AN EVALUATION OF THE USE AND FUTURE NEED OF REMOTELY SENSED IMAGES IN GRADES K-12

By

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Man is a creature who wants to know where he is. Significant to this knowledge is the fact that not only has our journey into space allowed us to set foot on the moon and explore the outer reaches of our solar system, but they have enabled man to literally set eye on the earth. Man is able for the first time to develop a true perspective of that beautiful wet, blue ball, as Archibald MacLeish described it, which possesses the millions upon millions of conditions that exist in that precise and exquisite combination that make life possible (Michener, 1976).

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CHAPTER I

INTRODUCTION

"For the present generation of human beings, the continuing search for new knowledge of our planet has been particularly exciting. From an extraordinary burst of research findings over the past 30 years, our view of the Earth has been totally transformed. An earlier notion of a static, placid planet has been swept away, replaced by the dynamism and drama of plate tectonics. Enormous sections of the crust of the Earth, formed at mid-ocean ridges, float upon the convective mantle of the Earth, jostling against neighboring plates until ultimate subduction back to the Earth's interior along continental plate boundaries. Patterns of mountain building, volcanism, and earthquake activity all fit consistently into this theory. Plate tectonics, has for the first time, provided a unified, coherent description of a Earth (National Aeronautics and Space Administration, 1986)."

"The past several decades have also seen advances in our knowledge of the fluid Earth. The oceans, atmosphere, and ice covered regions of the planet are now recognized as being closely linked to weather and climate. Aided by satellite observations of global temperature, moisture, and cloud cover, scientists have constructed numerical models of the atmosphere that have begun to provide reliable predictions of general atmospheric circulation (NASA, 1986)."

The biosphere is recognized as a major influence on global processes. Ocean biota have an important effect on climate through net removal of atmospheric carbon dioxide during formation of ocean sediments. Ocean biota and land ecosystems participate in the global cycles of chemicals essential to life. Land biota can also affect climate through important influences on albedo and water cycling.

Global observations of the surface and atmosphere from space began with the launch of the first experimental satellite in 1960. The first operational series of polar-orbiting weather satellites began in 1966, and a series of environmental satellites became operational in 1974. These satellites have permitted continuous global recording of temperature, cloud cover, and other atmospheric variables to supplement an increasingly refined series of measurements made from the ground and within the atmosphere itself (NASA, 1986).

"Studies of the land and ocean have produced additional benefits within the past generation. Research into crustal movements and plate tectonics has identified regions of potential volcanic and earthquake activity and has begun to develop predictors of these events. We have acquired a better understanding of the origin and distribution of Earth resources, including vast quantities of petroleum, natural gas, and mineral deposits. Spacecraft observations of the ocean have led to the identification plankton-rich regions and productive time periods important to the aquatic food chain (NASA, 1986)."

"Human activity has caused significant changes on a global scale within the span of a few generations. The burning of fossil fuel is injecting carbon dioxide into the atmosphere at unprecedented rates. The atmospheric concentration of this gas has increased nearly 25 percent since the Industrial Revolution, and by over 10 percent since 1958; at this rate it will double within a century (NASA, 1986)." At the present rate of increase of atmospheric carbon dioxide, climate models predict an average surface temperature increase of 2°C during the next century. Spacecraft have also recorded a continuing increase in a number of other "greenhouse gases", including methane, chlorofluorocarbons, and tropospheric ozone. Although the concentrations of these trace species are presently much less than that of carbon dioxide, they are increasing at a faster rate.

A variety of remote sensing satellites, initiated and operated by the National Aeronautics and Space Administration (NASA) and the National Oceanographic and Atmospheric Administration (NOAA), provide us with the unique opportunity to view the Earth and to continuously observe and measure the solid, fluid, and biological forces acting on our planet (Summers, 1982). Some of the most successful projects have involved meteorological/environmental satellites that are designed to send pictures and other data back to receiving stations on Earth.

Unfortunately, much of this knowledge that has been acquired from technology is not being transferred to students in elementary and secondary schools. Remotely sensed data holds promise of helping students become more aware of the world in which they live. If this awareness can be considered a basic objective in education at all levels, educators must find realistic and efficient approaches to accomplish the objective.

Need for the Study

During the summer of 1988, this author conducted a survey concerning the use of remote sensing as an educational tool in elementary and secondary schools. The objective of this study was to determine if remotely sensed images were being used in grades K-12. Surveys were distributed to 220 teachers attending summer workshops on aerospace education. These surveys were completed and returned directly to the Aerospace Education Specialist conducting the workshop (Allen, 1989).

The results from this study indicated little use of remotely sensed data in grades K-12. Of the 220 teachers that participated in this study, less than ten percent responded that remotely sensed data were used by their students. Nearly sixty-five percent of the survey population indicated that lack of funds for purchasing remotely sensed materials was a major reason for the lack of instruction. The accessibility of remotely sensed data limits development as an instructional tool (Allen, 1989).

During the Spring of 1990, this author was involved with two colleagues in identifying and describing eight remotely sensed images which appeared as inserts in the Journal of Geography (Vol.89, No.3 through Vol.90, No.2). The target group for these images were teachers and students in 7-9th grade. The purpose of these images was to introduce teachers and students to the benefits that remotely sensed data have to offer as educational tools. These 8x10 inch images, with a corresponding description on the backside, were inserted within the Journal of Geography and mailed to over 3,600 subscribers. Approximately 1,000 of these subscribers teach in grades K-12 nationwide. Additional images are available at a low cost to encourage teachers to order copies for use in their classroom.

To educate young people for the future by using only those tools and techniques which are most comfortable and secure, or by transmitting only information which is familiar is misleading. 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, the environmental changes taking place, and how they must participate as decision-makers in the future.

Purpose of the Study

The purpose of this study is to determine: **If educators in grades K-12 had access to remotely sensed images, would they use them in instructional projects**. The study will determine what training educators need to teach concepts with remotely sensed data. Also, an assessment will be made to understand what limits the use of remotely sensed data and how can this problem be resolved. Teacher responses and their recommendations on using remotely sensed images as educational tools may prove useful in the development of classroom materials and educational programs. A series of computer searches and an extensive search of the literature revealed little evidence that this technology is available to elementary and secondary level teachers.

A survey was developed for distribution to a random sample of teachers who subscribe to the Journal of Geography. Teachers taking this survey were asked to answer several questions about remote sensing and their perception of remote sensing as an educational tool. The participants were also asked to evaluate the images they received in the Journal of Geography. The participants were asked to make recommendations on how remote sensing could be introduced to their students, and if they have used the images in the Journal in their classroom. Teacher response to this survey will help the NASA Aerospace Education Services Program and the National Council for Geographic Education (NCGE) evaluate this process of disseminating information and to decide if future endeavors can enhance aspects of K-12 education with remotely sensed images.

Statement of the Hypothesis

It is proposed that educators would use remotely sensed images if:

1. they were taught the usefulness of remote sensing as an educational tool and shown how to use imagery effectively;
2. if remotely sensed images were readily available and reasonably priced; and
3. if educators were given curricula to integrate remote sensing into their existing classes.

