AN ASSESSMENT OF THE USE OF REMOTE SENSING IN K-12 EDUCATION

By

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SENSING IN K-12 EDUCATION

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CHAPTER I

INTRODUCTION

The urge to know is as old as the human race itself. Throughout the course of history, humans have explored the earth because they wanted to reach their distant neighbors, because some of the known trade routes were too dangerous or too costly, and because they wanted to learn about the environment (NASA Facts, 1975). The development of technology has assisted with the pace of exploration; compasses, maps, wagons, cars, and airplanes to name a few. During the last two decades, human interest has increased to include investigations and research of areas that were relatively inaccessible by conventional means.

With the arrival of the Space Age, orbiting satellites and spacecraft, at altitudes of 150 kilometers and higher, have completely revolutionized the methods of surveying earth resources. No area on earth can now be considered remote. Because a satellite can sweep an area so vast, no high flying photo-reconnaissance plane can match its performance. Because of the minimal distortion at the edges, together with the capability of images taken at different times of the year to be adjusted to similar photographic densities, satellite images can be joined in mosaics with very little of the special manipulation required for aerial photographs (Short, 1976). To use an aircraft would require 20 years to observe the same area that satellites can scan in 18 days or less.

The concept of using satellites to survey the earth is known as Remote Sensing. Sabins (1987) broadly defines remote sensing as the collecting and interpreting of information about an object without being in physical contact with the object. In a broader sense, it denotes the use of sensors, data processing equipment, and platforms, including spacecraft, for the purpose of carrying out Earth surveys. During the last 20 years, a variety of remote sensing systems have been developed for scanning the surface of the earth. These remote sensing systems have enhanced earth resource investigations in:

Agriculture
Forestry
Range Resources
Land Use
Mapping
Geology
Water Resources
Oceanography
Environmental Resources

Remote sensing has broad applications as an educational tool as evidenced by the disciplines employing the technique. Walsh (1984) believes that satellite information provides a unique perspective of our earth in a relatively unconventional and unfamiliar format to most students. Short (1982) states that one aspect of remote sensing which has direct implications for education is that images from satellites can be utilized to supplement and complement classroom instruction in various disciplines.

Benefits of Remote Sensing

Orbiting high above the Earth, satellites can acquire picture-like images of any area on the surface. From this perspective, these images are capable of revealing far more than regular photographs.

Every surface on the Earth receives solar radiation which is either reflected, absorbed or emitted in specific wavelengths, some which are invisible to the human eye. Each surface has a "spectral signature" that is made up of specific wavelengths which can be recorded by instruments called sensors. The spectral signatures are recorded as digital values which can be processed into photograph-like images.

An image is composed of thousands of individual picture elements, called pixels, each one containing a single unit of information which represents the spectral signature of the corresponding area on the Earth's surface. The resolution, ground area covered by each pixel, is generally equivalent to the dimensions of the smallest detectable object on the image. The information content, in digital form, can be analyzed by computer or converted to an image for visual analysis.

A wide range of earth resource and cultural investigations are possible by using remotely sensed information. Satellite images can be used to bring maps up to date and to improve the accuracy and content of maps and surveys. Earth science students are able to locate and identify gross geological features, drainage patterns, minerals and rock type, fault locations, earthquake hazards, volcanic activity, soil erosion and resources in a given area.

Science and math students can use remotely sensed data for analyzing both quantity and quality of water resources, including the distribution of snow fields, soil moisture and glacial features. Ice concentrations can be measured in polar regions, water quality and water boundaries determined, along with surface water area and volume. Floods can be monitored to improve human safety.

In meteorology, students can study cloud features and moisture content, the effects of atmospheric disturbances on terrain, and solar and terrestrial radiation. In oceanography, students are able to detect living marine organisms, determine patterns of circulation, shoreline patterns, shallow areas, and detect ice flow.

In Social Studies and Ecology, students can use satellite images in land use mapping, crop identification, the study of surface mining and reclamation, detecting air and water pollution and its detrimental effects. Satellite images can be used to determine the effects of natural disasters, such as earthquakes, floods, tornados, etc. These images are also useful in surveying, urban studies, historical studies, and studying man's impact on the environment.

According to Kirman (1981), teachers can now utilize imagery of a particular area that is more up to date than traditional hand-drawn maps. Moreover, the imagery provides data about an area that is impossible to obtain from older style maps. Because the satellite image is an accurate representation of the surface of the earth produced with several spectral frequencies, a variety of uses can be made of them as are mentioned above. Satellite images are superbly accurate representations of the surface of the earth, and also timely representations.

Although the benefits of satellite imagery are well documented, little evidence exists in the literature that teachers are educating students in the concepts of remote sensing. With all of the money that has been spent on earth resource satellites by the National Aeronautics and Space Administration (NASA) and private industry, technology transfer to teachers or students in the elementary and secondary levels of education appears, at best, to be meager!

Another major problem with the use of satellite imagery is cost. Most schools have little or no money to spend on extra materials, especially for 30-40 students. To overcome this expense, a single image can be copied photographically. Most companies do not view this as an infringement on copyright laws because the image(s) are being used solely within the institution that ordered the information. Others may require you to sign a Partial Release Agreement form. Another benefit to help justify the cost is that the imagery is not restricted for use in only one class. If the teachers can agree on an image that is beneficial for many disciplines (math, science, social studies, etc...), the cost of an image becomes, perhaps, economically feasible.

Need for the Study

In a study by Kirman (1974), students in as low as the third grade were able to work with infra-red false color satellite images and obtain data from them. Teachers in this project appeared to be able teach about satellite images to their students. The level of instruction however appeared related to the background knowledge of the teacher. It was concluded that a more extensive training program than provided is necessary to provide teachers with remote sensing information.

Whiteford (1985) claims that satellite imagery, as an aid to classroom learning, can provide students with the ability and insights to monitor earth conditions. More people with greater resource needs means change can occur more rapidly. According to the 1974 study by Kirman, remotely sensed data can be integrated and applied to all levels and courses in a curriculum. Lillesand (1982) believes a dire need exists to facilitate the education of our future remote sensing teachers and users and to instruct more students about remote sensing at all educational levels and on a continuing basis.

