helens volcano were presented. The satellite imagery consisted of:

   a) pre and post-eruption Landsat (C-1) scenes of Mt. St. Helens
   b) black and white time-lapse satellite imagery recording the eruption sequence.

This second set of imagery consisted of five frames recorded by the Geosynchronous Orbiting Earth Satellite (GOES).

The time span of these images ranged from 15 minutes to 8 hours after the eruption. The scientific and technological (remote sensing) aspects of the eruption were illustrated.

2. In order to illustrate the social implications of the eruption, a 20 minute taped interview with a former resident of the Mt. St. Helens region was played. Personal losses incurred by the interviewee were related. In addition, the interviewee's philosophy towards life illustrated one way in which people cope with catastrophic situations.

3. The concepts of science, technology and society were then linked to the central issue "What are some of the scientific, technological (remote sensing) and social implications of the Mt. St. Helens eruption?". The students were then asked to suggest some appropriate research questions that would address this central issue.

4. Subsequently, the students generated ten questions. Each question was classified according to whether the students felt the question had scientific, technical or social implications. The ten questions generated by the students are listed below:

1. Why and how did the eruption occur? (Science and Technology)

2. What personal losses resulted from the eruption? (Societal)

3. What role did the scientists play in predicting the eruption of Mt. St. Helens? What instruments were used? (Science and Technology)

4. What effect did the eruption have on the physical and human environment? (Science and Societal)

5. What are some of the historical aspects of Mt. St. Helens - i.e., eruption history, origin of name, etc? (Science and Societal)

6. Are future eruptions likely? (Science and Technology)

7. Why didn't lava flow from Mt. St. Helens? (Science)

8. What were some of the social implications in terms of: relocation as well as the physical and mental health of those affected? (Societal)

9. What role did the government have during the pre, active and post-eruption periods? (Societal)

10. On what basis were people compensated for their losses? (Technology and Societal)

5. The students then proceeded to determine the method of allocating responsibilities. The student initiated design entailed the formation of five groups with each group having two members. Each group would consider two research questions. A lottery was chosen as the means by which group membership and assignment would be determined.

6. The students decided that each group would report their

findings in oral and written form. Students were then allowed to examine the materials displayed in order to identify which resources were appropriate to their research questions. In addition, other potential information resources were discussed.

7. The assignment for the following week required each group to provide the class with a progress report on their efforts. The progress report was to include those resources identified as being appropriate to the group's interest as well as the identification of problems encountered to date.

Participants' Perceptions (Day 5)

The scientific and technological aspects of remote sensing set the stage for a discussion of the social implications. The Landsat and GOES imagery of the Mt. St. Helens volcano elicited student comments like: "gee!"; "ooh!"; "I wouldn't want to live there" (referring to the environmental destruction). In addition, the tape containing the recollections of a Mt. St. Helens survivor prompted students to comment "She thought about other people - not just herself" and "She wasn't going to give up - she had a good attitude (towards life)".

The classroom teacher noted that the "Students (were) able to listen to (the) tape without signs of restlessness (and) related the experiences of the old woman to those of elders in their own families". The classroom teacher also noted "obvious interest" as students proceeded to generate research questions appropriate to the central issue (Appendix G).

Students initiated the notion of a division of responsibilities (in handling the research questions) and established a methodology (drawing lots) through which this was to be accomplished. Students were highly self-motivated to locate appropriate resources that were pertinent to their topics of consideration.

In summarizing the day's events, students commented that "we had remote sensing all day. I'm glad. It's great!"; and "The whole day was excellent. I really enjoyed it. I got a lot done".

Day 6

A flow chart indicating the research questions of concern to each of the five groups was distributed (see Appendix G). Students articulated their specific research questions and provided a general outline of their progress to date. The progress reports also revealed the resources used to date and provided students with the opportunity to relate any specific problems encountered to date. Subsequent to the presentation and discussion of the progress reports, the researcher worked with individuals and groups on their reports.

Participants' Perceptions (Day 6)

The progress reports indicated that the majority of students had been successful in obtaining appropriate resource material. One research question, "What physical and psychological effects did the volcano have on those affected by the eruption?", stimulated considerable discussion. The discussion centered on the decision of a long time Mt. St. Helens' resident (Harry Truman) to remain in the area - even though the eruption was imminent. Several students felt that individuals have the freedom to choose to die, while others raised legal and ethical implications of suicide.

The remaining portion of the class period was spent helping individual students with their reports. During this interval the classroom teacher noted that "Remote sensing terminology (was) just flowing from (the students') tongues".

Student reflections on the day's events included:

"Today, we did work on our reports, it wasn't that fun because I didn't have enough information".

"We are doing Mt. St. Helens. I love hearing about it. It's great! I hope we will keep working on it".

"Today, I had a good day. I have started my report from the notes I took at home".

Day 7 - all day

Four students were absent due to their participation in a school track meet.

A series of twenty slides were screened that illustrated the pre, during and post-eruptive phases of Mt. St. Helens. A Washington state map was utilized in conjunction with the slides to assist in orientating the students to the photographic angles of the slide imagery.

Four students orally presented their reports on their respective research questions. Subsequently, two video tapes entitled Pollution Below and Pollution Solution were screened and followed by discussion. Finally, a debate between two teams of three was organized and held on the pros and cons of remote sensing technology.

Participants' Perceptions (Day 7)

Students were able to determine the direction that a camera would have to point in order to obtain the variety of photographs screened. They were also able to differentiate between oblique and vertical aerial imagery.

The students commented that they "enjoyed the debate" and found that the remote sensing unit provided "more chance for discussion than other subjects". During the debate the "pros" focused on the general advantages of remote sensing while the "cons" addressed the disadvantages of the Landsat satellite.

Day 8

Prior to departing for a tour of the Alberta Remote Sensing Center (ARSC), students completed the posttest on the Social aspects of Science (TSAS - Appendix C). The ARSC tour (1½ hours) emphasized the technical equipment associated with the processing, interpretation and application of remotely sensed imagery.

Participants' Perceptions (Day 8)

Students completed the TSAS posttest in approximately

45 minutes. At the Alberta Remote Sensing Center (ARSC), personnel associated with the aspect of public education presented an overview of remote sensing and conducted a "hands on" tour of the center's equipment.

The classroom teacher observed that students were quick to demonstrate "how much background knowledge they already had" during the introductory overview. The students' background knowledge prompted ARSC personnel to note that "the students exhibited extraordinary skill at interpreting aerial and satellite imagery" in addition to their "very impressive background knowledge".

The classroom teacher noted that during the explanations of the technical equipment, the researcher endeavored to relate "aspects of the talk to particular facets discussed in class" which "seemed to help the students concentrate for a longer period of time than might have been possible". During the course of the tour the classroom teacher observed that "students asked a myriad of insightful questions and made considerable effort to understand and relate the technological aspects of the equipment to their present knowledge". The classroom teacher's final observation was: "None of the students appeared bored or distracted. There were definite signs of high interest throughout the tour, an awe and appreciation for the technology presented to them."

Additional perspectives were provided by personnel from the Alberta Remote Sensing Center. Center personnel have, for the past several years, lectured and conducted tours of the facility in order to increase public awareness and understanding of remote sensing. During the course of the field trip to the Center, Center personnel commented that they were "very impressed with the way in which the students integrated their background knowledge in order to interpret remotely sensed imagery". The same personnel also noted that when compared to other elementary, secondary and post-secondary students, this group exhibited "extraordinary skill at interpreting aerial and satellite imagery".

Student log entries relating to the field trip stated that: "The trip was excellent"; "I found it very interesting"; "fantastic" and "I learned a lot". One student noted the "machines were amazing" and wondered "who would have a head big enough to invent these things!".

The researcher perceived the field trip to be an excellent follow-up to the unit. Personnel at the center effectively incorporated imagery of Mt. St. Helens into the tour which served to reinforce the context of the unit. The one and one-half hour tour provided the opportunity for students to relate and enrich their conceptual background in remote sensing.

The analytical and interpretive equipment at the Center served to capture the interest, imagination and enthusiasm of the students. It was suggested by the classroom teacher that "another half hour or so might have been beneficial, allowing the students the opportunity to interact among themselves rather than just between adult and child". Several students commented that they would have liked more time with certain pieces of equipment. Future field trips could, if feasible, span two hours with a short break provided after the first hour. Students were, however, encouraged to return at anytime on their own, by both the Center personnel and the researcher.

<u>Day 9 - all day session</u> (5 hours)

A. Morning Session

The Remote Sensing Content Test (Appendix B), was administered. After the morning break, students worked on the ConSAT analysis (details in Chapter III).

B. Afternoon Session

Initially each student wrote letters to: (1) the staff of the ARSC, and (2) a friend, in which they were to describe the positive and negative aspects of the remote sensing unit. Secondly, a questionnaire evaluating the entire enrichment program (September-June) was distributed by the classroom teacher. Students were individually interviewed with respect to their ConSAT structures which had been generated in the morning session.

Participants' Perceptions (Day 9)

Unlike the pretest - most students completed the majority of questions on the Remote Sensing Content Post-test.

The ConSAT items (Appendix I) were arranged by students on an individual basis. One student reflected that the size of the cardstock (12" x 18") did not give him sufficient room to organize the items in the way he wanted to. The task proved to be lengthy (36 items to categorize), yet students persisted in their determination to complete the organization. A few terms presented difficulty for some students as revealed in the subsequent interview. The difficulty seemed to lie with those terms having multiple connotations for the student. As a consequence such terms were difficult to categorize. Students tended to do a lot of shuffling of items until they had established their categories. Once established, the categories were linked to more specifically related items.

In their letter to a friend, most students recommended the remote sensing unit as being "worthwhile", but cautioned that "a lot of work was required" and an initial "commitment (to the unit) was important".

During interviews with individual students about their respective ConSAT structures, the students explained their organization of the items and provided a rationale for their decisions. A sample (Student #6) ConSAT task is provided in Appendix J.

Final student journal entries included comments like: "Today, I wrapped up all I know about remote sensing. I think this unit was fun"; "All in all it's just another excellent day"; and "Too bad it's over".

SUMMARY

The unit's design and implementation encompassed a variety of materials and teaching strategies. The materials utilized included films, video tapes, slides, tape recordings, worksheets, satellite imagery, plus an assortment of reference materials, details of which are provided in Appendix F. Since satellite imagery is expensive and delicate, an effort was made to mount and laminate these materials in order that students could have a "hands on" experience.

In terms of teaching strategies, the lecture method was de-emphasized in favor of (1) working and sharing in small groups (2-3 students) and (2) the oral presentation of findings resulting from individual research projects.

In the capacity of "teacher", the researcher encouraged a collegial relationship with the students. Students were individually reinforced in their expressed achievements and interests both in and out of school. After completing the field work associated with the study, the author was invited by the class to return for the year end party. Under their own initiative, each student had gone to considerable effort to prepare a unique thank you card reflecting their appreciation. All the cards were prominently displayed on a bulletin board prior to the author's arrival. As a final touch, sitting on a table in front of the card display, was an attractively decorated cake. The cake had been made by a mother of one of the students and was subsequently decorated (under her son's supervision) with a Landsat satellite and the inscription "Here's looking at you!".

Profile of Field Activities

DAY	ACTIVITIES
1	*Administered the Test on The Social* Aspects of Science (TSAS) - See Appendix C. Personal interviews focused on student responses to selected items on the TSAS.
2	The pretest on remote sensing content (Appendix B) was administered prior to the screening of the film entitled <u>Science and Society</u>. Remote sensing was introduced as an example of a technology that has both scientific and social implications.
3	Students presented reports on remote sensing. Concepts developed by the students were then linked to the film <u>Remote Possibilities</u>. Landsat orbital characteristics were introduced.
4	Remote sensing concepts were developed through a series of slides entitled "Introduction to Remote Sensing" (Appendix E). Students superimposed transparent topographic maps on Landsat imagery.
5	Students completed the slide tape minicourse entitled "Landsat: An Earth Resources Satellite System". The central issue was introduced with the subsequent generation of ten research questions.
6	Individual progress reports were presented. Students articulated their specific research question(s) and identified the resources used to date.
7	Students presented reports which addressed their respective research questions. Students debated the pros and cons of remote sensing.
8	Students completed the TSAS post-test (See Appendix C). Students toured the Alberta Remote Sensing Center.
9	The posttest on remote sensing content (Appendix B) was administered. The ConSAT technique was also employed.

CHAPTER V

FINDINGS: QUALITATIVE EVALUATION

This chapter deals with the analysis and interpretation of the qualitative data generated by the study. Information from journals, class discussions, student reports and surveys along with observations made by personnel associated with the Alberta Remote Sensing Center, comprised the qualitative data base. For organizational purposes this chapter has been divided into two main sections. The first section deals, in turn, with the qualitative findings that relate to research questions 2 and 3:

(2) Can the technology of remote sensing serve as an interfacing medium in the context of an integrated scientific and social inquiry?

(3) What effect does remote sensing have on student motivation?

The second section considers those qualitative findings that relate to the unit's specific knowledge, skill and value objectives previously outlined in Chapter IV.