Assumptions

The following assumptions were made:

1. the participants responded honestly to the survey questions.
2. the participants were randomly chosen.
3. the data gathered were non-biased.
4. the data collection instrument was valid.

Limitations

Limitations of a study can exist relative to the sample, the questionnaire, and the statistical analysis. In a descriptive survey, bias can occur in the findings because of the absence of information from non-respondents. An instrument which relies on checks and short responses for information, although conducive to high responses, imposes limits upon the respondent and hinders their freedom of response. Whether asking the respondents to choose any suggested answer will cause bias remains a matter of conjecture. To help minimize this possibility, free responses were encouraged in part of the questionnaire.

The study was limited to teachers who receive the **Journal of Geography**. Belonging to the NCGE represents a level of professionalism because teachers elect to join and pay dues and therefore are concerned about enhancing their knowledge and their ability to perform their duties. No stipulations were made concerning the level of instruction or curriculum area in which the teacher was involved.

Brief Description of the Aerospace Education Services Program

The Aerospace Education Services Program (AESP) is one means through which NASA fulfills a requirement of the National Aeronautics and Space Act of 1958 to "provide the widest practicable and appropriate dissemination of information concerning its activities, and results thereof". Through this program, schools throughout the United States receive quality aerospace educational programming. The AESP is the continuation of a former educational outreach program known as "Spacemobile" which began in 1961 in conjunction with the Mercury manned-space program. The Spacemobile program was initiated by the Public Affairs Division of NASA Headquarters to acquaint schools with current aerospace research and programs. The AESP provides, free of charge, the professional services of a aerospace education specialist, demonstration equipment, and visual aids to teachers, students, and the general public. These specialists are professional educators 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 how these developments affect the world in which we live (NASA/AESP Brochure).

The National Council for Geographic Education

Mission Statement

The National Council for Geographic Education is a non-profit organization chartered in 1915 to enhance the status and quality of geography teaching and learning (NCGE, 1991). To meet this mission the NCGE:

- Develops coherent programs and policies for all aspects of geographic education
- Develops, publishes, and promotes the use of curriculum, resource, and learning materials
- Enhances the preparation of geographic educators with respect to their knowledge of content, techniques, and learning processes
- Encourages and supports research on geographic education
- Publicizes the importance and value of geographic education
- Cooperates with other organizations that have similar goals

Definition of Terms

Albedo - The ratio of the amount of electromagnetic radiation reflected by a body to the amount incident upon it, often expressed as a percentage, e.g., the albedo of the Earth is 34 percent.

APT - Automatic Picture Transmission

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

Chlorofluorocarbons - synthetic compound; carbon-linked chlorine, fluorine, and bromine molecules.

Color - That property of an object which is dependent on the wavelength of the light it reflects or, in the case of a luminescent body, the wavelength of light that it emits.

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

Electromagnetic Radiation - Energy transmitted through space or through a material medium in the form of electromagnetic waves. Whenever an electric charge oscillates or is accelerated, a disturbance characterized by the existence of electric and magnetic fields propagates outward from it. This disturbance is called am electromagnetic wave. The frequency range of such waves is broad and is known as the **Electromagnetic Spectrum**.

EOS - Earth Observation System

EOSAT - Earth Observation Satellite Company

EOSDIS - Earth Observation System Data and Information System

EROS-DC - Earth Resources Observation Systems-Data Center

ERTS - Earth Resources Technology Satellite (now LANDSAT)

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

GOES - Geostationary Operational Environmental Satellite

Ground Truth - Data/information obtained on surface/subsurface features to aid in interpretation of remotely sensed data.

HRPT - High Resolution Picture Transmission

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.

Micrometer - A unit of length equal to one-millionth (10^{-6}) of a meter or one-thousandth (10^{-3}) of a millimeter.

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.

MSS - Multi-Spectral Scanner

Nadir - The area directly below the observer.

NASA - National Aeronautics and Space Administration

NASA/AESP - NASA/Aerospace Education Services Program

NCGE - National Council for Geographic Education

NOAA - National Oceanic and Atmospheric 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.

Pixel - A data element having both spatial and spectral aspects; the spatial variable defines the resolution while the spectral variable defines the intensity of the spectral response.

Polders - Areas of low-lying land reclaimed from the sea, lake, or river, as by the building of dikes.

Radiation - The emission and propagation of energy through spaces or through a material medium in the form of waves; the emission and propagation of electromagnetic waves or of sound and elastic waves.

Remote Sensing - For the purpose of this study, remote sensing will be defined as "images or photographs of the atmosphere or physical features of the Earth that are created by the acquisition of data by airplane, satellite or spacecraft".

Resolution - The minimum distance between two or more adjacent features or the minimum size of a feature that can be detected and separated from its surrounding features.

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

TIROS - Television and Infrared Observation Satellite

TM - Thematic Mapper

USGS - United States Geological Society

CHAPTER II

REVIEW OF LITERATURE

Introduction

"We are privileged to live in an extraordinary age of scientific research. We are probing the structure of the fundamental particles of matter, unraveling the genetic code of life, exploring the outer planets of our Solar System, and pushing back the frontiers of astronomy to the beginning of the universe (NASA, 1986b)."

The study of the earth reveals wonders which impact fundamental understanding about where we live. Remotely sensed data holds promise of being an important educational tool in helping students become more aware of the world in which they live. How this technique is being used in K-12 education was the focus in the literature review, which included:

- A background of remote sensing.
- A brief history of remote sensing techniques which include aerial photography, space photography and satellite imagery.
- Previous educational studies which include the use of remotely sensed materials with students in grades K-12 and teacher education and preparation.
- Remotely sensed materials developed for grades K-12.
- The cost of remotely sensed imagery and its effect on classroom use.

- A 1988 assessment of the use of remote sensing by teachers and students grade K-12.
- A brief description of remote sensing education in NASA's Technology Transfer Program.

Background Information for Remote Sensing

Remote sensing is the name given to the technique of measuring information about a subject of interest without being in direct contact with that object. This technique relies on detecting electromagnetic radiation which is either reflected or emitted by the object. When applied to the earth as seen from the air or orbital altitudes, remote sensing has demonstrated the potential of yielding information which is of fundamental importance for the effective use and conservation of natural resources in both developing countries and technologically advanced nations (NASA, 1973b).

Bodechtel and Gierloff-Emden have called remote sensing the third discovery of the earth. They refer to voyages of exploration and discovery of continents outside the Mediterranean as the first phase, whereas the second discovery alludes to the work of such scientific adventurers as Livingstone and von Humboldt who explored much of the interior of Central Africa and Middle and South America, respectively. The third discovery of the earth has its beginnings in the development of non-terrestrial recording techniques, including aerial photography and satellite imagery (Bloemer, 1981).

Remote sensing is not new to humankind. Four of the five senses that humans possess are remote sensors, acquiring data concerning an object from a distance. The olfactory senses react with molecules given off by the object, providing odor detection. The ear detects pressure pulses. The skin has pressure and temperature sensors that do not require contact, and the eyes are sensitive to electromagnetic radiation in the 0.4 to 0.7 micrometer region (the visible spectrum).