Tindal (1978) states that satellite imagery holds promise of being important in helping students become more aware of the world in which they live. If this can be considered a basic objective of education at all levels, it is necessary that educators find realistic and efficient approaches to meet this objective.

It is difficult, at best, to adequately equip young people for the future by using only those tools and techniques which are most comfortable and secure, or by transmitting only the information which is familiar. Generally, new strategies and creative approaches to learning must be derived to deal with the unknown and unfamiliar. Satellite imagery offers a new alternative tool for instructing students about the earth.

Purpose of the Study

The purpose of this study is to develop a survey to assess if remote sensing concepts are being taught on the elementary and/or secondary levels of education. If the survey reveals that remote sensing concepts are not being taught, the survey is designed to assess why not. Based on the results of the survey, recommendations will be given on how to introduce teachers and students to the field of remote sensing.

Statement of the Hypothesis

I believe that the concepts of remote sensing are not being taught because of the lack of teacher knowledge in the field of remote sensing. Another reason I believe these concepts are not being taught is that most school systems have little or no money for such extra materials. With the help of this survey, I will be better informed of why remote sensing concepts are not being used, and in what area(s) of the curriculum help is needed to implement these concepts into elementary and secondary level schools.

Definition of Terms

Band - (1) A selection of wavelengths. (2) Frequency band.

Color Composite - A color picture produced by assigning a color to a particular spectral band.

EOSAT - Earth Observation Satellite Company

False Color - The use of one color to represent another.

Image - The recorded representation of an object produced by optical, electro-optical, optical mechanical, or electronic means.

Imagery - The products of image-forming instruments (analogous with photography).

Map - A representation in a plane surface, at an established scale, of the physical features of a part of the Earth's surface.

Mosaic - An assemblage of overlapping aerial or space photographs or images whose edges have been matched to form a continuous pictorial representation of a portion of the Earth's surface.

NASA - National Aeronautics and Space Administration

Photograph - A picture formed by the action of light on a base material coated with a sensitized solution which is chemically treated to fix the image points at the desired density.

Remote Sensing - For the purpose of this paper, remote sensing will be defined as images or photographs of the Earth's surface that are created by the acquisition of data by satellite or spacecraft.

Spectral Signature - The spectral characterization of an object or class of objects on the earth's surface.

CHAPTER II

REVIEW OF LITERATURE

Introduction

During the spring of 1974, a meeting took place at the Marshall Space Flight Center in Huntsville, Alabama, which had significant implications for the Landsat program and elementary level school children. Representatives of NASA met with a group of social studies consultants from the National Council For The Social Studies to study the possible overtones of Skylab 2 on social studies education. The main result of the meeting did not turn out to be about Skylab. Instead, the spotlight fell on the Landsat (then known as ERTS) program (Kirman, 1977).

After a brief description of satellite imagery during the first day, considerable interest was generated by social studies people for the possible applications of satellite imagery in the classroom. The uses of these images in the classroom were obvious, because they were the most up to date portrayal of the earth's surface. These "pictures" of earth, not remapped by hand every ten years, but several times a month, were timely and accurate. For the first time, students could see a representation of the earth's surface, and accurate representations of surface geology, vegetation, seasonal changes and cultural features.

EOSAT describes the benefits of remote sensing in the following way:

> From earth resources satellites, a picture is not only worth a thousand words but a thousand pictures of the conventional kind. Look at it this way: Think of a familiarly, notable natural landmark, such as Mount St. Helens. Imagine it surrounded by a thousand people observing it at ground level. Assume each observer is a surveyor equipped with sophisticated equipment. Their picture of the volcano will still be a fragmented mosaic. Satellites observing the same scene from hundreds of miles in the sky see the "whole" picture in a fraction of the time, and in great detail. The satellite's scanning system not only reveals the true shape of the monolith but its lava flow patterns, surrounding vegetation and water, among many other details (EOSTAT, n.d.).

Elementary Level Studies

For those teaching secondary classes, the utilization of this imagery had real benefit. For the elementary school teacher, it was believed that these images with their large scale (1:1,000,000) and false color might be beyond the ability of elementary age children (Kirman, 1977). Further examination by Kirman, however, confirmed that elementary level children could work with traditional aerial photographs. But no studies had been pursued to determine if elementary school children could work with Landsat images.

B.E. Kingston (1969) used aerial photographs with children in grades one, two, and three. Kingston found that these children were able to read aerial photographs, but they had problems with interpretation without having previous instruction (Kirman, 1977).

In a study conducted by K.G. Dueck (1969), aerial photos were introduced to children in grades four, five, and six. It was found that these children could read and work with aerial photos and that no problem with scale occurred. Interpretation was not correlated with map reading ability and age during this study (Kirman, 1977). Blaut (1971) researched mapping behavior (the capability to work with and understand mapped representations of the earth) with children age three to twelve. Blaut concluded that mapping behavior was developed in preschool children (Kirman, 1977).

As noted earlier, these studies seem to confirm that elementary level children have the capability of working with and understanding a spatial representation of reality. Whereas these studies were helpful, doubts existed as to whether elementary level children could comprehend Landsat images.

With this idea in mind, J.M. Kirman (1977) conducted an exploratory study on the use of Landsat images by students and teachers in grades 3, 4, and 5. The objective of the study was to determine if teachers on these levels were capable of providing instruction about Landsat images that could be learned by the children. The specific research questions were:

1. Can teachers in grades three, four, and five comprehend Landsat images to plan classroom activities?
2. Can children in grades three, four, and five understand what Landsat images are and derive information from them?
3. Will teachers in grades three, four, and five be able to teach their students about Landsat images?

4. Will teachers in grades three, four, and five have to modify Landsat images in order to instruct their students about them?

To answer these questions, three teachers from the Edmonton Separate School System were selected to participate in the research. The Alberta Remote Sensing Center in Edmonton volunteered their help and facilities in training the teachers in the science of Remote Sensing.