RELATIONSHIP OF QUALITATIVE FINDINGS TO RESEARCH QUESTIONS

(2) Can the technology of remote sensing serve as an interfacing medium in the context of an integrated scientific and social inquiry?

The remote sensing unit developed scientific and technological aspects of remote sensing and related these aspects to a contemporary social issue (the eruption of Mt. St. Helens). The scientific aspects of remote sensing were developed within the context of the three major concepts of the elementary science curriculum (referenced in Chapter III and detailed in Chapter IV). This theme of developing an appreciation and understanding of the interrelationships among science, remote sensing technology and society was consistently reinforced by the NASA film series entitled Landsat: A Satellite for All Seasons (Appendix F).

Each film in the series addressed scientific and technological aspects of remote sensing and subsequently applied these aspects to an appropriate social context. For example, the film "Pollution Solution" applied scientific and technological aspects of remote sensing in order to identify a specific source of water pollution. Remotely sensed data was collected and introduced as evidence in court. This evidence, in turn, facilitated the identification and conviction of the party responsible for the pollution. In summary, the film clearly illustrated how remotely sensed data can enhance informed decision-making.

The films in the series were short (12 minutes), contemporary and served to illustrate various applications of remote sensing. During the screening of these films, both the classroom teacher and the author observed a high level of student attention and involvement, as students related to the scientific, technological and social aspects of the films.

In addition to the NASA film series, the role of remote sensing as an interfacing medium was manifest by the variety of research questions/topics developed by the students for their reports. On Day 5, for example, the students generated and classified ten research questions (Appendix G). Each question was classified in accordance with its perceived scientific, technological and social implication. Six out of the ten questions were deemed to warrant a multiperspective approach, meaning that the students felt these questions could best be answered through a consideration of more than one perspective, for example a science and societal perspective.

The following illustrates how this multiperspective approach was manifest in a student report on the topic "Are Future Eruptions of Mount St. Helens Likely?". In this report, the student chose to use the technology of remote sensing to interface the roles of scientists with the social significance of being able to provide timely warnings about potential natural disasters.

The researcher was most encouraged by the demonstrated ability of the students to generate appropriate research questions. The questions were considered to be appropriate because they addressed a variety of scientific, technological and social implications which related to the Mt. St. Helens eruption. The students went on to classify those questions which they perceived to have the following implications:

(a) Scientific and Technological implications - 3 questions

(b) Scientific and Social implications - 2 questions

(c) Technological and Social implications - 1 question

(d) Social implications - 3 questions

(e) Scientific implications - 1 question

It was interesting to note that students were capable of considering each research question from a multiple scientific, technological and social perspective, thus demonstrating a recognition that problems or issues may be resolved in various ways. An additional observation was the fact that none of the questions were perceived by students to only have technological implications. In those questions where technology was a factor it was invariably linked with either a scientific or social implication.

This later observation may lead to the inference that the students perceived remote sensing technology as having an integrative role in a science-related social issue.

The preceding qualitative data suggest that when remotely sensed information is related to an appropriate contemporary social issue, it can enhance the basis on which informed decisions are made. The data further suggests that it was not remote sensing education per se that facilitated the interface between science and social studies, but rather the data generated by remote sensing technology. Therefore, the interfacing potential of remotely sensed data will be dependent on the data available and the appropriateness of such data to the topic of interest.

(3) What effect does remote sensing have on student motivation?

The participants' perceptions (provided in Chapter IV) provide a basis for inferring the degree of student motivation during the remote sensing unit.

The students' journals provided insight into their perceptions of the remote sensing unit. From the outset of the unit, students recorded comments (cited earlier) that reflected a high degree of interest and enthusiasm for the remote sensing unit. Judging by the daily student comments that followed (referring to the student perceptions cited in Chapter IV), it would appear that this initial high level of interest and enthusiasm was maintained throughout the course of the unit.

In addition, the researcher observed that the students required little encouragement to participate in class discussion and in many cases were anxious to start class activities and homework assignments.

The classroom teacher's comments also reflected the degree of student interest: "Students (were) able to listen...without signs of restlessness"; "Students fascinated..."; "None of the students appeared bored or distracted. There were definite signs of high interest throughout...".

These findings tend to corroborate those of an earlier study (Smith, 1980) concerned with the use of Landsat imagery by secondary pupils. Smith (1980) observed that "Pupils showed that they enjoyed working with the new material (which proved to be a) very useful stimulus" (p. 48). Based on the findings of these two studies, it appears that the students involved (whether elementary or secondary) shared a similar high degree of interest and enthusiasm for remotely sensed information.

RELATIONSHIP OF QUALITATIVE FINDINGS TO UNIT OBJECTIVES

The qualitative data also provided a basis for inferring the extent to which the potential learning outcomes of the unit were attained. The unit's objectives (specified in Chapter IV) reflected a consideration of both the cognitive and affective domains as well as areas of skill development.

The extent to which the students associated the unit's content and strategies with an opportunity for learning were revealed in a survey (independent of this research) conducted on the final day of classes. The survey questionnaire, developed by the classroom teacher, consisted of fourteen open-ended questions and was intended to probe the students' perceptions about the 1981-1982 enrichment program. The remote sensing unit constituted one of over a dozen activities in which the students had engaged in. Two of the questions on the survey were: "What did you enjoy most about enrichment?"; and "What activity did you learn the most from?". Out of the eight questionnaires returned, two students identified remote sensing as the aspect of the program that they had enjoyed the most and six students chose remote sensing as being the activity through which they had learned the most.

The students manifested their degree of learning in numerous ways, for example, in their oral presentation of reports. The variety of topics addressed by these reports made it feasible to consider each of the science and social studies knowledge objectives. In presenting their reports, students adopted the role of "teacher" and frequently used their own illustrations supplemented by reference materials to explain and clarify their topic. Fellow classmates, in turn, questioned and criticized one another's reports.

The researcher endeavored to identify and express those elements of the reports that were common to one another and to integrate and reinforce 'known' knowledge with the films, lectures and class discussions.

In Chapter IV, additional perspectives that reflected the degree of student learning were provided by personnel from the Alberta Remote Sensing Center. Center personnel had commented on the high level of awareness and understanding which the students exhibited during the tour of the facility.

Many of the skill related objectives were also addressed through student research. Students gained further experience in the collection, analysis and synthesis of data during the course of preparing their reports. In addition, the unit provided students with the opportunity to pose relevant research questions and appropriate hypotheses with respect to the central issue "What were some of the scientific, technological and social implications of the Mt. St. Helens eruption?". Lastly, the students developed a recognition of some of the potential roles that remote sensing has in a study of natural disasters. Some of these roles were identified by students as being preventative, historical (providing a pre and post record of a natural disaster), environmental (impact analysis), plus related legal and economic applications.

The extent to which the value objectives were addressed by the unit is illustrated by the following example. Considerable class discussion and debate centered on the decision of Harry Truman to remain in the vicinity of imminent danger near Mt. St. Helens. Students raised the ethical and moral issue of whether "freedom of choice" in a democratic society includes the right to take one's own life. The variety of opinions expressed served to illustrate that alternative values sometimes conflict during the decision-making process. Additional perceptions of the social impact of the eruption were provided (on tape) by a former resident (of the Mt. St. Helens area) whose personal philosophy helped her to endure economic hardship resulting from the eruption.

An historical perspective of the Mt. St. Helens volcano was provided by a pair of students who chose to trace the magnitude and sequence of the volcano's previous eruptions in relation to those of other volcanoes.

The data provided in this second section (Relationship of Qualitative Data to Unit Objectives) reveals student behaviors which tend to reflect the knowledge, skill and value objectives of the unit. It appears that the opportunity for the oral presentation of student reports was a major contributing factor in facilitating the attainment of these objectives.

SUMMARY

The qualitative findings suggest that within the parameters of this study:

(1) the remote sensing unit provided a common interface for some of the major concepts of the elementary science curriculum (Alberta, 1980).

(2) remotely sensed information (earth-bound, aerial and satellite imagery) can interface with an appropriate social inquiry and enhance the process of informed decision-making.

(3) remote sensing technology facilitates links between elements of science and society in a science-related social issue.

(4) participants tended to view the remote sensing unit as a stimulating experience and perceived a positive correlation between the levels of motivation and learning.

(5) student learning was manifest in both the cognitive (knowledge objectives) and affective (value/attitude objectives) domains, as well as in the area of skill development.

CHAPTER VI

FINDINGS - QUANTITATIVE EVALUATION

Chapter VI deals with the analysis and interpretation of quantitative data generated by the three instruments described in Chapter III. For organizational purposes this chapter is divided into three main sections. The first section relates the findings from the Remote Sensing Content Test and the ConSAT Task Analysis to the question - "Can elementary students acquire and structure knowledge related to remote sensing?". The second section applies the findings from the Test on the Social Aspects of Science (TSAS) to the question - "Does student awareness and understanding of scientific, technical and practical aspects of remote sensing enhance the development of their understanding of the relationships among science, technology and society?". The final section discusses the relationship of the quantitative data to the unit objectives.

REMOTE SENSING CONTENT TEST AND ConSAT TASK ANALYSIS

1. Remote Sensing Content Test (RSCT)

The purpose of the RSCT was to assess initially the students' background knowledge with respect to remote sensing and then subsequently measure the extent of content mastery. The data provided by this instrument provided a basis for answering the question - "Can elementary students acquire knowledge related to remote sensing?". The pre and posttest results (provided in Appendix H-1) reveal that the mean of 8% on the pretest increased to 54% on the posttest.

In order to identify areas of strong and weak conceptual understanding, the eighteen questions were classified into three categories according to the following criteria:

<u>Category A</u> - questions on which five or more students received full credit.

<u>Category B</u> - questions on which five or more students received at least half credit but less than full credit.

<u>Category C</u> - questions on which the majority of students received less than half credit.

The items in each category are provided below:

<u>Category A</u>

2. Describe the Electromagnetic Spectrum.
3. What colors make up the visible region of the electromagnetic spectrum?
4. What is the difference between the thermal infrared and reflected infrared regions of the spectrum?
7. What is meant by the following terms: (a) multiband, (b) multistage, (c) multidate?

8. List four characteristics of the orbital path of the Landsat satellite:

10. Explain the terms orbital path and image center (row number).

12. What is the difference between the cultural and the natural features of our earth?

15. List some practical situations in which you may want to use remote sensing technology.

Category B

1. What is Remote Sensing?

6. What is the difference between an image and a photograph?

13. What are some advantages a[illegible]advantages of Landsat imagery when compared with [illegible]entional road maps?

18. Explain why green vegetation appears red on color infrared imagery.

Category C

5. What is meant when we say that an object has a spectral signature?

9. What are the two kinds of sensors aboard the Landsat satellite and what type of data (information) is collected by each?

11. What is a Landsat frame of data and how is this data used to produce an image?

14. What does the process of density slicing involve and what are some advantages of this process?

16. Explain why clear water appears black while water carrying sediment appears light blue on color Landsat imagery.

17. Explain why a coniferous forest usually appears darker in tone than a deciduous forest on a color Landsat image.

Students were most successful in answering those questions (Category A) that related to the physical properties of the electromagnetic spectrum and the technical aspects of the Landsat satellite. In addition, they could identify appropriate applications for the technology of remote sensing.

Students achieved marginal success on those questions in Category B which required the conceptual refinement of remote sensing terminology and phenomena.

Finally, in Category C, students experienced the greatest difficulty with questions relating to the technology of image processing and the application of scientific principles to explain observed phenomenon.

Student achievement on the Remote Sensing Content posttest may have been limited by the lengthy interval (five weeks) between instruction (Days 3, 4, and 5) and testing (Day 9). A more appropriate time for the posttest might have been the week following the instructional period; however such a strategy might have favored the assessment of the students' ability to recall rather than reflecting the students' accretion of learning. However, with respect to whether the students were able to relate an improved understanding of remote sensing, the pre and posttest means suggest a significant improvement.

Relating the purposes of the Remote Sensing Content Test to the findings, it is apparent that:

(1) students commenced the unit with a negligible conceptual background in remote sensing;

(2) the means of the pre and posttest scores increased from 8% to 54%;

(3) students were most successful in communicating their understanding of the electromagnetic spectrum and the technical aspects of the Landsat satellites; less successful in their development of an understanding of the technology of image processing and the application of scientific principles to observed phenomenon.

2. ConSAT Task Analysis

The ConSAT task was administered in order to determine whether or not elementary students can structure knowledge related to remote sensing. A list of the remote sensing items that the students were required to structure is provided in Appendix I.

An analysis of the structural representations generated by the students revealed clusters of items having some perceived commonality or interdependence. These findings were consistent with those reported by Champagne (1980b) in a similar study of 12 academically-talented seventh and

and eighth grade students. In general, the schematic representations associated with this study loosely resembled a triangular configuration with the item "Remote Sensing" at the apex. (A sample schematic representation is provided in Appendix J). It was further observed that half of the students paired the definition of remote sensing with the "Remote Sensing" item. Subsequently, eighty percent of the students proceeded to cluster the remaining items around two dimensions: (1) the "Landsat satellite" and (2) the "Electromagnetic spectrum". The preferred headings under the "Landsat satellite" domain were: orbit characteristics; scanner systems, receiving stations; Landsat frame and applications of Landsat imagery. All students clustered similar items representing regions of the electromagnetic spectrum under the second domain "Electromagnetic Spectrum".