To improve upon their data gathering techniques, humans can do two things:

- Better utilize their sensing devices (i.e., go to the top of a hill for a better view, get an aerial view), or

- Develop instruments with greater sensitivity than their own fairly limited senses.

Aerial photography, space photography and satellite imagery are examples of a combination of both of these improvements.

Aerial Photography

Our view of Earth was limited for centuries to what we could see as we moved about the surface. With the advent of flight, a new world emerged. To document this new world, photographers went up in balloons as soon as they, and their rapidly improving cameras, could be accommodated. The first aerial photographs were taken of Paris in 1858 from a hot air balloon. This technique was first used in the United States in 1860 to capture an image of Boston. General McClellan used aerial photographs to evaluate the Confederate strength at Richmond. Soon after the Civil War, cameras designed to take pictures automatically were sent aloft on balloons, kites, and even tied to pigeons. With the invention of the airplane in 1903, another Earth viewing platform was created; its reconnaissance gathering capabilities played critical roles in World Wars I and II (Good, 1982)

This new aerial view of the Earth was awesome. Rivers seemed to be ribbons of light flickering in the sunlight; forests became green carpets; and mountains showed the rhythmic signs of the Earth's contortions (Good, 1982).

In the early 1950's, cameras were sent high into the thin reaches of the atmosphere as the accelerated development of rocketry was pursued. The launch of Sputnik into orbit by the Soviet Union in 1957 ushered in the space age (Spenser, 1982).

Space Photography

The space program has allowed us to look at the Earth from a unique perspective. From the beginning of manned spaceflight, astronauts viewed Earth with interest, and photographed as many scenes as possible to record their experiences (Amsbury, 1989). Photographs of the whole Earth that were taken by the Apollo astronauts from the vicinity of the moon created new feelings and thoughts. These photos vividly portrayed the Earth as a small, seemingly fragile planet floating in the vastness of space (El-Baz, 1982). The results from Projects Mercury through Gemini to Skylab and Apollo-Soyuz is a legacy of some 38,000 photographs of the Earth which are available to the public (Amsbury, 1989).

In mission after mission, photographs taken from space revealed a great deal about the Earth, its landforms, and its natural resources. The National Aeronautics and Space Administration (NASA) reinstituted orbital photography of the Earth during the first Space Shuttle flight in April, 1981, following a six-year hiatus since the Apollo-Soyuz mission (Helfert, 1989). Today, we see an increasing emphasis throughout the world on the use of space photographs as a tool for resource development as well as environmental monitoring (El-Baz, 1982).

TABLE I

NASA ASTRONAUT SPACE PHOTOGRAPHY

Program/ Mission	Date(s)	No. of Photos	
Mercury	1961-63	400	
Gemini	1965-66	2520	
Apollo	1968-72	2138	
Skylab	1973-74	40,767	*
Apollo-Soyuz	1975	751	
Space Shuttle	1981-86	38,176	
Total		84,752	**

*Note 1 - This number includes both handheld (about 1800 frames) and S-190A photography during the three Skylab missions.

** Note 2 - About 10% of these photographs document mission activities; the remaining 90% are of the Earth.

Satellite Imagery

Orbiting high above the Earth, satellites can capture images of any area on our planet's surface. From this remote perspective, these images reveal far more than regular photographs. This "eye in the sky" provides us with detailed information, the uses of which are becoming more common and valuable as the technology continues to evolve.

Every surface of the Earth receives solar radiation which is either reflected, or absorbed and emitted in specific wavelengths, some of which are invisible to the human eye. Each surface has a "spectral signature" made up of specific wavelengths which can be recorded by special sensors on the satellite. Energy received from a surface is recorded in digital form. These digital arrays are transmitted to earth and processed into images that have photographic quality.

Each image is composed of thousands of individual picture elements, called pixels. Each pixel contains a single unit of information which represents the spectral signature of an area on the surface. The ground area covered by each pixel determines the resolution, generally equivalent to the dimensions of the smallest detectable object on the image. For Landsat MSS and TM data the resolutions are 80 m and 30 m respectively. The French satellite SPOT has 10 m resolution in the "panchromatic" (black and white) mode and 20 m resolution in the color infrared mode. The NOAA Advanced Very High Resolution Radiometer (AVHRR) has a ground resolution of 1.1 km at nadir. The information content of a pixel, in digital form, can be analyzed by computer or converted to images for visual analysis.

Remote sensing satellites are capable of providing images for large areas on the surface. Images can be acquired of any location, including those which are otherwise inaccessible for any reason.

The value of remotely sensed data has always been recognized in a wide variety of environmental disciplines, particularly those involving planning, management and development of human or natural resources. Disciplines for which remote sensing has traditionally played a valuable role are geology, hydrology, forestry, agriculture, cartography and land use/urban planning.

In 1957, Sputnik alerted the people of the United States that the American educational system was deficient. This event captured our attention so strongly that a reform movement was initiated which increased the science and mathematics in our schools. Many of the science and math educators, scientists and mathematicians today are products of that reform (Tillery, 1988).

The result of increased math and science education in the past two decades is a technology so rich and varied the quality of life in America in the 1980's is viewed as wonderful throughout the world. To maintain quality, however, mathematics and science skills must be improved to ensure continued American involvement in world technology (Stevenson, 1987).

Educational Studies

The recognition of objects and geographical areas, when presented in an aerial photograph, involves rotation from a horizontal to an orthogonal view of the landscape, reduction in scale, and abstraction to semi-iconic signs. These skills are developed as the child acquires shape constancy, size constancy, and the ability to recognize a generalized pattern. Because these operations are essential, one could predict that young children should be able to interpret aerial photographs, and also be able to work with cartographic maps (Spencer, 1980). Aerial photographs can provide detailed information about the landscape and are therefore an important component in geographical and environmental education, both in primary schools (Catling, 1981; Dale, 1971; Glendinning and Pearson, 1983) and in secondary schools (Barnett and Carswell, 1970; Boardman and Towner, 1980; Rumney, 1982).

Aerial photographs may be a transitional step between the real world and a conventional map because interpreting an aerial photograph requires some but not all the processes which have been assumed to be involved in reading a topographic map (Riffle, 1969). An aerial photograph involves reduction in scale, a degree of abstraction (for instance, in an aerial photograph houses are "represented" by roofs rather than by a three dimensional shape) and they also require some appreciation that the world can be pictured from above. On the other hand such photographs do not select and simplify the environment, nor do they include conventional symbols and labelling as do maps (Blades et al, 1987). A map shares with aerial photography the transformations of projection and reduced scale, but is a complete symbolic representation of reality whereas the photograph is reality (Spencer, 1980).

Spencer (et al,1980) argues that by presenting pre-school children with tasks which involve recognition rather than performance, one can demonstrate that young children have considerable ability to view and interpret the world in relation to oneself.

B.E. Kingston (1969) introduced aerial photographs to children in grades one, two, and three. Kingston concluded that children in these grade levels were able to work with aerial photographs, but that students may encounter problems with interpretation without having previous instruction (Kirman, 1977).