Because no validated instrument was found that could test the abilities of elementary level school children to read false color Landsat images, the researchers were forced to rely on direct questioning of students in each class, and on exams about Landsat images that were designed by the three participating teachers. The teacher-made exams were:

1. Tentative rather than definitive;
2. Specific to this study, rather then general;
3. Designed to elicit a response unique to the teaching procedures of each class and the information taught;
4. Designed to elicit responses to Landsat image questions considered correct by each teacher.

Under these circumstances, the teacher-made exams were considered valid for their particular classes. Because these instruments were unique to these teachers and children and not to be used again, the element of reliability appeared not to enter into this study (Kirman, 1977).

After instructing their students on Landsat images and allowing them to work with the images, the teachers tested the students on their capability to understand and work with Landsat images. Following the classroom phase of the study, the researcher interviewed three children on each grade level: above average, average, and below average for the class as determined by their teacher. The object of this evaluation was to determine if children of varying abilities, using false color Landsat images different from those used in their class, were able to derive information from them and answer questions about them. Each student was asked 15 questions, 13 of which could be graded as correct or incorrect. The questions were based upon a spring and a fall Landsat image, and one question was based upon a Landsat image and a road map of the area.

The results of the teacher-made tests and the oral evaluation demonstrated that the children were able to derive information from the Landsat images. It was noted that even those children with visual problems (wearing glasses, color blindness, etc...) were capable of working with Landsat images.

The third grade teacher stated that the children were able to identify "lakes, rivers, mountains, and cities," on their own, but the distance factor on the image was difficult for the students to comprehend. Some of the students in the fourth grade had problems in understanding the area covered by the image. The teacher added that this problem was overcome by instruction. Another aspect of Landsat images that caused a problem was understanding how the image was made, particularly with respect to light waves and radiation. The researchers were not concerned with this as the study was designed to find the level of application of Landsat images, not if the students could comprehend the technical level of the material.

The data that were gathered by this study appear to answer affirmatively research questions one and three regarding the ability of teachers in grades three, four, and five to work with Landsat maps. They are able to teach their students about satellite images. The teachers reported no difficulty in using the false-color images. The images would not have to be modified in order for the children to be able to use them. It was also concluded in a later study by Kirman (1984) that third grade children were able to deal efficiently with "Band 5" black-and-white Landsat images.

A major conclusion of the 1977 and 1984 studies dealt with the ability of the teachers. Because of the uncertainty and lack of familiarity with Landsat images by the teachers, the researchers recognized that a more extensive prepatory program was needed to train the teachers on working with Landsat images. Kirman (1981) stated that training teachers to use satellite imagery is one of the major reasons that this technique is not widely used in elementary and secondary level schools. With the exception of the University of Alberta, Kirman doubts that other universities prepare teacher candidates to work with satellite images. It is to be expected that teachers in the field are reluctant to use images because they lack knowledge of them. After extensive activity with hand drawn maps, it is difficult to work with new maps with false colors.

Another concern that Kirman (1981) raised was the probability of limited expertise about satellite images by professors of education and school board subject supervisors. Lack of familiarity with new technology may correct itself in the future. If the people that set up and develop pre-service and inservice teacher training lack expertise, however, teachers will not acquire the new knowledge. In order for teachers to acquire knowledge of satellite images and applications, school administrators must learn about this new technology.

As stated earlier, Lillesand (1982) believes a need exists to facilitate the education of our future remote sensing teachers and users. One way to accomplish this process is by conducting workshops aimed at instructing and training teachers who are involved in classes which can apply the applications and analysis available through remote sensing technology (Kirman 1981; Lillesand 1982; Walsh 1984).

Middle and Secondary Level Studies

During the summer of 1984 Dr. Stephen Walsh conducted two workshops at Oklahoma State University dealing with the technique and applications of remote sensing for middle school and high school Earth Science honors teachers. These workshops were designed to contribute to earth science education by introducing remote sensing as a tool to aid in the study of our earth and its resources. The fundamentals of remote sensing and the latest techniques and strategies in resource assessment and management were stressed through lecture, lab exercises, and "hands on" experience in remote sensing technology. The workshops assisted in the development of teacher learning units and the integration of remote sensing into middle school and high school earth science curricula (Walsh, 1984).

These workshops featured the explanation of electromagnetic energy, spectral signatures, single and stereoscopic interpretation and measurement of aerial photographs; description of the Landsat satellite system and uses of its images and digital data in earth science investigations; and a discussion of earth science, environmental arts, and the use of environmental simulations to transfer remote sensing technology in earth science education (Walsh, 1984).

Related exercises were utilized during each discussion topic to reinforce lecture material and to provide workshop participants with practical experience in the application of remote sensing concepts. The workshop concluded with a field trip to the study site over which the exercises and study materials were presented. A case study investigation involving the remote sensing techniques presented during the workshop was concluded. This study involved the analysis of forest clear cuts in southeastern Oklahoma and the assessment of levels of forest regeneration within the clear cuts.

As part of the requirements of the workshop, each participant developed a learning unit involving the application of remote sensing to an earth science issue. The learning unit was tested by each participant in his/her classroom. Some of the learning unit topics that were designed by the workshop participants were:

Introduction to Remote Sensing

Remote Sensing and Agricultural Production

Exploring the World - Past and Present - through Archaeology and Remote Sensing

Community Awareness for 1st Grade Children using Remote Sensing Techniques

Use of Remote Sensing in Geography

The Possible Impact of Remote Sensing on Early Exploration of the North American Continent

Weather Patterns

New Methods of Measurement

Landsat: A City Analysis

Mapping With Landsat

Oklahoma Strip Mining and Reclamation

In the published proceedings from the workshop for Earth Science teachers, Walsh (1984) stated that a need exists to utilize new technology in an effort to devise new strategies and creative approaches to learning. Walsh believed that remotely sensed images offer one alternative technique for instructing students about the earth. However, Walsh stated that teachers must receive instruction about applications and uses of remote sensing before satellite imagery could be an effective instructional tool.