Five of the students generated additional items which were incorporated into their respective structures. These additional items were "non-visible", "multistage", plus two additional applications of Landsat imagery.

The interviews that followed the ConSAT task revealed that those items perceived to have multiple relationships gave students the most difficulty. An illustration of this frustration can be found in the clustering of the items "Shoe Cove, Nfld." and "Prince Albert, Sask.". Some students (60%) chose to group these items under the sub-domain "Receiving Stations" while others (40%) chose to group these items under "Cultural Features".

Seventy percent of the students associated similar items under the sub-domains of "Orbit Characteristics" and "Applications of Landsat Imagery". Items relating to image processing (reception, conversion and transmission of data) were arranged less consistently.

The major findings generated by the ConSAT task include the following:

(1) Students cluster items according to their perceived commonality and interdependence.

(2) The remote sensing domain is conceptualized as consisting of two major dimensions: (1) the Landsat satellite and (2) the electromagnetic spectrum.

(3) Students share a common perception in their selection of items related to the electromagnetic spectrum.

(4) A consensus (within the first domain) exists among students with respect to the identification of clusters and the elements that comprise them. Specifically, common elements made up the "Orbit Characteristics" and "Applications of Landsat Imagery" clusters.

(5) Students encountered problems with items having multiple connotations. In some cases these items reflected a degree of conceptual ambiguity.

The ConSAT task revealed how some of the instructional experiences were interpreted by the students. The degree of consistency within these interpretations provides insight into how students structure their knowledge of remote sensing. In addition, the ConSAT task served to reveal the degree of disparity between the students' and instructor's conceptual interpretations. Alternative interpretations of the same instructional event are probable.

Students had considerable difficulty structuring items relating to image processing and had similar difficulty in answering corresponding items on the Remote Sensing Content Test. On the contrary, a consistent schematic interpretation (among students and between the students and instructor) of the electromagnetic spectrum netted a significant number of correct responses on question 2 (Describe the Electromagnetic Spectrum) of the Remote Sensing Content Test.

In summary, the ConSAT task provided students with an opportunity to discover and organize information which is "an educative exercise, over and above the sheer apprehension of facts" (Ward, 1961, p. 158).

TEST ON THE SOCIAL ASPECTS OF SCIENCE (TSAS)

The TSAS pre and posttest results provided a basis for drawing inferences about the students' perceptions of science, technology and society. A deliberate course of action was adopted by this researcher in order to minimize "teaching towards the test". Pretests were not corrected until the posttest results were accumulated. In addition, those questions reflecting the interactions among science, technology and society were not identified until after the completion of the unit.

The TSAS data generated in this study yielded pre and posttest means of 25.8 (50%) and 29.8 (57%) and pre and posttest standard deviations of 5.62 and 4.73 respectively. The decrease in the standard deviation (5.62 to 4.73) may lend support to the assumption that the remote sensing unit served as a common theme which tended to attract and focus student attention. The greater homogenity within the sample with respect to their perceptions of interrelationships among science, technology and society reflects a positive shift in student attitudes. It was also interesting to note that the posttest mean (29.8) was higher than the mean (28.3) obtained by 1494 high school students in an earlier study (Gallagher, 1969).

Three statistical treatments were performed on the TSAS data, namely:

(1) A sign test of the pre and posttest responses to the 52 TSAS items.

(2) A similar sign test on a TSAS sub-domain consisting of six items.

(3) A chi-square analysis of the shift dynamics within the previously mentioned sub-domain.

The first statistical treatment was concerned with the net directional shift of the student responses on the TSAS. Pre and posttest responses were compared to determine whether the student (on a given item) made a neutral, negative or positive shift in his or her response.

A neutral shift (0) was identified as being one that netted an unchanged status with respect to the item being right or wrong. This category therefore included student responses that reflected a consistently wrong or right position, identified as such by a comparative analysis of pre and posttest results. A negative shift (—) was identified as a response pair that shifted the student from a "right" to "wrong" status on a particular item. Conversely, a positive shift (+) was a response pair that shifted the student from a "wrong" to "right" status on a particular item. Table I provides data which reflect the net directional shift of the student TSAS responses.

TABLE I

Net Directional Shift of Student Responses on the TSAS

Student	Neutral Shift 0	Negative Shift —	Positive Shift +	Net Directional Shift
* 1	35	9	7	—
2	38	6	8	+
3	39	4	9	+
4	36	6	10	+
** 5	35	6	10	+
6	38	4	10	+
* 7	34	7	10	+
8	39	3	10	+
** 9	40	2	9	+
** 10	37	6	8	+

* no data for one item on the pretest
** no data for one item on the posttest

The results provided in Table I reveal that ninety percent of the students made more positive shifts (wrong-right) than negative shifts (right-wrong).

Under the assumption that the remote sensing unit was neutral in its net impact, the probability of a student showing a net positive shift is 0.5. Utilizing the binomial formula (sign test), the probability of nine or more than nine ($Pr\ X \geq 9$) out of ten students showing a positive shift can be computed as shown in Appendix H-2. The finding that nine out of ten students exhibited a positive shift was significant at the .01 level.

A second statistical treatment was performed on a sub-domain of the TSAS particularly relevant to this study (Research question 1.2). This sub-domain consisted of the following six items identified as being related to the interactions of science, technology and society (Aikenhead, 1979):

4. The growth of science in America would be aided by increasing our security restrictions on scientific knowledge.

12. Most of the evil in the world today is the responsibility of scientists since they have developed the knowledge that has led to such problems as nuclear weapons, pollution, etc.

28. The steam engine was one of the most important developments in the history of science.

33. Many of today's social, economic, and political problems require the use of science and technology for their solution.

37. Researchers in science use the theories and laws discovered by workers in technology.

48. In a democracy the public should ultimately control the support of science and the use of its achievements.

The responses of individual students within this sub-domain were subjected to a sign test. This analysis was consistent with the one done previously on the entire instument and reported in Table I. Table II provides the data relevant to the analysis of the TSAS science-society interaction sub-domain.

TABLE II

Sign Test of Individual Responses Within the TSAS Science-Society Interaction Sub-Domain

Student	Neutral Shift 0	Negative Shift —	Positive Shift +	Net Directional Shift
1	2	1	3	+
* 2	6	0	0	0
3	4	0	2	+
4	2	1	3	+
5	0	1	2	+
6	5	0	1	+
7	3	0	2	+
8	3	1	2	+
9	5	0	1	+
10	3	2	1	—

* The net directional shift of 0 was considered as a negative shift for statistical analysis.

Using the binomial formula to compute the probability (Pr X≥8) of such results (Appendix H-3), it was noted that a statistically significant (0.05) number of students shifted from wrong to right responses within the TSAS sub-domain dealing with the interaction of science, technology and society.

A final statistical test, enabling an analysis of the dynamics of student shifting within the science-society interaction sub-domain, was carried out using the McNemar (1969) chi-square statistic (Appendix H-4). Student responses with respect to the six item sub-domain were categorized as follows:

		Posttest right	Posttest wrong
Pretest	wrong	A	B
	right	C	D

*Results:

		Posttest right	Posttest wrong
Pretest	wrong	17	17
	right	18	6

* 58 responses - no data available for two items.

The resulting critical chi-square value of 5.26 which measures the frequency of positive shifts, approximates a probability significant at the 0.02 level.

A content analysis on four of the six items within the cluster provides a basis for the identification of areas of learning difficulty (Cooley & Klopfer, 1963). To illustrate this notion, almost half of the wrong-right (positive) shifts can be equally attributed to two questions:

28. The steam engine was one of the most important developments in the history of science;

and

33. Many of today's social, economic, and political problems require the use of science and technology for their solution.

A factor which may have contributed to a positive shift towards the "correct" answer (disagree) may have been the McGraw-Hill film entitled Science and Society. During a segment of the film illustrating a steam locomotive, the film narrator states "Changing heat energy into mechanical energy was a technological problem...". The steam engine evolved from the application of scientific principles (thermodynamics) and served to illustrate the notion of technology as applied science.

Question 33 also reflected a significant positive shift (disagree-agree) which may be due in part to the unit's emphasis on the various applications of remote sensing technology. Student reports, discussions and films addressed the role of remote sensing in resolving concrete and timely social, economic and political problems.

An examination of question 37 reveals a student misunderstanding which was retained during the course of the unit (40% of students made wrong-wrong neutral shifts).

> 37. Researchers in science use the theories and laws discovered by workers in technology.

In order to arrive at a "correct" response (disagree) for question 37, a student would have to have a clear perspective of the parameters of science and technology. Forty percent of the students were unable to associate the development of laws and theories with scientists. If this misunderstanding is to be remedied, a greater unit emphasis on the interrelationship between scientists and the evolution of theory will be required.

A final illustration of the shift dynamics within the TSAS sub-domain reveals the maintenace of a "correct" belief throughout the course of the unit. Forty percent of the students maintained the correct response (disagree) on question 12.

> 12. Most of the evil in the world today is the responsibility of scientists since they have developed the knowledge that has led to such problems as nuclear weapons, pollution, etc.

The content of the unit did little to dissuade these students from this position. One might assume that this group of students had a positive, predetermined disposition towards this item and that a curricular emphasis on developing such a notion may be unwarranted.

The inferences derived from the quantitative analysis of these four questions (28, 33, 37 and 12) serve to enhance the summative evaluation of the unit by assisting in the identification of specific areas of learning strength and weakness.

The statistically significant increase in student understanding of the interrelationships among science, technology and society contradicts the assumption that the remote sensing unit would be neutral in its net impact.

The results of the statistical analysis of the TSAS instrument are summarized in Table III.

TABLE III

Summary of the TSAS Quantitative Analysis

TSAS Domain	Statistical Treatment	Level of Significance
Net directional shift 52 items.	Sign Test	.01
Interaction of Science and Society Sub-Domain of 6 items. Individual responses.	Sign Test	.05
Interaction of Science and Society Sub-Domain of 6 items. Collective responses.	McNemar Chi-Square Test	.02

RELATIONSHIP OF QUANTITATIVE FINDINGS TO THE UNIT OBJECTIVES

The quantitative data generated by the three instruments provided a basis for assessing the extent to which specific unit objectives were attained. The Remote Sensing Content Test and the ConSAT task analysis provided the students with an opportunity to reveal their knowledge related to remote sensing and to demonstrate how they could schematically represent that knowledge. In addition, both of these instruments required the students to address the application of remote sensing technology in studying the environment. The increase in the mean (46%) between the pre and posttest results of the Remote Sensing Content Test suggests that the remote sensing unit enhanced the students' awareness and understanding of the scientific, technological and social applications of remote sensing.

The Test on the Social Aspects of Science generated statistical results which suggest that the remote sensing unit served to enhance student perceptions of the interactions among science, technology and society, the political and social responsibilities of scientists and the social nature of the scientific enterprise.

In summary, the quantitative data analysis provided a measure of the extent to which positive shifts in the cognitive and affective domains occurred. The shifts within these two domains reflected specific knowledge and value objectives, as well as the extent to which these objectives were attained.

SUMMARY

The analysis of the quantitative data suggested that elementary students can acquire and schematically represent knowledge related to remote sensing. In addition, the results of the Test on the Social Aspects of Science reflected a statistically significant positive change with respect to student perceptions of the social aspects of science. These findings led to the inference that the remote sensing unit served to enhance the attainment of specifically related knowledge and value objectives.

CHAPTER VII

SUMMARY AND CONCLUSIONS

SUMMARY

This study was undertaken for the purpose of investigating and assessing a potential role for remote sensing within the context of an integrated science-social studies curriculum at the elementary school level.

The author proceeded to develop, implement and evaluate a unit on remote sensing. The development phase of the unit reflected a consideration of the procedures for integrating science and social studies outlined in the Kirman-Nay (1975) model. In addition, the development of the unit was guided by the conceptual parameters of the Alberta (1981) elementary science and social studies curricula as well as the principles associated with the science-technology-society movement in education.

The implementation stage spanned twelve weeks and involved a sample of ten academically-talented grade six students. During this phase of the study the author adopted the role of "teacher" and utilized a variety of teaching strategies and materials which were intended to enhance the attainment of the unit's objectives. The overall objective of the unit was to develop an awareness and understanding of scientific and technological aspects of remote sensing and to relate this knowledge to a contemporary social issue, namely, the eruption of the Mt. St. Helens volcano.

Finally, the evaluation phase utilized qualitative and quantitative data in order to generate inferences with respect to the unit's cognitive and affective impact on the students. The qualitative data base consisted of the various perceptions provided by four categories of participants: the students, the regular classroom teacher, the researcher and personnel associated with the Alberta Remote Sensing Center. The quantitative data was generated by three instruments: the Remote Sensing Content Test, the ConSAT task analysis and the <u>Test on the Social Aspects of Science</u>. These evaluation instruments purported, in turn, to measure:

(1) the awareness and understanding of scientific, technological and social aspects of remote sensing.