In a study conducted by K.G. Dueck (1969), children in grades four, five, and six were introduced to aerial photos. This study concluded that children in these grades possessed the capability to 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).

The geographers, Blaut and Stea (1969), presented a series of aerial photographs and maps to children in Puerto Rico and the United States, asking each child to name anything they could see in the display. They found that children of preschool age could recognize two or three elements accurately on the aerial photographs.

Blaut, McCleary and Blaut (1970) tested North American children's ability to understand aerial photographs. They showed more than 100 children (aged 6 years) photographs of two areas which were unfamiliar to the children. One was a small town and surrounding countryside in a color aerial photograph taken from an oblique angle, and the other was a residential suburb in a black and white vertical aerial photograph. The children were asked to name and point to any feature which they could recognize in the photographs. Virtually all the children recognized the photographs as views of the landscape, and on the average were able to identify more than six features (such as cars, roads, houses, trees, grass, etc) on each photograph.

Spencer, Harrison and Darvizeh (1980) tested 3 to 5 years old children with six vertical aerial photographs and also two "perceptual maps". The latter are oblique cartographic views of particular cities with selected landmark buildings and features shown in three dimensions to help tourists find their way and orient themselves. The children saw all the photographs at the same time, were allowed unlimited time to look at them, and were encouraged to talk about them. A close correlation was established between the children's performance with the photographs and maps. Overall, they identified between 6 and 25 features. The children commented on the differences between town and country areas on the same or across different photographs and were particularly good at recognizing roads, trees, rivers, houses, railways, parks, and cars. Fewer children referred to features such as hills or fields. In describing the photographs the children often utilized contextual cues (for example, having identified a road they would then pick out cars on the road). In other words, having recognized one feature they could often identify others from it.

Three and four year old children may not be able to explain the perspective, or how the picture was made. Yet, in working with even younger children, we have come to the conclusion that linguistic ability is the limiting factor in investigating the earliest age at which children can interpret and use iconic representations of familiar geographical features from perspectives they have not seen (Spencer, 1980).

The results from these studies seem to confirm that preschool and elementary level children have some ability to understand aerial photographs and possess some 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, J.M. Kirman (1977) conducted a study on the use of Landsat images by students and teachers in grades 3, 4, and 5. The rationale for undertaking this study with elementary level children was that Landsat images were a new social resource, and the prime researcher was curious as to whether or not it could be used by young children. In addition, it might be presumed that secondary level students would probably be able to cope with many aspects of Landsat images, no such presumption could be made freely for elementary level students, given the magnitude of the scale involved. Hence, if such relatively young children could cope with these images, the potential for early introduction of them might be discerned (Kirman, 1977).

The results of Kirman's study demonstrated that the children were able to derive information from the satellite images. Even children with visual problems, including those wearing glasses or with color blindness, were capable of working with Landsat images.

Harnapp (1982) conducted a study with fifth grade students and concluded that these students were capable of working with satellite images. For this study two false color composites were obtained for the northern region of Ohio. The student had no previous experience with remote sensing principles or interpretation of satellite images. Following a pretest, students learned factual information concerning image production and interpretation. The students then applied this information to the images by classifying geographic features and producing various land cover maps using an overhead and transparencies.

At the conclusion of the unit, students were given an achievement test using two satellite images not previously seen by the students. The class performed much better on interpretive techniques than on general information. Students became proficient in identifying water, forests, urban areas, and transportation routes. The post-test marked a 100 percent improvement over the pretest. Harnapp believed that the increase in price of satellite images placed the future use of these material in elementary classrooms in doubt.

During the summer of 1984, two workshops, sponsored by the National Science Foundation, were conducted at Oklahoma State University. These workshops were designed to contribute to earth science education by introducing earth science teachers to remote sensing, a tool that could aid in the study of earth and its resources. The workshops stressed the fundamentals of remote sensing and the latest techniques and strategies in resource assessment and management. 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 curricula (Walsh, 1984).

These workshops were designed to present a framework within which concepts and techniques of remote sensing technology, specifically, Landsat-satellite data, could be transferred to middle and secondary-level earth science teachers through a five-day workshop format (Walsh, 1984).

Orbital imagery for the study of large areas of topography, where ground photos and normal aerial photography are inadequate, is an ideal instructional method in secondary schools. It often leads both students and teachers to a new perspective of our planet. During one particular lesson a 10th grade student literally jumped up from her seat while viewing a Meteosat image of Europe and exclaimed loudly, "Yes, now I see it! That's what Europe really looks like...and Italy *really is* a boot!" (Becker, 1989).

By using spaceborne imagery and corresponding line-art maps, Becker (1989) believes students can study major topographic or political features in a particular area. Becker believes this is especially useful for processes such as poldering in the Netherlands. Polders stand out visibly in a Landsat image, the students can even follow the developmental process by labeling and coloring corresponding line-art maps. Students eight and nine years old have no difficulty learning Landsat or GOES satellite instrumentation, understanding the digital telemetry process, or memorizing the basic infrared color code and applying it to image interpretation (Becker, 1989).

For secondary school students, often the most exciting and meaningful activities are interpreting satellite imagery in infrared and false color renditions, and tracking weather conditions. Students enjoy this kind of work because they have a chance to learn how to think individually and to arrive at a more stimulating real-life end-product (Becker, 1989).

During the summer of 1990 the Department of Aviation and Space Education at Oklahoma State University conducted a three week summer academy on aerospace education. Thirty high school students (juniors and seniors) were selected to participate in this academy. Several topics concerning aviation and space were covered, one of these topics being remote sensing.

The students were administered a pre-test that consisted of 10 questions concerning the principles of remote sensing (Appendix C). The students were then introduced to some basic principles of remote sensing. Some of the principles included were the electromagnetic spectrum, false color imagery and why it is used, active vs. passive scanning systems, characteristics of the Landsat-satellite system (history, orbit, resolution), effects of time on image acquisition, and the conversion of digital imagery to reality. Following the introduction the students were asked to answer 28 questions concerning the eight remotely sensed images that had been distributed by the Journal of Geography (Appendix D). The students showed great interest in these images and had little problems in answering the questions.

Lastly, the students were administered a post-test. To analyze the the data, the parametric t test ascertained if there was a significant difference between the pre-test and post-test scores. The data showed a positive change by increase in mean score. Information presented in Table II shows the average score achieved, out of a possible 100 percent. The difference in mean score was found to be significant at the 95% level.

TABLE II

PRETEST/POSTTEST RESULTS FROM THE 1990 OSU AEROSPACE SUMMER ACADEMY REMOTE SENSING UNIT

	Number	Mean	Change	Standard Deviation	t	Level of Significance
Pre-test	30	49				
			+25.33	3.32	7.63	.05
Post-test	30	74.33				

Teacher Education and Involvement

A major conclusion of Kirman's 1977 and 1984 studies involved the ability of the teachers to effectively use remotely sensed data in the classroom. Because of the uncertainty and lack of familiarity with Landsat images by the teachers, the researchers recognized that a more extensive preparatory 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. Kirman (1981) believes teachers in the field can be expected to be hesitant in using these images because of their lack of familiarity with them. It is difficult for a teacher used to hand-drawn maps with colors and symbols to suddenly have to work with a new "map" with strange colors not necessarily corresponding to natural 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 in-service 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.