Another concern is the cost of imagery. Many schools lack the necessary funds to invest in remotely sensed data. During the Carter administration, a technology transfer directive was designed which included a phase to commercialize the Landsat program, with expectations that the private sector would assume control by the early 1990's. In February 1983 this commercialization process was accelerated by President Reagan when he authorized formal proceedings to begin the search for a private operator. In July 1985 the contract was awarded to the Earth Observation Satellite Company (EOSAT). Prior to the private industry takeover of the Landsat program, satellite imagery was very inexpensive. A standard paper Color I image (1:1,000,000) cost about $12.00 in 1981. That same size image today costs $300.00, a 2,500% increase over an 8 year period. This makes the purchasing of class sets of images financially unfeasible for most school systems.

Kirman (1981) believes that as the amount of information about the surface of the earth provided by satellite increases, teachers will encounter these images more and more in the media and in educational materials. Supervisors, teachers, and those concerned with teacher training have a professional responsibility to make information about these images available.

Walsh (1984) believed that a student's educational development would be incomplete without an introduction to the basic uses of satellite exploration of the earth.

> The panoramic views generated by Landsat can be contribute to an improved understanding of global environmental conditions and their regional differentiation. The striking scenes of the Great Plains and the Nile Delta present dramatic visual examples of the profound impact human activity has on the natural environment. Images such as these do not need long-winded explanations; they are an invitation to explore the world beyond one's own horizon (Walsh, 1984, np).

As we have used and changed our planet, we have become aware that we are exhausting what we once considered to be its limitless resources - exhausting our food supplies, our sources of energy, our mineral wealth, and the potential of what we once thought to be our limitless oceans. Management of Earth resources is at a critical stage. It has never been more important that we understand the environmental relationships of our planet (Nixon, 1977). The benefit of space-age technology is essential to train students about the complex interactions of human and physical factors that comprise the natural system of planet Earth.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

Introduction

This study was conducted to evaluate the use of remote sensing in elementary and secondary education curricula. Aerospace education specialists, assigned to the Johnson Space Center, distributed 220 surveys to teachers attending summer workshops on aerospace education. These workshops were presented throughout the eight states that comprise the Johnson Space Center educational region (Table 1).

A short presentation on the basic concepts of remote sensing, specifically the Landsat program, were given before the survey was distributed. These basic concepts included the electromagnetic spectrum, radiation, satellite sensor characteristics (MSS and TM), Landsat orbit characteristics, and data retrieval and dissemination. The surveys were completed during the workshop and returned directly to the specialist who was conducting the workshop.

Brief Description of the Aerospace Education Services Project

The NASA Aerospace Education Services Project provides, free of charge, the professional services of a specialist in aerospace education to teachers, students, and the general public. These specialists are qualified educators who are knowledgeable in aeronautics and the space sciences and are able to communicate NASA's activities past, present, and future. The goal of this NASA program is to increase awareness and understanding of the scientific and technological developments that have occurred in space and its place in the world in which we live (NASA/AESP Brochure).

Description of Research Participants

Teachers from grades K-12, and the eight state region mentioned above, comprised the population for this research project. No specific techniques were employed to select the subjects in this study. The teachers were voluntary participants in aerospace education workshops presented by aerospace education specialists from the Johnson Space Center between July 20 - August 1, 1988.

TABLE I

LOCATION BY STATE OF THE AEROSPACE WORKSHOPS AND THE NUMBER OF PARTICIPANTS FROM THE 1988 SURVEY

Location *	Number
Colorado	26
Kansas	26
Nebraska	20
New Mexico	21
North Dakota	19
Oklahoma	40
South Dakota	18
Texas	50

* Johnson Space Center Region

Development of the Survey

The survey instrument used in this research project was developed by the author after little evidence was found in the literature that indicated the use of remote sensing in elementary or secondary education (Appendix A). Prior to the completion of the instrument faculty members in the Department of Aviation and Space Education at Oklahoma State University, who are knowledgable in the field of remote sensing, were asked to evaluate the instrument. Faculty input was utilized and revisions were made to assure the validity of the questions. To establish reliability and readability, the instrument was tested on participants in a 1988 summer aerospace workshop held at Oklahoma State University. The participants reported no problems in reading and understanding the questions.

This survey was designed to evaluate if remote sensing concepts are being taught in elementary and/or secondary education. The first section of the survey dealt with demographic information. At the end of this section the participants were asked if they taught remote sensing concepts. If they answered yes, they were asked to complete parts A and B of the survey. If they answered no, they were told to skip part A and complete the survey beginning with part B.

Part A of the survey contained 22 questions about the perceived knowledge level of the participant in the field of remote sensing. The participant was asked to answer each question yes or no. If the participant answered no, they were then asked to rate their degree of need by choosing no, low, moderate, or high need.

Part B asked the participants "If you have been or were given the responsibility of teaching remote sensing concepts, how much of a problem is or would be presented by each of the following?" The participants then answered 19 questions dealing with perceived problem areas in the teaching of remote sensing. The participants were asked to choose one of four possible responses for each question:

1. not a problem
2. small problem
3. moderate problem
4. big problem

Analysis of the Data

The observations from Part A in this study, which are the responses of those that teach remote sensing concepts, are presented in the number responses for each question. The results from Part B, which are the responses of all the participants, will be presented in percentage form, however, these will be the percentages of teacher responses from grades K-5, 6-9, and 10-12. Based upon the purpose of the survey, the results in the form of raw data clearly demonstrate why remote sensing is not an integral part of elementary or secondary education. Because comparable data are lacking, specifically for other geographical regions, no insights would be gained with quantitative evaluation of the raw data.

CHAPTER IV

ANALYSIS OF SURVEY RESULTS

This chapter presents the results of the questionnaire responses. Tables have been prepared to show the percent and number of responses for each question.

Demographic Information

A total of 220 teachers of grades K-12 participated in this study. All of the teachers were voluntary participants in aerospace education workshops presented by the aerospace education services project of NASA. These teachers completed a survey (Appendix A) on the use of remote sensing in K-12 classrooms. Of the total population 116 taught K-5, 84 taught 6-9, and 20 taught 10-12. The years of teaching experience ranged from first year teachers to those who have taught for more than 13 years. Dividing the years of experience into four groups revealed the dominance of experience in the 3-7 and 13+ categories. These results are presented in Table II.