(2) the extent to which students can develop a schematic representation of their remote sensing knowledge which reflects their cognitive learning.

(3) the degree to which students recognize and understand the interrelationships among science, technology and society.

The qualitative and quantitative findings provided a basis for generating inferences concerned with the research questions posed and the extent to which the objectives of the unit were attained.

FINDINGS AND CONCLUSIONS

The qualitative and quantitative findings generated by the strategies outlined above are provided in Chapters V and VI respectively. This section will present and discuss these findings in relation to the research questions and the specific objectives of the unit.

Relationship of Findings to Research Questions

With respect to the specific research questions posed in Chapter I, the findings suggest that:

(1) elementary students were capable of acquiring and structuring knowledge related to remote sensing.

(2) the remote sensing unit appeared to influence, in a positive direction, the development of understanding with respect to the interrelationships among science, technology and society.

(3) the remote sensing unit served as a medium for integrating some of the major concepts of the elementary science curriculum. In addition, remotely sensed data products enhanced the decision-making process of an appropriate social enquiry. These dual functions of remote sensing served to manifest its role as an interfacing medium between the subject areas of science and social studies.

(4) student participants viewed the remote sensing unit as a stimulating experience and perceived a positive correlation between their level of motivation and degree of learning.

Discussion

The findings that relate to specific research questions and which led to the preceding conclusions form the substance of the following discussion.

1.1 Can elementary students acquire and structure knowledge related to remote sensing?

The qualitative data revealed that the students perceived that they had learned a great deal (by the end of the unit). These perceptions were reflected by the student responses on a questionnaire (independent of the study) and were corroborated by the perceptions of the classroom teacher, the researcher and personnel associated with the Alberta Remote Sensing Center.

An additional finding that had implications for the extent to which the students acquired knowledge relating to remote sensing was the increase of 46% in the mean (between the pre and posttest) of the Remote Sensing Content Test. Finally, student performance on the ConSAT task analysis indicated that they were capable of constructing and explaining a schematic conceptualized structure consisting of a number of items related to remote sensing. The results of the ConSAT analysis technique (in addition to demonstrating that students could structurally represent their remote sensing knowledge) also implied a positive correlation between items on the ConSAT Task and the Remote Sensing Content Test. The data analysis suggested that items that were difficult for the students to structurally represent corresponded to items on the Remote Sensing Content Test that were poorly answered and vice versa.

1.2 Does student awareness and understanding of scientific, technical and practical aspects of remote sensing enhance the development of their understanding of the relationships among science, technology and society?

Students were able to consider research questions from more than one perspective. They demonstrated this ability when they identified various combinations of scientific, technological and social implications for specific research topics. In addition, this ability to recognize multiple implications of the same issue was manifest in student reports which applied scientific and technological aspects of remote sensing to a social context. The application of remote sensing in science-related social issues was repeatedly reinforced by the NASA film series entitled Landsat: A Satellite For All Seasons.

A quantitative analysis of the Test on the Social Aspects of Science data reflected a decrease in standard deviation from 5.62 to 4.73 (between the pre and posttest). This decrease in standard deviation may have implications regarding the potential of the remote sensing unit to attract and focus student attention on the social aspects of science. An additional finding generated by the TSAS results reflected a statistically significant change ($p = .02$) in a positive direction with respect to student understanding of the interrelationships among science, technology and society.

2. Can the technology of remote sensing serve as an interfacing medium in the context of integrated scientific and social inquiry?

The qualitative findings suggest that remotely sensed information can enhance the basis on which informed decisions are made. Students utilized such information in assessing the environmental, economic, and social impact of the Mt. St. Helens eruption. In addition, the concept of remote sensing demonstrated its potential as an interface for the major elements of the Alberta (1980) elementary science curriculum. The findings suggest that when these elements are applied to an appropriate science-related social issue, a potential interface between the subject areas of science and social studies may be realized.

In identifying an "appropriate" science-related social issue the author considered the availability, relevance and potential application of the remotely sensed data for the topic of consideration. The eruption of the Mt. St. Helens volcano was selected as a topic in this study because of its timeliness, magnitude and potential motivational impact. In addition, there existed a variety of support materials (imagery and references) enabling a consideration of the topic's scientific, technological and social implications.

3. What effect does remote sensing have on student motivation?

The findings that relate to this question were based upon data reported in Chapter IV and discussed in Chapter V. The data consisted of quotations from student journals as well as observations of student behavior recorded by the classroom teacher and researcher. The findings suggest that the students maintained a high level of interest and enthusiasm throughout the duration of the unit. With reference to the student journals, it was observed (after completion of the study in order to minimize contamination of the data) that the students' daily log entries tended to describe what they had done, rather than reflect how they felt about what they did. This observation suggests that students at this level may require prior instruction and practice in recording their perceptions and feelings.

The researcher identified a number of potential reasons for the high level of student motivation:

(1) the "halo" effect associated with membership of a research sample.

(2) the extent to which the students perceived the remote sensing unit to be relevant, significant and challenging.

(3) the unit's "space age" emphasis on the technology of satellite reconnaissance.

(4) the students' perceptions of, and responsiveness to, the researcher as a "teacher".

Given the preceding discussion of the relationship of the findings with respect to the four research questions, certain inferences may be drawn with respect to the central research question, "Is the concept of remote sensing appropriate for elementary students?". In order to be deemed "appropriate", the concept of remote sensing should: (1) be within the cognitive ability of the students; (2) be compatible with prescribed curricula; and (3) be sufficiently motivating to enhance the achievement of desirable learning outcomes. The findings suggest that the achievement of the above criteria was feasible with a sample of grade six academically-talented students.

Relationship of Findings to Unit Objectives

A discussion of the qualitative and quantitative data in relation to the unit objectives is provided in Chapters V and VI respectively. The findings that reflect the attainment of certain knowledge and value objectives have been previously discussed in relation to specific research questions. Specific reference is made to those findings that reflect (1) the acquisition and application of science-related remote sensing knowledge and (2) the development of understanding with respect to the interrelationships among science, technology and society. It suffices to say that the findings suggest the remote sensing unit had a positive influence on these aspects of cognitive and affective learning.

The author perceived the strategy requiring the students to research and present reports to be instrumental in facilitating the attainment of the knowledge, value and skill objectives outlined in Chapter IV. It should be noted that the students possessed the prerequisite research skills required to develop and organize comprehensive research reports. In addition to these research skills, the students made effective use of their verbal and written communication skills in class discussion, debate and in the writing and presentation of research reports. These incoming research and communication skills enabled the students to be effective "teachers" as well as learners. The student reports provided a medium for generating and sharing information, provoking discussion and enhancing student awareness of their potential for self-directed learning.

IMPLICATIONS

Curricular Implications

The findings generated by this study indicate that prior instruction in the scientific and technological aspects of remote sensing can enhance the utility of remotely sensed data in the classroom.

In terms of the instruments utilized in this study, the results of the Test on the Social Aspects of Science (TSAS) suggest a potential use for this instrument with grades below the secondary level. In addition, the results generated by the ConSAT Task provided a window for "'looking into' what and how" students think (Champagne, et al, 1980a, p. 27), as well as an additional perspective on the unit's cognitive impact. The ConSAT findings further implied that conceptualized schematic representations of knowledge may serve to reflect areas of learning strength and weakness.

The findings also have implications for the pedagogical application of principles associated with the science, technology and society movement in education. Future curricular development in this area may consider the potential of technology as an interfacing medium between science and society, as well as the significance of selecting an appropriately "real" context in which the chosen technology is to be applied.

With respect to the education of the academically-talented, this study has provided the results and implications of a number of teaching strategies as well as some student perceptions which may be relevant to "gifted" education.

Finally, this study has translated a procedural model (Kirman and Nay, 1975) for the integration of science and social studies into practice and has served to demonstrate how these seemingly disparate subject areas can be mutually enhanced by the technology of remote sensing. This mutual enhancement was facilitated by the free flow of compatible ideas between the two subject areas.

Implications for Further Research

This study has by no means exhausted the potential resources for assessing the appropriateness of remote sensing in an elementary curricular context. Future research may well consider replication of the present study or alternative implementation and evaluation strategies, curricular contexts, and/or sample parameters.

As well as variations of the present study, the following related considerations warrant further study:

(a) The ConSAT Task Analysis

To what extent is the ConSAT task analysis technique dependent upon the developmental stage of the child?

(b) Test on the Social Aspects of Science

What potential does the TSAS instrument have for grades other than those associated with the secondary level?

What alternative treatments manifest the

TSAS shift dynamics similar to those generated by this study?

CONCLUDING STATEMENT

Society is becoming increasingly aware that we are simply one people on one planet. Coupled with this realization is a growing public concern regarding the ability of science and technology to resolve the global problems that face mankind. This concern is manifest by the increasing public participation in the decision-making process. If future decisions are to be made on an informed basis by an informed public, an appreciation of the interrelationships between science and society may serve to enhance the basis for such decisions. This study represents a curricular response to the increasing alienation of society towards the symbionic association of science and technology.

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APPENDIX A

Scale for Rating Behavioral Characteristics of Superior Students

SCALE FOR RATING BEHAVIORAL CHARACTERISTICS OF SUPERIOR STUDENTS

NAME ______________________ DATE ______________________

SCHOOL ______________________ GRADE _____ AGE ______________
Years Months

Teacher or person completing this form ______________________

How long have you known this child? ____________ Months

DIRECTIONS - These scales are designed to obtain teacher estimates of a student's characteristics in the areas of learning, motivation, creativity, and leadership. The items are derived from the research literature dealing with characteristics of gifted and creative persons. It should be pointed out that a considerable amount of individual differences can be found within this population, and therefore, the profiles are likely to vary a great deal. Each item in the scales should be considered separately and should reflect the degree to which you have observed the presence or absence of each characteristic. Since the four dimensions of the instrument represent relatively different sets of behaviors, the scores obtained from the separate scales should not be summed to yield a total score. Please read the statements carefully and place an X in the appropriate place according to the following scale of values:

1. If you have seldom or never observed this characteristic.
2. If you have observed this characteristic occasionally.
3. If you have observed this characteristic to a considerable degree.
4. If you have observed this characteristic almost all of the time.

Space has been provided following each item for your comments.

SCORING - Separate scores for each of the three dimensions may be obtained as follows:

.... Add the total number of X's in each column to obtain the "Column Total".

.... Multiply the Column Total by the "Weight" for each column to obtain the "Weighted Column Total".

.... Sum the Weighted Column Totals across to obtain the "Score" for each dimension of the scale.
.... Enter the scores below.

Learning Characteristics .... ____________________

Motivational Characteristics ..... ____________________

Creativity Characteristics .... ____________________

Leadership Characteristics .... ____________________

PART 1: LEARNING CHARACTERISTICS

	1 2 3 4 *
1. Has unusually advanced vocabulary for age or grade level; uses terms in a meaningful way; has verbal behavior characterized by "richness" of expression, elaboration, and fluency.	_ _ _ _
2. Possesses a large storehouse of information about a variety of topics (beyond the usual interests of youngsters his age).	_ _ _ _
3. Has quick mastery and recall of factual information.	_ _ _ _
4. Has rapid insight into cause-effect relationships; tries to discover the how and why of things; asks many provocative questions (as distinct from informational or factual questions); wants to know what makes things (or people) "tick".	_ _ _ _

* 1 - Seldom or never
2 - Occasionally
3 - Considerably
4 - Almost Always

	1 2 3 4 *
5. Has a ready grasp of underlying principles and can quickly make valid generalizations about events, people, or things; looks for similarities and differences in events, people, and things.	___ ___ ___ ___
6. Is a keen and alert observer; usually "sees more" or "gets more" out of a story, film, etc. than others.	___ ___ ___ ___
7. Reads a great deal on his own; usually prefers adult level books; does not avoid difficult material; may show a preference for biography, autobiography, encyclopedias, and atlases.	___ ___ ___ ___
8. Tries to understand complicated material by separating it into its respective parts; reasons things out for himself; sees logical and common sense answers.	___ ___ ___ ___
Column Total	___ ___ ___ ___
Weight	1 2 3 4
Weighted Column Total	___ ___ ___ ___
Total	___

* 1 - Seldom or never
2 - Occasionally
3 - Considerably
4 - Almost Always

1 2 3 4 *

PART 11: MOTIVATIONAL CHARACTERISTICS

1. Becomes absorbed and truly involved in certain topics or problems; is persistent in seeking task completion. (It is sometimes difficult to get him to move on to another topic.) ____