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).

The realization of the future benefits derived from Earth Observation from space depends on the creation of a national appreciation of the possibilities which now exist and the potential of developments now taking place. This appreciation can only be created and fostered by harnessing the powers of the national educational system at all levels (Gathercole, 1987).

By its nature earth observation from space is multi-disciplinary and no one academic subject has a monopoly such that it can serve as a vehicle for the dissemination of knowledge in this field. At the secondary level it requires at least the cooperation of the teachers in physics and geography, the former to cover the underlying scientific principles, the latter to interpret the Earth surface features displayed (Gathercole, 1987).

Becker (1989) believes the training of teachers should be a major priority of remote sensing industries because the education community cannot accomplish the task on its own and the skills of the information processing economy are not being taught to teachers.

Remote sensing technology works hand-in-hand with the information processing economy in the creation of database systems, monitoring Earth systems, and the use of digital imagery as a disciplinary tool. Becker (1989) states that every teacher he has trained in the use of remote sensing skills which they can take back to their classroom has been astonished at the simplicity of the technology and the broad range of application to everyday classroom subjects they are already personally teaching.

Remote sensing for geography and geology led Becker to construct a visual system for teacher training to compare three different types of valuable imagery for the same region: (1) on-site ground truth photos, (2) normal aerial photo-reconnaissance imagery from low-flying aircraft, and (3) satellite digital data imagery. The result is an instructional method Becker has named "Three Dimensional Perspective in Reality", illustrated in Figure 1, which has immediate application for students from 4th grade through upper graduate levels, and with the adult public (Becker, 1989).

This system allows a viewer to see the same region from three different levels - ground level, aircraft (3 to 16 km), and satellite (800 km). For teacher training, where adults have had a much broader real-life geography experience, the system is proving to be a remarkable aid in remote sensing studies (Becker, 1989).

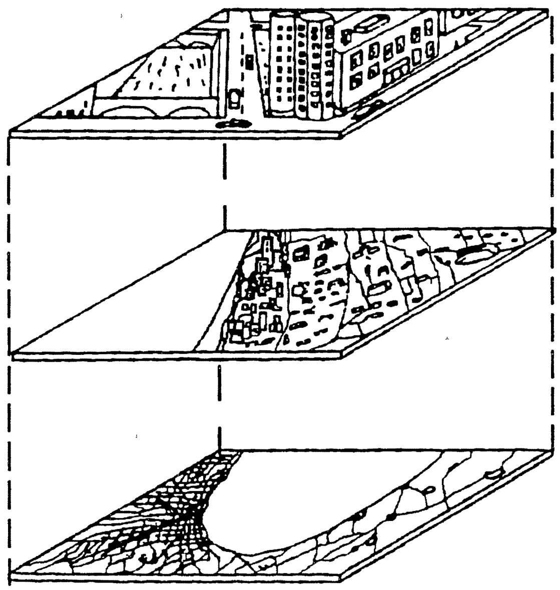


Figure 1. Schematic of the "Three Dimensional Perspective in Reality" concept. The teaching method permits students to see the same region in three interrelated views.

Becker (1989) states that there must be a cooperation between industry and education to provide remote sensing as an important educational tool to teachers and students. Employees in the industry liaison office devoted to education can learn much by working hand-in-hand with educators instead of ignoring them, or by hiring competent professional teachers. Industry employees, once they understand the basic needs of an educational system and the daily classroom teacher, can assist in different ways:

- training of public school administrators,
- teacher training in technologies and applications,
- simple re-formatting of products for better classroom use,
- general community support through television and print media,
- plant tours and update briefings for teachers,

- advice and assistance in the preparation of specific classroom materials, and
- internships during off-school hours.

Space-intensive companies can go one step farther by making kits of information available to teachers and school districts, sending news releases to schools requesting them, and furnishing visual materials to teachers at cost plus mailing and packaging costs. National space agencies can announce educational programs and materials through educational publications or in the general media (Becker, 1989).

Educational Materials Developed for Using Remotely Sensed Data in Grades K-12

In 1973 the first educational activity booklet for remote sensing , Earth Resources: Workshop Activities and Information, was prepared for the NASA Educational Programs Division. This booklet provided information and workshop activities concerning the Earth Resources Technology Satellite (ERTS), now known as Landsat, for junior high and high school students. This publication has been continuously revised to keep up with the technological changes that have affected earth observation and the Landsat program. This publication is now named Observing The Earth From Space: Information and Activities and is currently available from NASA Headquarters (NASA, 1988a).

The years 1976-1978 appear to be the peak for the development of educational materials for remotely sensed data. During this time period the Educational Programs Division of NASA produced several two to three page activity sheets for using remotely sensed data in grades K-12 (Appendix B).

These educational activities utilized images that became available with the publication of Mission to Earth: Landsat Views the World in 1976. The basic objectives of these materials was to allow students to gain some experience in utilizing false color infrared Landsat imagery to study a relevant topic (geology, water resources, etc..). This was usually accomplished by the student tracing a designated image outline and having them identify certain features.

In 1976 NASA, in conjunction with The Public Schools of Jefferson County, Colorado, published What's the Use of Land? This publication was one of the first efforts in social studies teaching to show how NASA's space observations can integrate with other data sources in social studies, as well as in environmental science. It is a valuable, pioneering effort in curriculum literature of the social studies (NASA, 1976b).

The prime objective of What's the Use of Land? was to stimulate in the mind of the educational reader an awareness of the role that can be played in educational programs by information generated in advanced technology programs, such as aircraft or spacecraft land surveys. A second objective was to show the reader how to get the information needed and suggest ways in which the information could be applied (NASA, 1976b).

Using data from such programs, educational materials can be prepared that are valuable adjuncts to existing curriculum materials. The application of such data can enrich curricula by providing more up-to-date information than published texts may achieve, and can foster studies of local features to a level of detail that standard texts can never achieve (NASA, 1976b).

In 1978 NASA published Educator's Guide For Mission to Earth: Landsat Views the Earth. This publication was designed to provide teachers with information and suggestions for using Landsat imagery to teach basic concepts in several content areas which included Earth Science, Environmental Studies, Geography and Social Studies (NASA, 1978).

This guide must be used in conjunction with *Mission to Earth....* to be of any value to the teacher. All background information relative to the history and technology of Landsat, the concept of remote sensing, how images are obtained and interpreted, and detailed information about each scene in the book is not included in this guide, but can be found in *Mission to Earth* (NASA, 1978).

One aspect of the Landsat program which has direct implications for educators is that the images returned by the spacecraft can be utilized to supplement and compliment classroom instruction in various disciplines . Landsat imagery holds promise as an educational tool for use in instructing students about the earth. It was hoped that this guide would make it possible for teachers to understand and use Landsat imagery as an effective instructional tool. Each image contains so much information that teachers and students in many disciplines areas will find much of interest and value (NASA, 1978).