When the teachers were asked what subjects they taught, the largest percentage (44%) said that they teach elementary school. The second most common response (31%) stated that they taught science courses. The results of the teachers responses are presented in Table III. The percentages add up to greater than 100% and the number of teachers add up to greater than 220. Many of the teachers currently teach more than one subject which contributes to a total that exceeds 100 percent.

TABLE II

YEARS OF TEACHING EXPERIENCE OF THE
1988 SURVEY PARTICIPANTS

Years of Experience	No. of Teachers	Percent of Teachers
0-2	22	10
3-7	68	31
8-12	29	13
13+	101	46

TABLE III

SUBJECTS CURRENTLY TAUGHT BY THE
1988 SURVEY PARTICIPANTS

Subject	No. of Teachers	Percent of Teachers
Elementary Education	97	44
Science	68	31
Math	24	11
Language Arts	13	6
Social Studies	9	4
Special Education	6	3
Business	2	1
Other	33	15

The majority of the teachers (63%) are certified in elementary education, whereas 44% are certified in secondary education. These results add up to greater than 100% because some of the teachers have more than one area of certification (Table IV). Of the 220 teachers, 189 had continued their education beyond the Bachelor's degree. The highest degree/credit earned response was divided into six categories (Table V).

The largest percent of the respondents (53%) received their degree in elementary education. Of the remaining teachers, 36% received degrees in science and 11% received degrees in some other area (Table VI). One hundred and fifty-six (71%) of the teachers devoted 10% or less of their class time to the instruction of earth science. Only six teachers (3%) devoted more than fifty-one percent (51%) of their class time to earth science (Table VII).

The grades were separated into ten categories to show where the sample population devoted its effort. The most common levels of organization were 7-12 with fifty-nine (27%) responses and K-6 with fifty-three (24%) responses. The level of organization and responses are illustrated in Table VIII.

Results from Part A of the Survey

Of the 220 teachers who completed the survey, only 13 (6%) responded affirmatively that they taught remote sensing concepts in their classes. All 13 teach at the secondary level of education. If the participant stated that they taught remote sensing concepts, they completed PART A of the survey. The questions in PART A involved the perceived abilities or knowledge levels of the participants who stated that they did teach remote sensing concepts. The first part of each question required a YES or NO response. If the response was YES, the degree of need in the area of remote sensing was not needed. If

TABLE IV

TEACHING CERTIFICATES HELD BY THE
1988 SURVEY PARTICIPANTS

Area	No. of Teachers	Percent of Teachers
Elementary Education	139	63
Secondary Education	97	44
Middle School Science	15	7
Other	24	11

TABLE V

THE HIGHEST DEGREE OR CREDIT EARNED
BY THE 1988 SURVEY PARTICIPANTS

Highest Degree/ Credit Earned	No. of Teachers	Percent of Teachers
Bachelor's	31	14
Bachelor's +15	84	38
Master's	35	16
Master's +15	20	9
Master's +30	44	20
Doctorate	6	3

TABLE VI

THE COLLEGE OR UNIVERSITY MAJOR OF THE
1988 SURVEY PARTICIPANTS

Major	No. of Teachers	Percent of Teachers
Elementary Ed.	117	53
Biology	53	24
Physical Science	11	5
Chemistry	6	3
Geology	6	3
Physics	3	1
Other	24	11

TABLE VII

PERCENTAGE OF TEACHING LOAD DEVOTED TO EARTH SCIENCE
BY THE 1988 SURVEY PARTICIPANTS

Percentage of Time	No. of Teacher	Percent of Teachers
10% or less	156	71
11-25%	42	19
26-50%	16	7
51-75%	2	1
76-100%	4	2

TABLE VIII

GRADE LEVEL ORGANIZATION IN WHICH THE 1988 SURVEY PARTICIPANTS TAUGHT

Grade Level	No. of Teachers	Percent of Teachers
K-5	24	11
K-6	53	24
K-8	6	3
6-8	11	5
7-8	16	7
7-9	20	9
7-12	59	27
9-12	11	5
10-12	9	4
Other	11	5

the response was NO, respondents were asked to rate their need for instruction of remote sensing concepts as 1) no, 2) low, 3) moderate, or 4) high need. The responses of the 13 participants that completed Part A of the survey are presented in Table IX.

Results from Part B of the Survey

In Part B of the survey, completed by all 220 participants, the teachers were asked "If you have been or were given the responsibility of teaching remote sensing concepts, how much of a problem would be presented by each of the following?" The teachers answered 19 questions about perceived problem areas in remote sensing education. The results to Part B are presented in Table X. The information from this section of the survey was separated into three school organizational levels: K-5, 6-9, and 10-12. The grades K-5 were the responses of 116 teachers. There were eighty-four teachers in grades 6-9. Grades 10-12 consisted of 20 teachers. The information was separated into these levels to achieve a better understanding of in what grade levels these perceived problems may be of the greatest effect.

TABLE IX

THE RESULTS FROM PART A OF THE SURVEY
THE TEACHERS WHO DO TEACH
REMOTE SENSING CONCEPTS

	Questions	Knowledge of Remote Sensing		Level of Need			
		YES	NO	1	2	3	4
1.	techniques for working with students in small groups	7	6	0	1	5	0
2.	physical science content	7	6	0	3	3	0
3.	methods of measuring pupil readiness for learning	7	6	0	1	3	2
4.	sources of free or inexpensive science materials	5	8	0	0	2	6
5.	methods for teaching science using hands-on materials	7	6	1	0	2	3
6.	techniques for developing better science reasoning skills in students	5	8	0	3	3	2
7.	sources of special equipment for remote sensing instruction	3	10	0	0	4	6
8.	techniques for teaching a unit on geomorphology	1	12	0	3	6	4
9.	availability of library materials to supplement student's classroom learning	2	11	0	1	5	5
10.	techniques for developing student skills in creative thinking	7	6	0	3	2	1
11.	techniques for using computers to teach remote sensing concepts	1	12	1	1	6	5
12.	environmental science content	7	6	0	4	1	1
13.	earth science content	7	6	1	2	2	1
14.	proper use of science equipment	9	4	1	1	1	1

TABLE IX (Continued)