2. Is easily bored with routine tasks. ____

3. Needs little external motivation to follow through in work that initially excites him. ____

4. Strives toward perfection; is self critical; is not easily satisfied with his own speed or products. ____

5. Prefers to work independently; requires little direction from teachers. ____

6. Is interested in many "adult" problems such as religion, politics, sex, race - more than usual for age level. ____

7. Often is self assertive (sometimes even aggressive); stubborn in his beliefs. ____

8. Likes to organize and bring structure to things, people, and situations. ____

* 1 - Seldom or never
2 - Occasionally
3 - Considerably
4 - Almost Always

1 2 3 4 *

9. Is quite concerned with right and wrong, good and bad; often evaluates and passes judgment on events, people, and things. ____ ____ ____ ____

Column Total ____ ____ ____ ____

Weight 1 2 3 4

Weighted Column Total ____ ____ ____ ____

Total ____

PART 111: CREATIVITY CHARACTERISTICS

1. Displays a great deal of curiosity about many things; is constantly asking questions about anything and everything. ____ ____ ____ ____

2. Generates a large number of ideas or solutions to problems and questions; often offers unusual ("way out"), unique, clever responses. ____ ____ ____ ____

3. Is uninhibited in expressions of opinion; is sometimes radical and spirited in disagreement; is tenacious. ____ ____ ____ ____

4. Is a high risk taker; is adventurous and speculative. ____ ____ ____ ____

* 1 - Seldom or never
2 - Occasionally
3 - Considerably
4 - Almost Always

1 2 3 4 *

5. Displays a good deal of intellectual playfulness; fantasizes; imagines ("I wonder what would happen if..."); manipulates ideas (i.e., changes, elaborates upon them); is often concerned with adapting, improving and modifying institutions, objects, and systems. _ _ _ _

6. Displays a keen sense of humor and sees humor in situations that may not appear to be humorous to others. _ _ _ _

7. Is unusually aware of his impulses and more open to the irrational in himself (freer expression of feminine interest for boys, greater than usual amount of independence for girls); shows emotional sensitivity. _ _ _ _

8. Is sensitive to beauty; attends to aesthetic characteristics of things. _ _ _ _

9. Is nonconforming; accepts disorder; is not interested in details, is individualistic; does not fear being different. _ _ _ _

10. Criticizes constructively; is unwilling to accept authoritarian pronouncements with critical examination. _ _ _ _

* 1 - Seldom or never
2 - Occasionally
3 - Considerably
4 - Almost Always

Column Total	___ ___ ___ ___
Weight	1 2 3 4
Weighted Column Total	___ ___ ___ ___
Total	___

PART IV: LEADERSHIP CHARACTERISTICS 1 2 3 4 *

1.	Carries responsibility well; can be counted on to do what he has promised and usually does it well.	___ ___ ___ ___
2.	Is self confident with children his own age as well as adults; seems comfortable when asked to show his work to the class.	___ ___ ___ ___
3.	Seems to be well liked by his classmates	___ ___ ___ ___
4.	Is cooperative with teacher and classmates; tends to avoid bickering and is generally easy to get along with.	___ ___ ___ ___
5.	Can express himself well; has good verbal facility and is usually well understood.	___ ___ ___ ___

* 1 - Seldom or never
2 - Occasionally
3 - Considerably
4 - Almost Always

		1 2 3 4 *
6.	Adapts readily to new situations; is flexible in thought and action and does not seem disturbed when the normal routine is changed.	_ _ _ _
7.	Seems to enjoy being around other people; is sociable and prefers not to be alone.	_ _ _ _
8.	Tends to dominate others when they are around; generally directs the activity in which he is involved.	_ _ _ _
9.	Participates in most social activities connected with the school; can be counted on to be there if anyone is.	_ _ _ _
10.	Excells in athletic activities; is well coordinated and enjoys all sorts of athletic games.	_ _ _ _
	Column Total	_ _ _ _
	Weight	1 2 3 4
	Weighted Column Total	_ _ _ _
	Total	___

* 1 - Seldom or never
2 - Occasionally
3 - Considerably
4 - Almost Always

APPENDIX B

Remote Sensing
Content Test

NAME____________________

DATE____________________

SCIENTIFIC, TECHNOLOGICAL AND SOCIAL IMPLICATIONS OF REMOTE SENSING

1. What is Remote Sensing?____________________ (2)

2. Describe the Electromagnetic Spectrum____________________ (2)

3. What colors make up the visible region of the electromagnetic spectrum?____________________ (2)

4. What is the difference between the thermal infrared and reflected infrared regions of the spectrum?____________________ (2)

5. What is meant when we say that an object has a spectral signature?____________________ (2)

6. What is the difference between an image and a photograph? ____________________

____

____

____________________ (2)

7. What is meant by the following terms?

(a) multiband ____________________

____

(b) multistage ____________________

____

(c) multidate ____________________

____________________ (3)

8. List four characteristics of the orbital path of the Landsat satellite:

(a) ____________________

(b) ____________________

(c) ____________________

(d) ____________________ (2)

9. What are the two kinds of sensors aboard the Landsat satellite and what type of data (information) is collected by each?

____

____

____________________ (2)

10. Explain the terms orbital path and image center (row number). ____________________

____________________ (2)

11. What is a Landsat frame of data and how is this data used to produce an image?________________________

____

____ (2)

12. What is the difference between the cultural and the natural features of our earth?____________________

____

____ (2)

13. What are some advantages and disadvantages of Landsat imagery when compared with conventional road maps?

____

____

____ (2)

14. What does the process of density slicing involve and what are some advantages of this process?____________

____

____

____ (2)

15. List some practical situations in which you may want to use remote sensing technology.____________________

____

____

____ (2)

16. Explain why clear water appears black while water carrying sediment appears light blue on color Landsat imagery.

____

____ (1)

17. Explain why a coniferous forest usually appears darker in tone than a deciduous forest on a color Landsat image.____

____

____ (1)

18. Explain why green vegetation appears red on color infrared imagery.____

____

____

____ (2)

Total = $\frac{\quad}{35}$ = ___%

APPENDIX C

Test on the
Social Aspects
of Science

TEST ON THE SOCIAL ASPECTS OF SCIENCE*

On the following pages there is a list of statements about the relationship among science, technology, and society. After reading each statement carefully, mark ON THE ANSWER SHEET the response which indicates your evaluation of the statement:

A. if you strongly AGREE with the statement

B. if you AGREE but have some reservations

C. if you don't understand the meaning

D. if you DISAGREE but have some reservations

E. if you strongly DISAGREE with the statement

Use only a pencil.

Give only one response to each statement.

Answer every question.

Please do not mark these pages in any way.

*Adapted from: Korth, Willard W. "The Use of the History of Science to Promote Student Understanding of the Social Aspects of Science." Unpublished Doctoral Thesis, Stanford University, 1968.

TEST ON THE SOCIAL ASPECTS OF SCIENCE

	agree			disagree	
1. The many changes our culture is undergoing today have largely been caused by advances in science and technology.	A	B	C	D	E
2. Statements are not accepted as scientific knowledge unless they are absolutely true.	A	B	C	D	E
3. Scientists have advanced knowledge by consistently following, step by step, a definite procedure called the scientific method.	A	B	C	D	E
4. The growth of science in America would be aided by increasing our security restrictions on scientific knowledge.	A	B	C	D	E
5. Scientists should be concerned with the potential harm that might result from their discoveries.	A	B	C	D	E
6. The most important requirement for the continued progress of science is large sums of money for scientific research.	A	B	C	D	E
7. The judgment of scientists on political matters should be highly respected since they are likely to approach such problems with a scientific attitude.	A	B	C	D	E
8. It is extremely difficult to anticipate how new scientific knowledge may affect society.	A	B	C	D	E
9. The primary objective of the working scientist is to improve human welfare.	A	B	C	D	E
10. The scientist should attempt to report his findings to the general public in a manner that the layman can understand.	A	B	C	D	E

	agree			disagree	
11. Winning the esteem of his associates is one of the main incentives of the scientist.	A	B	C	D	E
12. Most of the evil in the world today is the responsibility of scientists since they have developed the knowledge that has lead to such problems as nuclear weapons, pollution, etc.	A	B	C	D	E
13. Scientists are strongly influenced by the attitude and interests of the general public.	A	B	C	D	E
14. A scientist is likely to be unbiased and objective, not only in his own field of work, but in other areas as well.	A	B	C	D	E
15. A scientist is expected to share the knowledge he discovers with other scientiests rather than use it exclusively for his own profit.	A	B	C	D	E
16. Modern science is too complicated for the average citizen to understand and appreciate it.	A	B	C	D	E
17. The increased use of automation and computers will probably reduce the need for people trained in science.	A	B	C	D	E
18. Most scientists are not interested in public recognition for their discoveries.	A	B	C	D	E
19. Although advance in science and technology may improve living conditions they offer little help in solving today's social problems.	A	B	C	D	E
20. Since scientists are a rather select group, the educational level of the rest of the people has little effect on a nation's scientific achievements.	A	B	C	D	E
21. Because of the high cost of scientific research it would seem wise to cut down on research that does not appear to have any practical value.	A	B	C	D	E

	agree			disagree	
22. The principal aim of science is to provide the people of the world with the means for living better lives.	A	B	C	D	E
23. The economic prosperity of most nations today depends on their ability to discover and use scientific knowledge.	A	B	C	D	E
24. Science is primarily a method for inventing new devices.	A	B	C	D	E
25. Scientists are usually more poorly informed on political matters than other educated citizens since their work tends to isolate them from the rest of society.	A	B	C	D	E
26. In modern industrial societies science and technology have little to do with each other.	A	B	C	D	E
27. Scientists often question established social and political ideas. This is true because most scientists are political radicals and atheists.	A	B	C	D	E
28. The steam engine was one of the most important developments in the history of science.	A	B	C	D	E
29. Science would advance more efficiently if it were more closely controlled by the government.	A	B	C	D	E
30. Many of the scientific theories of the past have been disproved or modified as they have been found inadequate. However, the theories and laws of modern science are accurate and are likely to endure in their present form.	A	B	C	D	E
31. A scientist should withhold a discovery from the world if he thinks it may have undesirable social consequences.	A	B	C	D	E
32. A great research scientist is usually little concerned with the practical applications of his work.	A	B	C	D	E

	agree			disagree	
33. Many of today's social, economic, and political problems require the use of science and technology for their solution.	A	B	C	D	E
34. The greatest accomplishments of science consist of the many useful products it has produced.	A	B	C	D	E
35. The principal function of scientific societies is to promote the exchange of ideas.	A	B	C	D	E
36. The free flow of scientific information among scientists is essential to scientific progress.	A	B	C	D	E
37. Researchers in science use the theories and laws discovered by workers in technology.	A	B	C	D	E
38. The political climate of a nation has little effect upon its scientists since they are pretty much isolated from the rest of society.	A	B	C	D	E
39. Scientists have no business investigating topics that may question people's religious beliefs.	A	B	C	D	E
40. Social and economic changes will probably be needed to keep pace with the rapid advance of science and technology.	A	B	C	D	E
41. Communication between scientists and the public is essential if the voting public and the national leaders are to make wise decisions on important issues.	A	B	C	D	E
42. Most scientists are reluctant to share their findings with foreigners because of the danger of exposing secret scientific information.	A	B	C	D	E
43. The aim of science is to increase man's knowledge of the physical and biological world.	A	B	C	D	E

agree — disagree

44. Technology often provides the tools and techniques that lead to new discoveries in science. A B C D E

45. The scientific investigation of human behavior is of little value since it must involve the personal opinion of the investigator. A B C D E

46. The honesty and accuracy commonly attributed to scientists' reports of their work is largely due to the fact that scientists as a group tend to be more honest than other types of people. A B C D E

47. New scientific knowledge affects society only through the practical use made of it. A B C D E

48. In a democracy the public should ultimately control the support of science and the use of its achievements. A B C D E

49. It would be a good idea to slow down science until society has had a chance to adjust to the changes science has brought about. A B C D E

50. The scientist generally has little control over the use society may make of his discoveries. A B C D E

51. A fundamental rule of science is that discoveries should have some practical value. A B C D E

52. Many of today's social and political problems are related to science and technology. Since scientists are experts in this field we should accept their judgment in such matters. A B C D E

TEST ON THE SOCIAL ASPECTS OF SCIENCE

(TSAS)

ANSWER KEY

A. if you strongly AGREE with the statement

B. if you AGREE but have some reservations

C. if you don't understand the meaning

D. if you DISAGREE but have some reservations

E. if you strongly DISAGREE with the statement

1. a - b
2. d - e
3. d - e
4. d - e
5. a - b
6. d - e
7. d - e
8. a - b
9. d - e
10. a - b
11. a - b
12. d - e
13. a - b
14. d - e
15. a - b
16. d - e
17. d - e
18. d - e
19. d - e
20. d - e
21. d - e
22. d - e
23. a - b
24. d - e
25. d - e
26. d - e
27. d - e
28. d - e
29. d - e
30. d - e
31. d - e
32. a - b
33. a - b
34. d - e
35. a - b
36. a - b
37. d - e
38. d - e
39. d - e
40. a - b
41. a - b
42. d - e
43. a - b
44. a - b
45. d - e
46. d - e
47. d - e
48. a - b
49. d - e
50. a - b
51. d - e
52. d - e

APPENDIX D

Locating Specific Orbital Path and Image Center Numbers

NAME ____________________

DATE ____________________

LOCATING SPECIFIC ORBITAL PATH AND IMAGE CENTER NUMBERS

1. Connect the town to the correct map location.

2. Beside each town list the orbital path number and image center number that would place the town as close to the image center as possible.