Moreover, it was hoped that the information given in this guide would serve as a beginning-a challenge-extended to each teacher to use this guide not as a text, but as a springboard from which to devise new strategies for studying, interpreting, and using Landsat imagery in the classroom (NASA, 1978).

With the exception of the remotely sensed images that were distributed in the Journal of Geography in 1990-1991 and the 1988 revision of Observing The Earth From Space, little information was found in the literature concerning educational materials developed for remotely sensed data after 1978. Those materials cited above are no longer in publication and therefore unavailable to educators.

Cost of Remotely Sensed Data

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.

The Director of the U.S. Geological Society (USGS) announced recently that approximately 600,000 Landsat scenes, all those acquired by multispectral scanners (MSS) aboard Landsat satellites more than two years in the past, are now available at reduced prices from the Earth Resources Observation Systems (EROS) Data Center (DC) in Sioux Falls, South Dakota (NASA, 1991).

The new arrangement was made possible by a recent agreement between the National Oceanic and Atmospheric Administration (NOAA) and Earth Observation Satellite (EOSAT) Corporation, the firm that was awarded control over distribution of Landsat data in 1985. EOSAT retains exclusive sales rights to MSS data that are less than two years old and will have exclusive rights for all Landsat Thematic Mapper (TM) data until July 1994, at which time TM data more than 10 years old will become available from the EROS-DC (NASA, 1991).

The new prices for the historic MSS data are substantially lower than the prices for more current data and images that are less than two years old. For example, a 9.5-inch black and white paper print of an historic Landsat image sells for $10.00 from EROS-DC, compared with $95.00 from EOSAT for an images less than two years old (NASA, 1991).

Assessment of the Use of Remote Sensing in K-12 Education

During the summer of 1988, this author conducted a study to determine if remotely sensed images were being utilized as educational tools at elementary and secondary educational levels. This assessment was facilitated through the administration of a Remote Sensing Survey designed by the author. The research survey was tri-sectional, 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.

The analysis of the data produced evidence to substantiate several conclusions about the level of remote sensing concepts currently being taught. The majority of teachers who completed the survey are not using materials acquired from remote sensing techniques for educational purposes. Only 13 of the 220 participants (9 percent) responded that they use remotely sensed images in their classroom.

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 using remotely sensed materials. 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 use of remotely sensed materials for instruction, funding would be available for purchasing images, equipment, and related supplies.

Eighty percent of the teachers believed their students would be interested in using remotely sensed imagery. 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 aerial and 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 use of remotely sensed materials for educational purposes. 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 unable to utilize these types of materials in the classroom. Moreover, most school systems do not have these facilities or materials because of the lack of funding.

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

In the published proceedings from the workshops 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 offered 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.

Satellite technology may be the key to improving education in the 1990's as Sputnik was in the late 1950's. Today, more than 500 academic institutions, including high schools, are receiving, reproducing and studying data transmitted from GOES and TIROS satellites (Tillery, 1988). Tillery (1988) first became involved with the use of APT (Automatic Picture Transmission) from weather satellites for use with his high school biology classes. Besides APT, other forms of earth sensing can be used for instruction, such as aerial photography, High Resolution Picture Transmission (HRPT) and LANDSAT images. He soon realized that remotely sensed data could be used all across the curriculum, i.e., earth and space science, biology, chemistry, physics, math, geography, English and vocational subjects.

Whereas some institutions and teachers have begun to use remotely sensed imagery in their curriculum, the educational potential is basically untapped. A need exists for greater transfer of this technology to elementary and secondary level schools. Remotely sensed data can be used in many aspects of K-12 education. These data permit development of new educational materials and lesson plans. They also contribute to realistic and stimulating experiential learning in all subject areas and at all age levels. Remotely sensed data also appeal to children's curiosity and permit concepts to be taught at an earlier age, thereby improving technological literacy (Tillery, 1988).

Technological literacy is not a new component in education but it is a new element in cross-curriculum education. Technological literacy implies having the mental ability to enter into complex thinking and problem solving (Ost, 1985). Students must be aware that knowledge and data bases constantly change. Individuals must know how to access information, how to use technological information, and how to appreciate the tentativeness of any solution to a problem because of changing data and knowledge.

Remote Sensing Education in NASA's Technology Transfer Program

Education in remote sensing was an important component of NASA's Technology Transfer Program from 1977 to 1984. This program was established to extend the benefits of NASA developed space technology to a broader sector of the economy. Remote sensing was a principle focus of activity with major attention given to remote sensing education in the Regional Program and the University Applications Program (Weinstein, 1981).

Regional Remote Sensing Applications Program

From 1976 to 1984, NASA's Regional Remote Sensing Application Program was directed at making Landsat technology available to state and local government users through a systematic program of liaison, training, technology demonstration and technical assistance.

The specific objectives of training efforts in the program were two-fold, namely (1) the short term goal of preparing state/local government technical personnel for direct participation in the technology demonstration projects; and (2) the long term goal of building a self-sustaining base for training of additional resource managers in the state (Weinstein, 1981).

University Applications Program

NASA has worked since 1974 with the academic sector to develop and strengthen related curricula and basic research through the University Applications Program. The universities work with state and local governments in applying this technology to current operational problems with demonstrated benefits to the taxpayer. A survey of this program conducted in 1978 showed that they had demonstrated the value of the technology to state and local governments since they added approximately $1 million in 1977 to the same programs for additional remote sensing products (Weinstein, 1981).

Prior to the transfer of the Landsat Program to private industry, NASA had published several activities for using remotely sensed data as educational tools (Appendix B). Since this transfer has taken place, NASA has published very little information on remote sensing for K-12 educational purposes.

The value of remote sensing technology to the K-12 classrooms may be immeasurable if these resources can be incorporated into education curricula. From the arid deserts of Africa to jungle-hidden Mayan cities in South America, remote sensing has played a critical role in reshaping our comprehension of the world in which we live. Literally, millions of lives and billions of dollars in property, have been saved because of early weather warnings from satellites (Becker, 1989).

Becker (1989) believes that remote sensing as a new and more meaningful approach to teaching geography, geology, international affairs, global culture, and related subjects is an excellent tool to focus in daily instruction. Teachers find space education in general a strong motivating force in attracting and holding student interest because of its "real world" nature. Remote sensing technology, however, is a highly productive instructional tool in geography and geology because it allows students to see the Earth as it truly is, and also provides opportunities for detailed study of topographic features and ecological relationships.

If we are to use this most fundamental tool of all the space technologies adequately and responsibly, then we must encourage it as a classroom necessity and work directly with our public and private schools to teach it as one of the best and most competent of the available space technologies (Becker, 1989).

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

Introduction

The purpose of this study was to determine: If educators in grades K-12 had access to remotely sensed images, would they use them in instructional projects. To answer this question, questionnaires concerning the use of remotely sensed data were mailed to teachers in grades K-12 who receive the Journal of Geography. This sample population was selected because they would have access to the seven satellite images and one high altitude photograph which were inserted in the *Journal*, (Vol.89, No.3 through Vol.90, No.2). These participant responses also generated a geographical representation for the level of remotely sensed data being used in elementary and secondary education in the United States. The remotely sensed images distributed by the NCGE were intended to demonstrate the capability of the sensor system, provide elementary and secondary classroom instructors with visual examples of remotely sensed geographic phenomena, and to contribute to education by introducing teachers to a tool that can aid in the study of the earth and its resources.