THE RESULTS FROM PART A OF THE SURVEY
THE TEACHERS WHO DO TEACH
REMOTE SENSING CONCEPTS

	Questions	Knowledge of Remote Sensing		Level of Need			
		YES	NO	1	2	3	4
15.	techniques for using computers to simulate lab activities	3	10	0	1	4	5
16.	techniques for making remote sensing meaningful to students	2	11	0	1	6	4
17.	general science content	10	3	0	2	1	0
18.	methods for developing student appreciation of remote sensing	3	10	0	3	5	2
19.	development of effective lesson plans pertaining to remote sensing	1	12	0	1	8	3
20.	simple demonstrations of remote sensing principles	3	10	0	1	4	5
21.	use of non-profit media (films) to supplement remote sensing instruction	1	12	1	3	4	4
22.	selection of appropriate remote sensing curriculum materials	3	10	0	2	4	4

TABLE X

THE RESULTS FROM PART B OF THE SURVEY
COMPLETED BY ALL OF THE
SURVEY PARTICIPANTS

Potential Problem	Grade Level	Percentage of Responses				No.
		1	2	3	4	
23. Lack of student interest	K-5	45	36	12	7	116
	6-9	45	37	13	5	84
	10-12	45	20	15	20	20
24. Lack of materials	K-5	5	17	34	44	116
	6-9	4	5	17	74	84
	10-12	5	35	40	20	20
25. Lack of teacher planning time	K-5	5	32	34	29	116
	6-9	14	20	35	31	84
	10-12	10	40	25	25	20
26. Inadequate facilities (classroom, lab)	K-5	28	13	29	30	116
	6-9	5	5	48	42	84
	10-12	5	15	30	50	20
27. Not enough time to teach remote sensing	K-5	10	19	40	31	116
	6-9	10	17	44	29	84
	10-12	10	20	35	35	20
28. Class size too large	K-5	23	30	30	17	116
	6-9	24	31	24	21	84
	10-12	65	25	5	5	20
29. Inadequate library (or instructional media lab)	K-5	9	13	38	40	116
	6-9	5	26	29	40	84
	10-12	15	15	25	45	20
30. Lack of audiovisual equipment	K-5	31	24	24	21	116
	6-9	39	27	17	17	84
	10-12	5	15	30	50	20
31. Lack of supplementary science books on the appropriate grade level for students	K-5	17	37	26	20	116
	6-9	5	11	49	35	84
	10-12	10	15	30	45	20

TABLE X (Continued)

THE RESULTS FROM PART B OF THE SURVEY
COMPLETED BY ALL OF THE
SURVEY PARTICIPANTS

Potential Problem	Grade Level	Percentage of Responses 1	2	3	4	No.
32. Lack of funds for purchasing remote sensing equipment	K-5	10	19	17	54	116
	6-9	4	8	10	78	84
	10-12	0	0	35	65	20
33. Lack of administrative support	K-5	30	27	28	15	116
	6-9	11	36	42	11	84
	10-12	10	5	45	40	20
34. Out-of-date teaching materials	K-5	12	25	22	41	116
	6-9	12	26	29	33	84
	10-12	10	20	25	45	20
35. Class ability range too wide	K-5	25	39	29	7	116
	6-9	24	37	26	13	84
	10-12	20	25	40	15	20
36. Lack of funds for purchasing consumable materials (chemicals, paper, etc...)	K-5	5	47	19	29	116
	6-9	0	10	30	60	84
	10-12	0	5	20	75	20
37. Limited teacher access to a computer	K-5	22	27	31	20	116
	6-9	21	24	31	24	84
	10-12	20	55	20	5	20
38. Lack of computer software available	K-5	4	26	35	35	116
	6-9	1	19	36	44	84
	10-12	5	15	30	50	20
39. Lack of audio-visual materials such as films, videotapes, and slides	K-5	11	50	28	11	116
	6-9	6	13	48	33	84
	10-12	0	5	25	70	20

TABLE X (Continued)

THE RESULTS FROM PART B OF THE SURVEY
COMPLETED BY ALL OF THE
SURVEY PARTICIPANTS

Potential Problem	Grade Level	Percentage of Responses				No.
		1	2	3	4	
40. Limited student access to computers	K-5	16	22	34	28	116
	6-9	14	24	36	26	84
	10-12	10	30	30	30	20
41. Lack of computers in the school	K-5	26	32	22	20	116
	6-9	25	30	24	21	84
	10-12	20	30	25	25	20

CHAPTER V

SUMMARY, CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine if the instruction of remote sensing concepts is occurring at the elementary and secondary levels of education. This assessment was facilitated through the administration of a Remote Sensing Survey (Appendix A) designed by the author. The research survey was trisectional, with the first portion comprised of demographic information. The second portion of the survey contained 22 questions about the perceived knowledge or abilities of those participants that stated that they taught remote sensing concepts in their classroom. The remaining portion of the survey contained 19 questions to assess the types of problems that occur in the instruction of remote sensing. This last portion of the survey was completed by all of the participants.

Three additional questions solicited ideas on:

1) questions not covered in the survey
2) knowledge of anyone who teaches remote sensing
3) suggestions for the incorporation of these concepts into elementary and secondary curricula

The responses in the third portion of the survey were separated into three school organizational levels: grades K-5, 6-9, and 10-12. This was done to better understand what level(s) of education experienced what specific problem(s).

Conclusions

The analysis of the data produced evidence to substantiate several conclusions about the level of remote sensing concepts that is being taught by the participating. The majority of teachers who completed the survey are not instructing students in the concepts of remote sensing. Only 13 of the 220 participants (9 percent) responded that they teach remote sensing concepts. This observation supports Kirman (1977) who stated that the uses of satellite imagery are most obvious to secondary level teachers. The greatest use and education of satellite imagery occurs at this level of education. Although it was shown in Kirman's 1977 study that students as low as third grade could work effectively with satellite images, the findings in this study confirm that education of remote sensing concepts are not being taught at the elementary level.