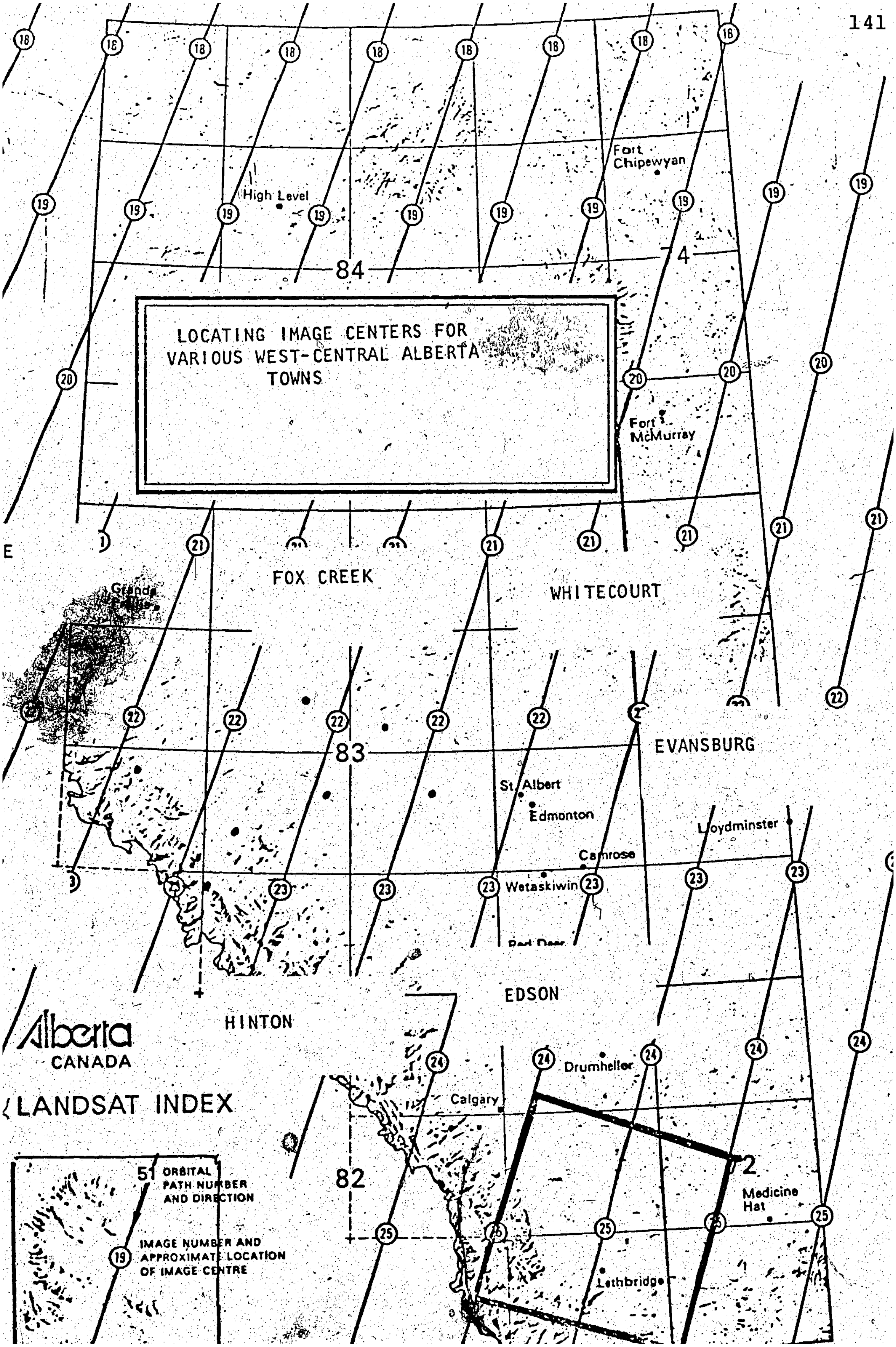
EXAMPLE	ORBITAL PATH NUMBER	IMAGE NUMBER
Lethbridge	44	25
Jasper		
Hinton		
Grande Cache		
Edson		
Evansburg		
Whitecourt		
Fox Creek		
Edmonton		

3. Approximately how many overlapping images are required to cover Alberta?

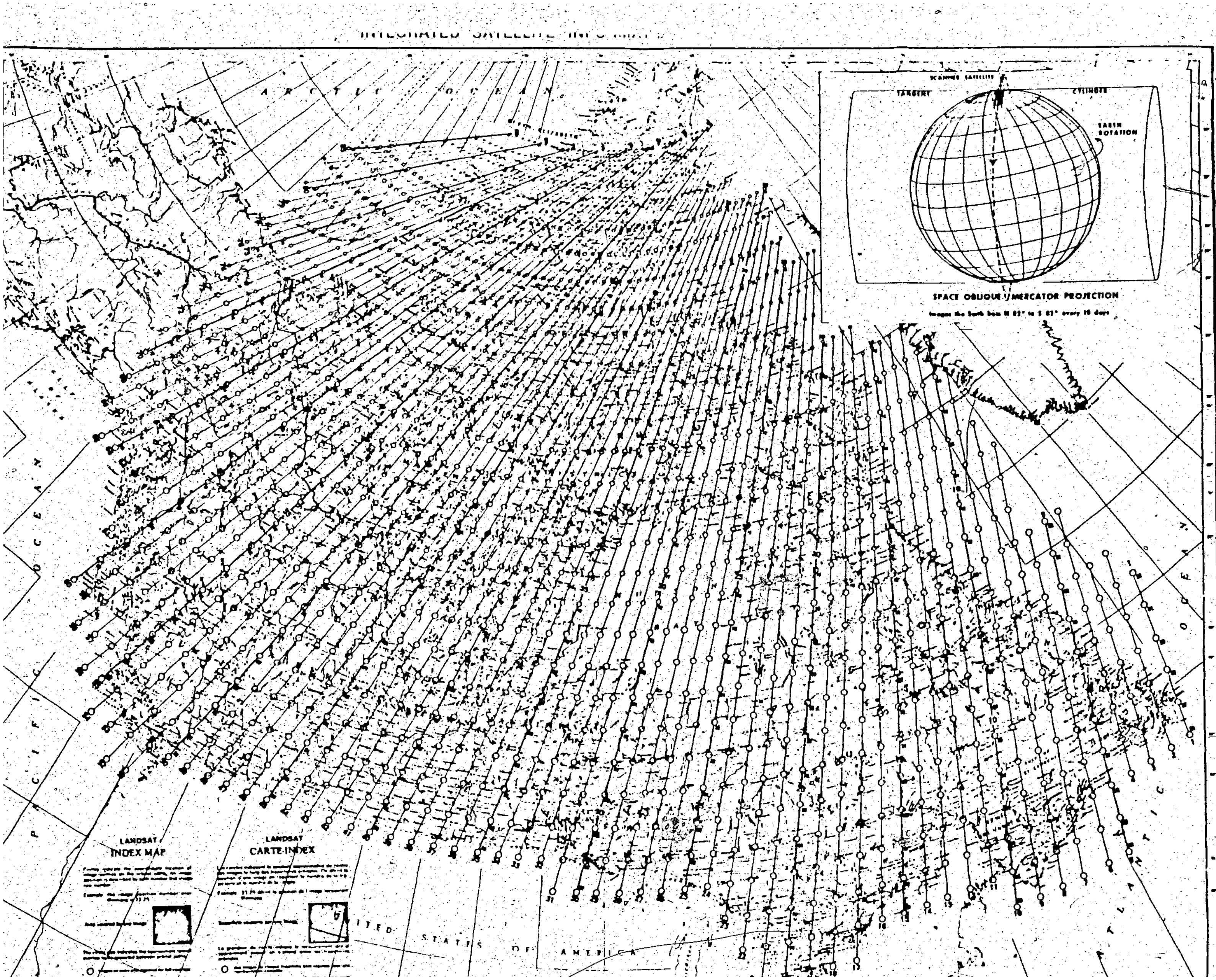
4. Why must the images overlap?

5. How many images would be necessary to study the area which would include all the towns listed in question 2?

6. Study the orbital path numbered map for all of Canada. What is the lowest orbital path number in Canada? ____________. What is the highest orbital path number in Canada? ____________.


LOCATING IMAGE CENTERS FOR
VARIOUS WEST-CENTRAL ALBERTA
TOWNS
FOX CREEK
WHITECOURT
EVANSBURG
EDSON
HINTON
Alberta
CANADA
LANDSAT INDEX
51 ORBITAL PATH NUMBER AND DIRECTION
19 IMAGE NUMBER AND APPROXIMATE LOCATION OF IMAGE CENTRE
84
83
82
High Level
Fort Chipewyan
Fort McMurray
St. Albert
Edmonton
Lloydminster
Camrose
Wetaskiwin
Drumheller
Calgary
Medicine Hat
Lethbridge

FINE PRINT



LANDSAT IMAGERY

This map locates the complete pattern of orbital tracks and fixed centres along the World (Fleming) System for all image data recorded over Canada by the Landsat satellites. Any point in Canada is located by reference to its nearest track and frame numbers EG:

	TR	FR
Calgary	45	24
Whitehorse	64	17

For ordering purposes, please use the following method:

(1) Choose the tracks and frame numbers you need.

(2) Consult the enclosed Landsat-1 and Landsat-2 timetables and list the cycles which cover the time-frame for which you are ordering the imagery.

EG:

CYCLE	DAY	TR	FR	LS2
9	17	45	24	

locates Calgary on 18/7/75.

APPENDIX E

Introduction to Remote Sensing

INTRODUCTION TO REMOTE SENSING

This kit contains 58 slides, explanatory tape plus typed script and provides general background information on Remote Sensing.

Title Slide - shows the Landsat Satellite plus color aerial and Landsat imagery photographs.

Slide 1 - This is the first air photograph taken in Canada in 1883 at Halifax, Nova Scotia. This photo was taken from a balloon by the British Army stationed there. The balloon was tied to the ground. What we see here is part of the British military camp. We can see highly reflective sandy roads, the barracks and a horse-drawn vehicle moving along the road.

Slide 2 - Almost 100 years have passed and this is what the type of imagery we get now in 1979. This is a colour composite image taken at 720 kilometres or 572 miles showing an area covering 13,000 square miles. This is a Landsat image. This particular image is an area showing Edmonton and Beaver Hill Lakes.

Slide 3 - The third slide depicts a homing pigeon carrying a small camera. Before the first aircraft was flown in 1903, aerial photography was attempted using carrier pigeons and balloons. The pigeons were equipped with small cameras containing 20 frame film. The pigeons were released from the home nest beyond the target area. A clockwork mechanism triggered the camera when they hoped the pigeon would be over the desired target area.

Slide 4 - Here we see an actual photograph of a homing pigeon taken in Germany with a camera attached.

Slide 5 - This is a balloon used by the Canada Center for Remote Sensing and purchased from France. They suspended a camera from a wire attached to the balloon. This was a captive balloon used for stationary aerial photography. It was used in traffic engineering -- for example, to photograph a busy intersection over a period of hours. The photographs could then be studied to determine traffic flow.

Slide 6 - Here we have displayed one of the many definitions of remote sensing. It is the detection, identification and evaluation of objects by aerial sensing devices. This definition can apply to black and white, colour and thermal photography. Remote Sensing is really just studying something at a distance and it could involve the use of a camera, a telescope or binoculars. Such equipment that we've just mentioned would enable us to detect and identify features. Features like treetops, stream pollution, rock formations and so on. The evaluation component of the definition attempts to determine "Is there pollution? What types of trees exist? What kinds of rock formations exist?" This detection, identification, and evaluation is done on objects. Now the word "object" could refer to a stream, or to the pollution that goes into a stream. Or it could be an entire town. Generally, however, we group objects into features. A feature is usually made up of many objects. For example, an oil refinery complex. This is called a cultural feature (one that is man made) and each of the various tanks and towers in the complex could be referred to as an object within the feature. In nature we find natural features like hills, valleys, streams and mountains; all of which are made up of various objects, e.g. rocks, crevices, trees or rapids.

Now this detection, identification and evaluation of objects is carried out by aerial sensing devices. Note we say devices, not just cameras. You see, remote sensing involves more than just the use of cameras and film within the visible portion of the spectrum. We now can use wave bands within the visible spectrum and beyond the visible spectrum. Some of the remote sensing devices, in fact, are non-photographic. They don't involve cameras or film. The Landsat satellite, for example, doesn't use a camera and film combination. It uses a scanner that picks up reflective light energy which is passed through a series of prisms and then is microwaved (telemetered) to a ground receiving station. Technically speaking, Landsat does not produce photographs, but rather images that resemble photographs. Thus we see that a wide variety of devices, not just cameras can be used in remote sensing.