Development of the Survey

The survey instrument used in this research project was developed by the author after a literature search failed to locate a suitable instrument. Prior to the completion of the instrument, faculty members in the Department of Aviation and Space Education and the Department of Geography at Oklahoma State University, who are knowledgeable in the field of remote sensing, were asked to evaluate the instrument. Advice was also received from faculty members from the Department of Applied Behavioral Studies in Education at Oklahoma State University who are knowledgeable in educational research and instrument design . Two members from the Department of Geography at Texas A&M University , Dr. Robert Bednarz and Dr. John Giardino, were also asked to evaluate the research questionnaire. Drs. Bednarz and Giardino are editors for the Journal of Geography and were responsible for the idea of including color images in the *Journal.* The questionnaire was also evaluated and approved for use by the National Council for Geographic Education (NCGE) and the Oklahoma State University Institutional Review Board for Human Subjects Research. All input from these parties was utilized and contributed to revisions which were made to assure the validity and content of the instrument. A copy of the research instrument is included as Appendix A.

The first section of the questionnaire contained 14 questions concerning the eight remotely sensed images that were distributed in the *Journal* and the teachers perceived use of these materials in the classroom. The respondents were asked to answer yes, no, or unsure to nine of these questions. These questions included: did the respondent examine the images?, were the written description of the images easy to understand?, the respondents level of formal training in remote sensing?, would the respondent use the images as educational tools if available?, interest in additional inserts being added to the *Journal* ?, and the respondents willingness to attend a workshop on the principles of remote sensing and its integration into the classroom. These questions were included to receive better awareness to the knowledge level of educators in remote sensing, the present use of remotely sensed data in the classroom and educator interest in learning how these materials can be used as educational tools.

In a descriptive study such as this, bias can occur in the findings because of the absence of information from respondents. Free responses were included, and encouraged, throughout the questionnaire to help minimize the respondents from choosing a suggested answer. Five questions in the first section called for free responses on the part of the respondents. The free response questions included: perceived barriers to adopting remotely sensed images for classroom use; suggestions for acquiring remotely sensed images; world regions respondents would like to see in future projects; how the respondents introduced the images to their students; and how teachers can use remotely sensed images and materials in a classroom situation. These questions were asked to achieve understanding through teachers response to problems or hindrances to adopting these materials as educational tools and educator interest in continuing programs of this type by the NCGE. The response of how these materials were introduced to students will provide insight to effective techniques for integrating remotely sensed imagery in K-12 classrooms.

The second section of the questionnaire was designed to gather information concerning the characteristics of the survey participants. The questions in this section included the respondents state of employment, sex, grade level(s) and subjects taught, size of school, average number of students in class, undergraduate major and minor, and the highest educational degree attained.

Where educators were found to use these remotely sensed materials in educational projects, the study was designed to assess what types of training are necessary for educators to effectively use these materials as educational tools. Another purpose of this study was to acquire an understanding of what limits the use of remotely sensed data in K-12 education and to make recommendations to resolve this problem. These assessments were facilitated through the Remote Sensing Questionnaire (Appendix A).

Collection of the Data

The Remote Sensing Questionnaire was administered by mail to 951 teachers that receive the Journal of Geography. These teachers represented elementary and secondary levels of instruction and various curriculum areas. The questionnaires were mailed February 7, 1991 with a return deadline of April 1, 1991. A self-addressed stamped envelope was included with the questionnaire to improve response percentage. Response to the survey was voluntary and no techniques were used to match individual teacher responses with teacher names. The formula (1) used for estimating sample size came from Issaac and Michael's book, Handbook in Research and Evaluation for Educational and Behavioral Science.

$$S = \frac{X^2 NP\ (1-P)}{d^2\ (N-1) + X^2 P\ (1-p)} \qquad (1)$$

where

S = required sample size

N = the given population size

P = population proportion that has been assumed to be .50, as this magnitude yields the maximum possible sample size requires

d = the degree of accuracy as reflected by the amount of error that can be tolerated in the fluctuation of a sample proportion *p* about the population proportion P - the value for d being .05 in the calculation

X^2 = table value of chi square for one degree of freedom relative to the desired level of confidence, which was 3.841 for the .95 confidence level

For a population of 951, a minimum sample size of 274 was required for a study to be statistically significant. For the 951 surveys sent, 329 were returned completed. Twenty-three were returned because of an incorrect mailing address. Of the completed surveys, 321 were suitable for data interpretation. The 33.8 percent of surveys returned exceeds the level to claim the results are statistically relevant.

CHAPTER IV

ANALYSIS OF SURVEY RESULTS

The purpose of this study was to determine if educators in grades K-12 had access to remotely sensed images, would they use them in instructional projects. Chapter IV presents the findings of the study utilizing the Remote Sensing Questionnaire.

Analysis of the Data

Upon receipt of the completed questionnaire at Oklahoma State University, the questionnaire was coded and entered into a computer database. Analysis began with frequency counts tabulated for each question and percentages made for the total population of returned questionnaires. The results of participant responses are presented in the form of number of responses and percentages. Based upon the purpose of the study, the results as raw data can effectively demonstrate the lack of remotely sensed data as educational tools in elementary and secondary education. Moreover, because of the lack of comparable data from other research, quantitative evaluation of the data is not essential to support conclusions.

These data are presented in two sections. Section one contains responses to the survey questions concerning the use of remotely sensed images in education whereas the second section contains responses concerning demographic information.

Responses to the Questionnaire

Of the three hundred and twenty-one participants in this study, three hundred and five (95%) stated that they did examine the images that were inserted in the Journal of Geography. This large response indicates that the respondents are interested in remotely sensed images and took the time to examine them. Two hundred and fifty-seven participants (80%) agreed that the written descriptions of these images were easy to understand. This large response reflects a level of understanding regarding physical geography, physical geology and geomorphology by a majority of the respondents. This high response may also be attributed to the fact that after the completion of the first draft, five teachers from the Stillwater, Oklahoma school district were asked to read these descriptions for the purpose of clarifying the descriptions for elementary and secondary educational levels. Nineteen (6%) disagreed and forty-five (14%) were unsure if the descriptions were easy to understand. These responses may be attributed to the fact that many of the respondents, especially those that do not teach in the fields of social studies or earth science, may possess a limited educational background in these fields and therefore may have trouble in understanding the descriptions.

The majority of the teachers (85%) have not had training in remote sensing. This training includes formal college courses in remote sensing, college courses in which remote sensing was covered or workshops concerning remote sensing. 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 expressed doubts that other university educational faculty presently prepare teacher candidates to work with satellite images.

Although these educators appear to lack knowledge on remote, two hundred and two teachers (63%) responded that they would use remotely sensed images as educational tools if they had access to numerous types of these materials. Ninety-six (30%) responded that they would not use these materials if they easily available.