Nearly sixty-five percent of the teachers indicated that the lack of funds for purchasing remote sensing equipment and consumable materials was a major reason for not teaching remote sensing to their students. This problem arises in most school systems because, at this time, the cost of a standard paper Color I image (1:1,000,000) is $300.00 and these prices are on the rise. One surprising result of the survey that directly deals with the lack of funding was that only sixteen percent of the teachers viewed lack of administrative support as a problem. It would seem that if the school administration supported the teaching of remote sensing, funding would be available for purchasing images, equipment, and related supplies.

Eighty percent of the teachers believed that students are interested in satellite imagery. Although only three teachers were involved in Kirman's study, their statements that the students expressed great interest and enthusiasm in using the images represent previous confirmation of my observations. Whiteford (1985) stated that the interest demonstrated by the students result from allowing them to make their own investigations and discoveries. If this unique and different perspective is true, the students will become interested in satellite imagery if it is made available for examination.

Nearly sixty percent of the teachers stated that inadequate facilities, out-dated materials, or the lack of materials were major problems in the instruction of remote sensing. One major reason for this statement, as indicated by the survey results, is that few teachers are knowledgeable in the concepts of remote sensing and therefore have no need for this equipment. Moreover, most school systems do not have these facilities or materials because of the lack of funding. Over fifty percent of the teachers in grades K-9 reported that teachers and students have problems with access to computers. The teachers also stated that they have no computer software in their school systems designed for remote sensing. Prior to the transfer of the Landsat Program to private industry, NASA had published several pamphlets for using remotely sensed images as educational tools. Since this transfer took place, NASA has published very little information on remote sensing for educational purposes. Recently, joint efforts between government and private industry have produced laser discs that contain satellite images. One disc, with more than 1,600 Landsat images of the United States and over 400 international images, minimizes storage space and maximizes accessibility of remotely sensed images.

Greater than eighty-five percent of the teachers believe that they do not have enough teacher planning time or classroom time to teach remote sensing concepts. With the high activity loads demanded from teachers in the public school system, this response came as no surprise.

Limitations

This study was limited to teachers in the Johnson Space Center Region who attended summer workshops presented by the NASA aerospace educational services project. No stipulations were made concerning the level of instruction or curriculum area in which the teacher was involved.

Another limitation of this study was that the survey did not have any questions relating to the size of the school or school system that the participants taught in. This type of question may have given a clearer idea of where remote sensing concepts are being taught.

The results of this study are not generalizable beyond the population that was studied.

Recommendations

The data indicate that teachers have an interest in remote sensing but are not instructing students in the concepts of remote sensing for a variety of reasons. The lack of instruction might best be reversed if the following recommendations could be implemented. The most important step for implementation of remote sensing instruction into the curricula is to educate teachers about the curriculum value of these techniques. Teachers need to be informed how remote sensing can offer something to all academic subjects at all levels of education. I believe that education is the most important step because these individuals work directly with the students. Teachers "touch the future" and can shape the direction of education.

I believe that the best way to accomplish this task would be to develop a national educational center whose primary responsibility would be the development and dissemination of interdisciplinary classroom materials and activities about remote sensing. This center should be a cooperative educational effort among schools, universities, government agencies, and private industries. This cooperative agreement should aim to lower costs and at the same time increase technology transfer to the educational community.

The center would be responsible for the organization of workshops and mini-courses to provide teachers with a working knowledge of the fundamentals of remote sensing. This could be accomplished through lectures, related activities, computer simulations, and hands-on experiences. Remote sensing programs would also be designed to meet the special needs of teacher inservices and/or classroom presentations. The main objective of the teacher inservice and classroom presentations would be in the interpretation of the images and what information can be derived from an image. Interpretation would be stressed because this is the main use of images in class. This center would be a valuable resource for the evaluation of new technological equipment, in demonstrating specific educational applications of remote sensing, and in suggesting ways to integrate these concepts into educational curricula.

Another method of information dissemination would be with a comprehensive series of remote sensing related activities produced for educational television. Although this type of technology transfer removes the personal aspect of education, it has the potential to reach a larger audience and allows educators and students the ability to "see" things that otherwise might not have been possible. The main advantage of the educational center is as a central source for development and information dissemination of remote sensing educational ideas.

I also believe it would be best to have regional offices to help coordinate workshop activities for certain areas of the country. Kirman (1977) stated that teachers should begin by using regional images as a way to familiarize themselves with satellite images and remote sensing concepts. Teachers usually know more about the local area than about distant places and are more likely to teach about the local region. Moreover the users of local data can go on field trips to compare reality with the satellite image. Regional offices would be an invaluable resource to assist teachers with image selection.

The cost of satellite imagery is, perhaps, the greatest obstacle to the use of remote sensing in K-12 education. Purchasing images can become more financially feasible if several teachers from different disciplines agree on a certain number of images that they consider valuable for their specific subject(s). Choosing images that can be used in more than one subject may cut down on the number of images that are necessary for effective instruction. School administrations also need to get more involved. Until this level of school organization observes the benefits of remote sensing as an educational tool, funding for these types of equipment and materials will not occur.

Dissemination of the materials that are presently available should also be of top priority. Materials, such as Kirman's instructional ideas and Walsh's book with its already designed lesson plans, are the types of efforts necessary for the introduction of remote sensing concepts to K-12 curricula.

Further study of "spaceship Earth" will become increasingly important in a world of decreasing finite resources and increasing population and environmental problems. Studies, such as Kirman's, Walsh's, and this study, which provide some insight into the level of instruction of remote sensing concepts may act as "fuel on the fire" towards realizing that no other visual means is available to allow students and teachers to develop a keen awareness of the intricate interrelationships that exist in the real world environment. Future studies are needed to look at the costs for developing remote sensing packages or modules for instruction. Further studies should also be completed on determining the most effective method for instructing both students and teachers to work effectively with remotely sensed images. It is also recommended that future studies involving the use of remote sensing in K-12 curricula be expanded in scope, in population size, and in geographic distribution.

As Socrates stated in 450 B.C.

> Man must rise above the Earth - to the top of the atmosphere and beyond - for only then will he fully understand the world in which he lives.