Slide 7 - Multiband. This means the recording of various features of an area in many wave length bands in and beyond the visible spectrum. Let's take a look, for example, at the visible spectrum which is made up of the same colours that the rainbow is made up of. Suppose we take a filter and attach it to the outside of the camera and this filter blocks all of the light except say, the green portion of the spectrum. That is, we would only allow the green wave length of light to penetrate the filter and to reach the film. This is what we mean by multiband. Or we could use a red filter to block all light except the red from reaching the film. Or we could use an infrared film which is sensitive to wavelengths of light just beyond what the eye can see. The Landsat scanner, for example, breaks up the reflective light it receives into four different wavebands, one in the green, one in the red, and two in the near infrared regions of the spectrum. This is all done simultaneously. Thus, using these four different wavebands, we can obtain much more information about an area from a variety of wavebands than you can in just one waveband.

Slide 8 .- Shown here is a diagram of the electromagnetic spectrum. The spectrum extends from very short wavelengths for gamma rays and x-rays up to long wavelengths for radio waves. You can see that the part of the spectrum which affects our eyes and which we all call light is only a very small part of the whole spectrum. On each side of this visible part of the spectrum is an area which is very close to being visible. The border between visibility and non-visibility varies from one individual to the next and some people can see a little further into these regions than others. On the shorter wavelength side, that is to the left, we have the ultraviolet rays. These are the rays which give us a tan in the summer time. At the long wavelength end, on the right of the spectrum, we have the infrared rays and they give us the sensation of heat. All of these rays, from the gamma rays to the radio waves are emitted by the sun, but much of this radiation is absorbed by the earth's atmosphere as it passes through it. This is fortunate for us because we would have all been burnt to death long ago. As you are aware, the light that we see is made up of many colours; violet, blue, green, yellow, orange and red. These colours make up what we call the visible portion of the spectrum. Just as we can measure waves of water, we can also measure light waves. Light waves are measured in micrometers, where one micrometer is equal to one millionth of a meter. Examine the visible spectrum shown on the slide. Note that the visible spectrum ranges from .4 up to .7 micrometers. This small part of the vast spectrum of electromagnetic radiation is the <u>only</u> part that we can use to transmit messages to our brain through our eye. However, the camera film is able to record images over a much wider range. It can make use of both the ultraviolet and near infrared regions. Other types of sensors are capable of detecting even longer wavelengths such as those further out in the infrared known as the thermal infrared region. And also into the microwave region that is used in radar. We are all used to seeing things in colour. The differences in colour we see are due to the differences in wavelength of the light reaching our eyes. Looking at the visible spectrum again, if light with a wavelength of about .45 micrometers strikes the retina behind our eyes, we see a flash of what colour of light? You're right if you said blue light. If light with a wavelength of approximately .7 micrometers strikes our eyes we would see what colour of light? You're right if you said red light. And so the procedure continues. Each wavelength gives us a different piece of information when the message reaches our brain. This explains why different lights give different colours. Sodium lamps, which are often used around airports are bright orange yellow. What wavelength of light are sodium lamps emitting? You're right if you said about .58 micrometers.

Slide 9 - The next two slides show pictures of the airborne unit of the Canada Remote Sensing Center. The first slide is of a CF 100 which was used for aerial remote sensing.

Slide 10 - Our second slide is of a C47 Dakota which was a low level aircraft also used in the past by the Canada Center for Remote Sensing. We will now examine various examples of conventional photography. You will see examples of black and white, colour and infrared colour photography taken from either balloons or airplanes.

Slide 11 - The first slide is a conventional black and white photograph taken from a balloon. It is of a traffic circle and the important thing to note are the shadows that are obtained from such an aerial view. Shadows are a good indicator of what we see at ground level. You may note the person standing near the bench and you may also note the shadow which reveals the two legs of that person.

Slide 12 - The next slide shows a conventional air photograph done in black and white. It is of the North Saskatchewan River. That long white clear cut that you see is a cut line under which a pipe line has been imbedded. You will note the North Saskatchewan River appears totally white.

Slide 13 - Our next slide shows the same scene taken with a different film -- infrared film. What you see here is an example of an infrared black and white photograph. Unlike the last photograph -- rather than seeing a total area of gray we see various shades of gray and these various shades of gray enable us to tell the different tree types. Deciduous trees are those trees with large leaves and naturally reflect a lot more infrared energy than do conifers or cone bearing trees which have small needles. Therefore, we can say that the lighter areas in this photograph are probably deciduous trees, perhaps aspen poplar, whereas the darker areas are most likely conifers. The forestry department now makes use of this type of photography to survey the forest holdings in this province. Of interest is the North Saskatchewan River now. Unlike the last photo in which it appeared all white you can see that the river has numerous sand bars. You can also see the darker portions of the river are clear water. Water, you see, absorbs infrared energy and as such does not reflect any back.

Slide 14 - Now let's turn our attention to colour photography. This is an aerial view of the North Saskatchewan River just outside of Edmonton and shows the North Saskatchewan River with a large meander or loop and in between the meander you'll notice a gravel pit. These natural colours enable us to identify many natural features, for instance the rape fields appear yellow and the summer fallow appears black.

Slide 15 - Another shot of Edmonton, this time an aerial view in infrared colour. You'll notice the river appears black and the perimeter of the city can be easily seen. Also, the large lake can also be seen and is once again black.

Slide 16 - On the next slide we see an oblique view, once again an aerial view, of the Hinton area. This is looking west from Hinton at Brule Lake and you can see the mountains in the distance. This, once again, is an infrared colour photograph taken from an airplane.

Slide 17 - Here is an aerial colour photograph showing a farmer's field and a double lane highway with a vehicle on it. You'll note a tractor in the field with a farmer ploughing his field.

Slide 18 - Here we have a shot showing an infrared colour photograph of the same area. You'll notice that the vegetation appears bright red and we can see the area that the farmer has swathed very clearly.

Slide 19 - Multistage. This is a sampling technique where imagery of an area is recorded at different altitudes to provide more data. In other words, it's getting information about an area from different heights.

Slide 20 - Our next slide shows a large population of baluga whales taken from an airplane at an altitude of about 300 feet. Should we want to get a closer look at these whales we take another photograph at a lower altitude (multi-stage).

Slide 21 - In this next slide we see the baluga whales with their calves. We can use this information to do a population study on a herd of whales.

Slide 22 - Our next slide is an example of yet another kind of photography -- black and white ultraviolet photography. Here we see a polar bear with her three cubs. Normally, the bears would turn up white in such a scene but since the bears absorb ultraviolet energy, they appear black in this photograph.

Slide 23 - The next image we see is a thermal infrared image of Edmonton. Now thermal means heat. This image was taken at an altitude of 1600 feet in the middle of the night. On board the airplane was a thermal scanner. This scanner scans the ground and picks up the emitted heat energy from various objects. What you see in this image are various shades of black and white with white areas being the hottest and black areas being the coldest. The various shades of black and white in between are of course various temperatures. The whiter areas like the river and the roads are the hotter areas. These areas are slow to heat up and slow to lose their heat, so at night time they remain hotter than the surrounding land areas.

Slide 24 - The next slide shows a piece of equipment used at the Alberta Remote Sensing Center. This piece of equipment is called a density slicer and it has a special T.V. camera with a lens. What we can do is put a photograph or image on the light table. The light passes through the image and goes into the special T.V. camera. Beside the camera there is a switchboard. By selecting these various switches, they can assign colours to the various shades of gray in the photograph. Now the human eye is very limited in the number of shades of gray that it can see -- usually 15 to 18, whereas our eyes are much more sensitive to seeing many, many colours -- well over 100. What this machine does is gives various shades of gray which we can't see with our eyes various colours which we can see.

Slide 25 - Our next slide shows Barriere Lake, west of Calgary. This is a standard thermal aerial shot. When this picture is placed in the density slicer we can assign various colours to the various shades of gray. And here's what we get.

Slide 26 - We now see a rainbow of colours. Each colour may mean a certain type of rock or vegetation or certain temperature. We could use this principle to determine the total number of acres of wheat in the whole world. Say we assign a certain colour representing wheat and then we examine all the Landsat photographs all around the world. We can calculate the number of acres of wheat by using this method.

Slide 27 - The next slide of Barriere Lake shows temperature differences within the lake. The darker areas at the two ends of the lake would indicate either a deep, cooler area of the lake, or, perhaps, there are cooler springs feeding into these areas. Where the two lakes join at the neck we can see the water must be fairly shallow because the temperature differences there are fairly slim. Well, to date we have just looked at standard aerial photography. We have examined various types of film, infrared, black and white, infrared colour as well as an example of ultraviolet film. Now we want to have a look at the big look -- the total look. In our multistage idea of remote sensing, we are now going to look at the Landsat Satellite program.

Slide 28 - Landsat was launched from Cape Kennedy by NASA. Canada and the many other countries cooperate with NASA in the financing and participation in this remote sensing program. In the nose of the rocket we would find our Landsat satellite with the various propellant systems following. This is the method in which Landsat is lau[illegible] into the orbit.

Slide 29 - This is a close-up diagramatic representation of the Landsat satellite. It is approximately 13 feet high and weighing about 2,000 pounds. It's comparable to a Volkswagen beetle standing on end in weight and in height. The obvious solar panels can be seen and these are used to collect solar energy to power the satellite.

Slide 30 - Our next slide shows Landsat over Alberta scanning an area in northern Alberta and relaying the signal back to a ground station at Prince Albert, Saskatchewan. As mentioned earlier, there are no pictures taken -- merely energy that is collected, transformed and transmitted to a ground receiving station.

Slide 31 - The next slide is a flat map of the world. We know that Landsat takes 104 minutes to complete each orbit of the earth, but since the earth is rotating underneath it, each time the Landsat completes an orbit it is over a different area of the world on its next orbit. The Landsat satellite passes over the same locale every 18 days, but since there are two Landsat satellites currently in orbit, these are staggered so that a Landsat satellite passes any given area on this earth every nine days.

Slide 32 - Looking at Alberta, we can see the path of the Landsat satellites over our province. The satellites run north-east to south-west and their orbital paths are numbered. Specifically, in Alberta, they range from about 44 up to about 53. We use these orbital path numbers at the top of the slide plus the red numbers in the circles called image center numbers to order specific Landsat images of a given area. The Hinton area would be located by ordering orbital path #48 and image center #23. This frame would include the town of Hinton and Grande Cache. A Landsat image frame covers 32,000 square kilometers and is 185 kilometers by 185 kilometers square.

Slide 33 - Our next slide shows the path of two Landsat orbits. The blue arrow on the east coast of North America represents one Landsat orbit which will take 104 minutes to complete. After completing this orbit, we know the earth has rotated from west to east so that the next time the satellite passes over the north pole the earth will have turned and the satellite will follow the path shown by the westerly blue arrow.

Introduction to Remote Sensing

There are approximately 1,288 kilometers between the first orbit and the second orbit. Now the red arrows indicate the orbital path of Landsat on the next day. You notice that there is a considerable overlap over the blue arrow or orbital path of the previous day. This is to ensure that no part of the earth is overlooked. After completing the first orbital path once again the second one is 1,288 kilometers further west and so the cycle continues until in 18 days Landsat has covered the entire earth.

Slide 34 - At this point we have a sequence of slides showing various orbital routes over Canada. Our first slide is of the Montreal area. Montreal shows up light blue and the St. Lawrence River is dark blue.

Slide 35 - 104 minutes later we find Landsat passing over Winnipeg. The earth has turned approximately 1,288 kilometers in between the first and second orbit.

Slide 36 - 104 minutes after passing over Winnipeg we find Landsat over the Rocky Mountains. This is a slide of the interior of B. C.

Slide 37 - And 104 minutes later we find Landsat over Vancouver Island. The blue area at the tip of

Vancouver Island is, of course, the city of Victoria. The black body of water, of course, is Juan de Fuca Strait separating Vancouver Island from the United States mainland. As we mentioned earlier, Landsat records images in various wave bands.

Slide 38 - Here we see a band 5 image of an area south of Edmonton. From top to bottom we see Pigeon, Gull and Sylvan Lakes. This band #5 is very useful for detecting cultural features. The town of Red Deer may be seen, as well as farmers' fields very clearly. You may also note Rocky Mountain House and the North Saskatchewan River.

Slide 39 - Simultaneously, Landsat records the same scene in a different band -- band 7. Note, bodies of water show up very clearly in this image. Such an image is very useful for hydrologists -- people who study water supply and water management.

Slide 39a - By combining three of the four wave bands available from Landsat we can product what we call a composite colour image.

Slide 40 - This colour is added at the ground stations and transformed into a colour composite image. The advantage of this should be obvious. We get the benefit of three different wave bands in one image.

Slide 41 - By using a different combination of wave bands we can produce a blue composite colour image. Now this type of imagery is very useful in bringing out water detail. You will notice that lakes and swampy areas appear much darker than in the last image. The next two slides illustrate a similar principle.

Slide 42 - Here we have a colour composite image of an area north of Cold Lake and the next slide,

Slide 43 - a blue composite of the same area showing the detail of water again.