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APPENDIX A

REMOTE SENSING QUESTIONNAIRE

CONFIDENTIAL

Use of Remote Sensing In Education
Dept. of Aviation and Space Education
Oklahoma State University
Summer 1988

1. School District Name: ________________________________

2. Town: ________________________

3. State: ________________________

4. Gender: ___ Male ___ Female

5. What grade level (s) do you currently teach?

   ___ K ___ 1 ___ 2 ___ 3 ___ 4 ___ 5 ___ 6
   ___ 7 ___ 8 ___ 9 ___ 10 ___ 11 ___ 12

6. How many years have you taught?

   ___ 0 - 2 ___ 3 - 7 ___ 8 - 12 ___ 13+

7. What subjects do you currently teach? Please check all areas that apply and list specific courses.

   ___ 1. Science ___ 2. Math ___ 3. Language Arts
   ___ 4. Art ___ 5. Social Studies ___ 6. Special Ed.
   ___ 7. Business ___ 8. All (elementary)
   ___ 9. Other

   ____
   ____

8. What is your area of certification?
   (check all that apply)

   ___ 1. elementary education ___ 2. secondary education
   ___ 3. middle school science endorsement
   ___ 4. other (please specify)

   ____
   ____

9. Highest degree/credit earned?

   ___ 1. Bachelors ___ 2. Bachelors +15 ___ 3. Masters
   ___ 4. Masters +15 ___ 5. Masters +30 ___ 6. Doctorate

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10. College or university major?

___ 1. elementary educ. ___ 2. biology ___ 3. chemistry
___ 4. physical science ___ 5. geology ___ 6. physics
___ 7. other

11. What percentage of your teaching load is devoted to teaching earth science?

___ 1. 10% or less ___ 2. 11 - 25% ___ 3. 26 - 50%
___ 4. 51 - 75% ___ 5. 76 - 100%

12. Grade level organization of the school in which you teach?

___ 1. K - 5 ___ 2. K - 6 ___ 3. K - 8 ___ 4. 6 - 8
___ 5. 7 - 8 ___ 6. 7 - 9 ___ 7. 7 - 12 ___ 8. 9 - 12
___ 9. 10 - 12 ___10. other

Do you teach remote sensing concepts? _ YES _ NO

If you answered **YES** please complete parts A and B. If you answered **NO** please skip part A and complete the survey beginning with part B

PART A

The following questions deal with perceived abilities or knowledge levels of teachers in the field of **REMOTE SENSING.**

Answer the first part of each question **YES** or **NO**. If you answer **YES, DO NOT** rate your degree of need in the area of remote sensing. If you answer **NO**, rate your degree for assistance or instruction by choosing a number, 1-4 indicating no, low, moderate, or high need. Please circle the appropriate number.

1 = no need
2 = low need
3 = moderate need
4 = high need

In my teaching of remote sensing, I have sufficient knowledge regarding:

	YES	NO	
1. techniques for working with students in small groups	___	___	1 2 3 4
2. physical science content	___	___	1 2 3 4

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		YES	NO	
3.	methods of measuring pupil readiness for learning	____	____	1 2 3 4
4.	sources of free or inexpensive science materials	____	____	1 2 3 4
5.	methods for teaching science using hands-on materials	____	____	1 2 3 4
6.	techniques for developing better science reasoning skills in students	____	____	1 2 3 4
7.	sources of special equipment for remote sensing instruction	____	____	1 2 3 4
8.	techniques for teaching a unit on geomorphology	____	____	1 2 3 4
9.	availability of library materials to supplement student's classroom learning	____	____	1 2 3 4
10.	techniques for developing student skills in creative thinking	____	____	1 2 3 4
11.	techniques for using computers to teach remote sensing concepts	____	____	1 2 3 4
12.	environmental science content	____	____	1 2 3 4
13.	earth science content	____	____	1 2 3 4
14.	proper use of science equipment	____	____	1 2 3 4
15.	techniques for using computers to simulate lab activities	____	____	1 2 3 4
16.	techniques for making remote sensing meaningful to students	____	____	1 2 3 4
17.	general science content	____	____	1 2 3 4
18.	methods for developing student appreciation of remote sensing	____	____	1 2 3 4
19.	development of effective lesson plans pertaining to remote sensing	____	____	1 2 3 4

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20.	simple demonstrations of remote sensing principles	____	____	1 2 3 4
21.	use of non-profit media (films) to supplement remote sensing instruction	____	____	1 2 3 4
22.	selection of appropriate remote sensing curriculum materials	____	____	1 2 3 4

PART B

<u>If you have been or were given the responsibility of teaching remote sensing concepts, how much of a problem is or would be presented by each of the following?</u>

1 = not a problem
2 = small problem
3 = moderate problem
4 = big problem

23.	Lack of student interest	1	2	3	4
24.	Lack of materials	1	2	3	4
25.	Lack of teacher planning time	1	2	3	4
26.	Inadequate facilities (classroom, lab)	1	2	3	4
27.	Not enough time to teach remote sensing	1	2	3	4
28.	Class size too large	1	2	3	4
29.	Inadequate library (or instructional media lab)	1	2	3	4
30.	Lack of audiovisual equipment	1	2	3	4
31.	Lack of supplementary science books on the appropriate grade level for students	1	2	3	4
32.	Lack of funds for purchasing remote sensing equipment	1	2	3	4
33.	Lack of administrative support	1	2	3	4
34.	Out-of-date teaching materials	1	2	3	4
35.	Class ability range too wide	1	2	3	4

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36.	Lack of funds for purchasing consumable materials (chemicals, paper, etc...)	1	2	3	4
37.	Limited teacher access to a computer	1	2	3	4
38.	Lack of computer software available	1	2	3	4
39.	Lack of audio-visual materials such as films, videotapes, and slides	1	2	3	4
40.	Limited student access to computers	1	2	3	4
41.	Lack of computers in the school	1	2	3	4

---

42. Please describe any problems that teachers may have that are not mentioned above

____

____

43. Do you know of anyone that is teaching remote sensing concepts?

___**YES** ___**NO**

If you answered **YES**, please list his or her name and address so they may be contacted.

____

____

____

____

44. Do you have any suggestions or innovative ideas on how teachers can use remote sensing materials and/or techniques in classroom situations?

____

VITA [2]

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