Slide 43a - This slide is a colour composite of the MacKenzie Delta area and the Arctic Ocean. One can clearly see the sediment deposits as the river empties into the ocean.

Slide 44 - Multidate. Multidate is just imagery recorded of the same area on a series of prescribed dates for comparative analysis. All this means is taking an image of an area one day and following it by an image of the same area at some later date. Compare the two images to note any changes.

Slide 45 - The first example is of the southern Alberta area around Lethbridge in July. Here we see the prominent red fields around Lethbridge.

Slide 46 - You will note that the irrigated areas are no longer as red as in the previous slide. This is because this image was taken in the fall and the crops have since hardened up and as a result are not as brilliant a red colour as they were in the previous slide.

Slide 47 - The next two slides in our multidate series are of the Peace Athabasca region. The first slide is a colour composite of the Peace Athabasca delta 1974.

Slide 48 - On a different date (multidate comparative photography) we can see that the delta has been flooded considerably. This image was taken one year later in the spring time. You can see that the delta is loaded with sediment which appears much lighter than the non-sedimented areas of the delta. This is because the sediment in the water reflects more infrared energy than the clearer parts of the lake and delta areas.

Slide 49 - This is a photograph taken from a map of northern Alberta. This is the Zamma Lake area of Alberta. This was, up until Landsat, the only map of this area.

Introduction to Remote Sensing

Slide 50 - The next slide shows a Landsat view of the same area. Here we can see cultural features such as roads, seismic lines and timber cutting activities which were not indicated on the previous map. Thus we can use Landsat as a method of updating older maps.

Slide 51 - This slide is of Keller Lake in the Northwest Territories and shows us a forest fire recorded by Landsat. The forest fire covered about 100 square kilometers and one can detect the direction of the forest fire from the winds carrying the smoke. Forest managers can use such information to determine the amount of timber that has been lost and to also suggest methods of controlling such a fire.

Slide 52 - The next two slides are Landsat colour composite images of Jasper National Park. If you look closely you can identify the Athabasca River, Brule Lake and the various lakes just outside Jasper.

Slide 53 - Mount Robson is also visible. The red areas are, of course, the valleys, and the white areas are the snow capped peaks of the mountains. Scientists are currently working on methods by which they can calculate the depth and amount of snow that is present in the mountains in order to forecast the amount of water that will be made available by the river systems in the spring.

Slide 54 - When we speak of the future we have to think of the space shuttle Columbia. This is a re-usable flying machine capable of entering space, returning, and then entering again. It flies at approximately 483 kilometers above the earth, carrying scientific equipment which will enable us to better understand our planet earth.

Slide 55 - In closing, we draw from Socrates, 500 B.C., who said that man must rise above the earth to the top of the atmosphere and beyond, for only thus will he fully understand the world in which he lives.

APPENDIX F

Teaching Unit References

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The Fractured Look
Growing Concerns
Pollution Solution
Land for Bears
Remote Possibilities

C. Landsat Imagery

1. C-1 color composites (1:250000) available from the Canada Center for Remote Sensing, Prince Albert, Saskatchewan. S6V 5S7.

The four C-1 composites at a scale of 1:250000 used in this unit were of the West-Central region of Alberta.

(a) Orbital Path 49 Image Center 22
(b) " " 48 " " 22
(c) " " 47 " " 22
(d) Edmonton-Beaverhill Lake

D. Maps

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C. 1. Landsat Imagery of Mt. St. Helens (1:12[illegible])

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b) Post-eruption - July 1[illegible]. Scene number 821999[illegible]0 (49-28).
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[illegible] U-2 Imagery (1:120,000)

a) Post-eruption - June 19, 1980. Roll 580002891- Frame 38 or 99.

3. Geosynchronous Orbiting Earth Satellite (GOES) Imagery.

GOES Imagery of the Mt. St. Helens volcano eruption (sequential imagery ranging from 15 minutes to 8 hours after the eruption). Alberta Remote Sensing Center, 9820 - 106 St., Edmonton, Alberta. T5K 2J6.

APPENDIX G

Research Questions Related to the Central Issue

CENTRAL ISSUE

What are some of the Scientific, Technological (Remote Sensing), and Social implications of the Mt. St. Helens eruption?

GROUP 1

Are future eruptions likely?

On what basis were people compensated for their losses?

GROUP 2

What physical and psychological effects did the volcano have on those affected by the eruption?

What role did the government play before, during and after the volcano erupted?

GROUP 3

What personal losses resulted from the eruption?

What effect did the eruption have on the physical and human environment?

GROUP 4

What role did the scientists play in predicting the eruption? What instruments were used?

Why didn't lava flow from the Mt. St. Helens' eruption?

GROUP 5

Why and how did the eruption occur?

What is the history of Mt. St. Helens?

APPENDIX H

Statistical Computations

Statistical Computations

H-1 Remote Sensing Content - Pre and Posttest Results

STUDENT	PRETEST SCORE /35	%	POSTTEST SCORE /35	%	NET SHIFT
1	6	17	24	69	+52%
2	1½	4	17	49	+45%
3	4	11	14½	41	+30%
4	2	6	23½	67	+61%
5	2½	7	19½	56	+49%
6	1½	4	15½	44	+40%
7	4	11	19½	56	+45%
8	1	3	19½	56	+53%
9	6	17	18	51	+34%
10	1	3	18½	53	+50%
MEAN	3	8	19	54	+46%
STANDARD DEVIATION	5.81		7.98		

H-2 TSAS Sign Test

Computing the probability that 9 or more than 9 ($Pr\ X \geqq 9$) out of ten students would show a positive net directional shift:

$$\begin{bmatrix}10\\10\end{bmatrix}\begin{bmatrix}\frac{1}{2}\end{bmatrix}^{10}\begin{bmatrix}\frac{1}{2}\end{bmatrix}^{0} + \begin{bmatrix}10\\9\end{bmatrix}\begin{bmatrix}\frac{1}{2}\end{bmatrix}^{9}\begin{bmatrix}\frac{1}{2}\end{bmatrix}^{1} = \frac{1}{1024} + \frac{10}{1024} = \frac{11}{1024} = .01$$

H-3 TSAS (Sub-Domain) Sign Test

Computing the probability that 8 or more than 8 ($Pr \cdot X \geq 8$) out of ten students would show a positive net directional shift within the 6 item TSAS sub-domain:

$$\left[{10 \atop 10}\right] \left[\tfrac{1}{2}\right]^{10} \left[\tfrac{1}{2}\right]^{0} + \left[{10 \atop 9}\right] \left[\tfrac{1}{2}\right]^{9} \left[\tfrac{1}{2}\right] + \left[{10 \atop 8}\right] \left[\tfrac{1}{2}\right]^{8} \left[\tfrac{1}{2}\right]^{2} =$$

$$\frac{1}{1024} + \frac{10}{1024} + \frac{45}{1024} = \frac{56}{1024} = .05$$

H-4 Chi-square

McNemar (1969) chi-square statistic on the TSAS domain:

$$X^2 = \frac{(A - D)^2}{(A + D)}$$ with 1 degree of freedom. where A and D are cell frequencies in the following contingency table.

		Posttest right	Posttest wrong
Pretest	wrong	A	B
	right	C	D

*Results:

		Posttest right	Posttest wrong
Pretest	wrong	17	17
	right	18	6

* 58 responses - no data available for two items.

$$X^2 = \frac{(17 - 6)^2}{(17 + 6)} = \frac{121}{23} = 5.26$$

APPENDIX I

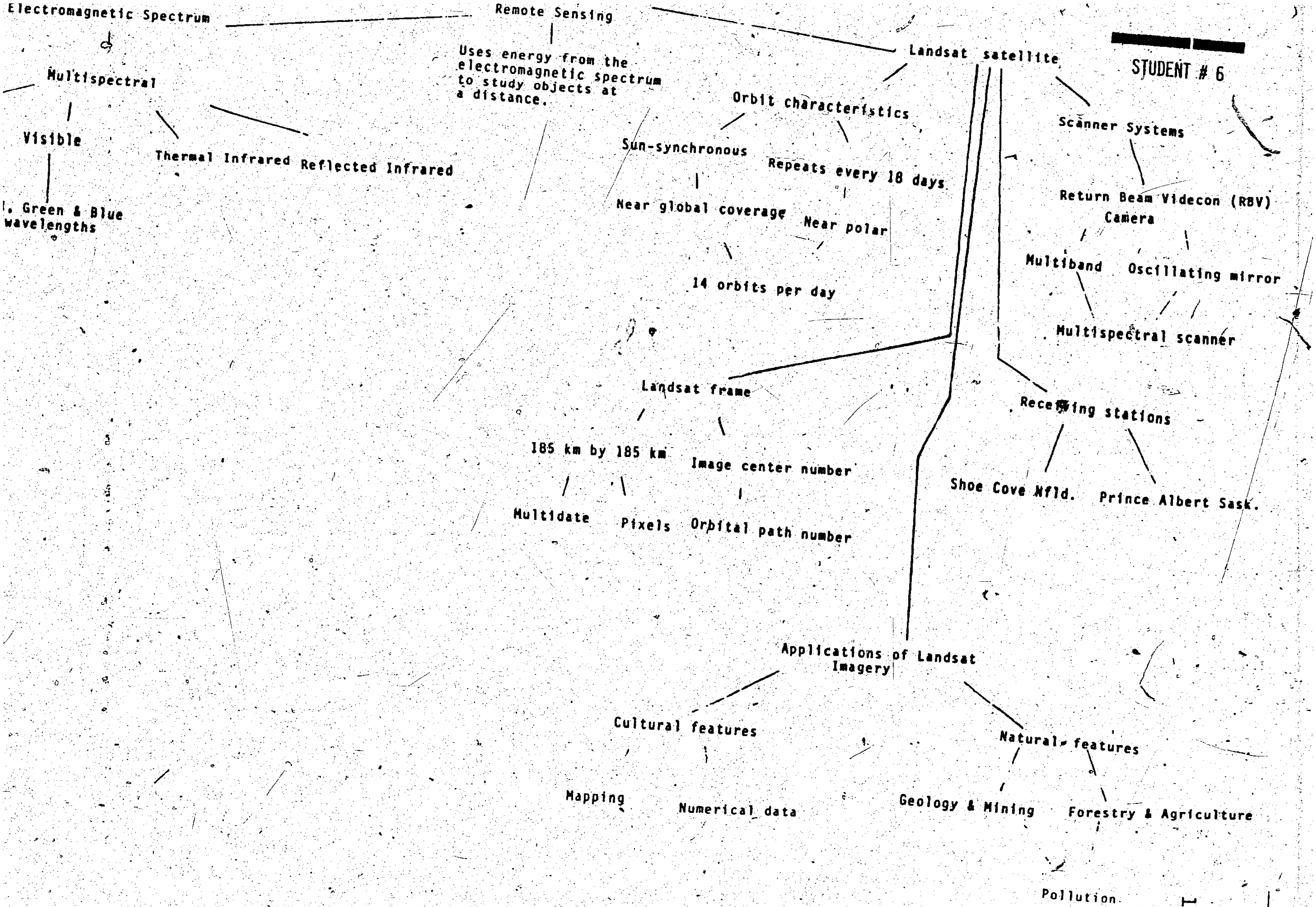
ConSAT Task Items

ConSAT TASK ITEMS

Remote Sensing	Multispectral Scanner	Mapping
Electromagnetic Spectrum	Landsat Satellite	Pollution
Ultraviolet	Orbital Path Number	Red, Green & Blue Wavelengths
Visible	Image Center Number	Multiband
Reflected Infra-red	Cultural Features	Multidate
Sun-synchronous	Oscillating Mirror	Repeats every 18 days
Near Polar	Numerical Data	14 Orbits Per Day
Near Global	Telemetered	Uses energy from the electromagnetic spectrum to study objects at a distance.
Orbit Characteristics	185 km by 185 km	
Receiving Stations	Pixels	
Prince Albert, Sask.	Landsat Frame	Name:__________
Shoe Cove, Nfld.	Applications of Landsat Imagery	Date:__________
Scanner Systems	Forestry & Agriculture	
Return Beam Videcon (RBV) Camera	Geology & Mining	

APPENDIX J

Sample ConSAT Structure


[redacted]
STUDENT # 6
Remote Sensing
Uses energy from the electromagnetic spectrum to study objects at a distance.
Electromagnetic Spectrum
Multispectral
Visible
., Green & Blue wavelengths
Thermal Infrared
Reflected Infrared
Landsat satellite
Orbit characteristics
Sun-synchronous
Repeats every 18 days
Near global coverage
Near polar
14 orbits per day
Scanner Systems
Return Beam Videcon (RBV) Camera
Multiband
Oscillating mirror
Multispectral scanner
Landsat frame
185 km by 185 km
Image center number
Multidate
Pixels
Orbital path number
Receiving stations
Shoe Cove Nfld.
Prince Albert Sask.
Applications of Landsat Imagery
Cultural features
Mapping
Numerical data
Natural features
Geology & Mining
Forestry & Agriculture
Pollution