The majority of the respondents (44%), as the data shows in Table III, were unsure if their school administration would be receptive to acquiring remotely sensed materials as a tool. Kirman (1981) expressed concern about the probability of limited familiarity about remotely sensed images by professors of education and school board supervisors. If the people that set up and develop pre-service and in-service teacher training lack expertise, teachers will not acquire this new knowledge. In order for teachers to acquire knowledge of satellite images and applications, school administrators must learn about this new technology and be willing to provide training for teachers in remote sensing and provide materials for use in the classroom.

TABLE III

PERCEIVED WILLINGNESS OF SCHOOL ADMINISTRATION TO ACQUIRE REMOTELY SENSED IMAGES

Teacher Response	No. of Teachers	Percent of Teachers
Yes	135	42
No	45	14
Unsure	141	44

The data in Table IV shows that when the teachers were asked what they perceived to be the greatest barrier(s) to adopting remotely sensed images in their classroom, 56% answered that the cost for the images and/or materials would be the greatest constraint. This is a common problem for many school systems nationwide because of budget cuts and funding problems. At the time the surveys were mailed to the teachers, it cost approximately $300.00 for a standard color image and $95.00 for a black and white image (1:1,000,000) . Shortly after the surveys were mailed the Director of the U.S. Geological Society (USGS) announced that approximately 600,000 Landsat scenes, all those acquired by multispectral scanners (MSS) aboard Landsat satellites more than two years in the past, are now available at reduced prices from the Earth Resources Observation Systems Data Center (EROSDC). The new prices for the historic MSS data are substantially lower than the prices for more current data and images that are less than two years old. For example, a 1:1,000,000 black and white paper print of an historic Landsat image sells for $10.00 from EROSDC, compared with $95.00 from EOSAT for an images less than two years old (NASA, 1991). The second most common perceived barrier (26%) was the lack of teacher knowledge with these types of materials. Kirman (1981) stated that lack of teacher knowledge with satellite imagery is one of the major reasons that this technique is not widely used in elementary and secondary level schools. Other response data as to the perceived barriers are also presented in Table IV.

After responding about barriers, the participants were asked to make suggestions that would facilitate teacher acquisition of remotely sensed images. The most common suggestions were that workshops (15%) and in-service programs (15%) be conducted to instruct teachers on how to use these materials. Because of the uncertainty and lack of familiarity with Landsat images by the teachers, Kirman (1977, 1984), recognized the need for more extensive preparatory programs, including workshops and in-service programs, to train the teachers on working with satellite images. Lillesand (1982) stated that 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 and in-service programs 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). Becker (1989) believes the training of teachers should be a major priority of the remote sensing industry because the educational community cannot accomplish the task on its own. These responses were followed closely by the suggestion that lesson plans accompany the images (11%). These and other teacher suggestions can be viewed in Table V.

Relating to the data concerning teacher suggestions for integrating remotely sensed data into the classroom, the data presented in Table VI shows that two hundred and sixty-six educators (83%) stated they would be willing to attend a workshop on the principles of remote sensing and its integration into the classroom if such a course could be arranged within commuting distance from their home. This high response indicates that educators are willing to take the time to learn about remote sensing and how this technique may be integrated into the classroom.

TABLE IV

PERCEIVED BARRIERS FOR USING REMOTELY SENSED IMAGES IN CLASSROOMS IN ORDER OF IMPORTANCE

Perceived Barrier	No. of Teachers	Percent of Teachers
Cost of Images/Materials	180	56
Lack of Teacher Training	83	26
Class Size to Large	64	20
Too Technical for Students	19	6
Value in Classroom	16	6
Time Constraints	13	4
Availability of Images	13	4
Number of Copies Supplied	10	3
Little/No Geography Required	6	2
Lack of Lesson Plans	6	2
Size of the Images	6	2

TABLE V

SUGGESTIONS FOR INCORPORATING REMOTELY SENSED IMAGES IN CLASSROOMS IN ORDER OF IMPORTANCE

Suggestion	No. of Teachers	Percent of Teachers
Conduct Workshops	48	15
Provide In-Service Programs	48	15
Provide Lesson Plans	35	11
Place Images in Catalogs	22	7
Keep Cost of Images Down	22	7
Use Slides/Transparencies	13	4
Utilize Geographic Alliances	13	4
Apply for Grants	13	4

TABLE VI

RESPONSE OF THE WILLINGNESS TO ATTEND WORKSHOPS ON THE PRINCIPLES OF REMOTE SENSING

Answer	No. of Teachers	Percent of Teachers
Yes	266	83
No	16	5
Unsure	39	12

Of the two hundred and sixty-six participants willing to attend a workshop, all 266 (100%) indicated, as shown in Table VII, that they would be willing to attend a weekend workshop on remote sensing. One hundred and seventy (64%) indicated they were willing to attend a one week workshop and ninety-eight (37%) indicated that they would be willing to attend a two week workshop. It would be best if these workshops take place during the summer months when teachers generally have more time for these types of activities. Many of the respondents stated that financial assistance and college credit would make the one and two week workshops more appealing.

TABLE VII

LENGTH OF TIME RESPONDENTS WOULD BE WILLING TO DEVOTE TO A REMOTE SENSING WORKSHOP

Answer	No. of Teachers	Percent of Teachers
Weekend workshop	266	100
One week workshop	170	64
Two week workshop	98	37

When participants were asked how many of their colleagues would be interested in receiving remote sensing training free of charge, or for a minimal fee, 292 (91%) responded that 0-5 of their colleagues would be willing to receive training. Twenty-two (7%) responded that 6-10 would be willing to receive training. The results from this question may be misleading because of the way this question was worded. The participants should have had the option to select 0 or 1-5 colleagues instead of 0-5 colleagues. These teacher responses are tabulated in Table VIII.

TABLE VIII

NUMBER OF RESPONDENTS COLLEAGUES WILLING TO RECEIVE TRAINING IN REMOTE SENSING

Number	No. of Teachers	Percent of Teachers
0 - 5	292	91
6 - 10	22	7
> than 10	7	2

Information in Table IX shows that two hundred and sixty-six participants (83%) recommend that additional images concerning remote sensing be added to the Journal of Geography, whereas forty-five participants (14%) would not recommend additional images be inserted. Those participants that responded they would like to see additional images were asked to indicate the type(s) of images and/or photographs they would be interested in. The most common responses were natural color images or photos (80%), high altitude photography (76%), and space shuttle imagery (74%). The percentages add up to greater than 100% and the number of teachers add up to more than 266. Many of the teachers indicated that they would like to see several different types of remotely sensed materials. These observations support Kirman (1981) who believes teachers in the field can be expected to be hesitant in using false color images because of their lack of familiarity with them. It is difficult for a teacher used to hand-drawn maps with colors and symbols to suddenly have to work with a new "map" with strange colors not necessarily corresponding to natural colors.

TABLE IX

IMAGES OR PHOTOGRAPHS THAT WOULD BE OF INTEREST IN FUTURE ISSUES

Format	No. of Teachers	Percent of Teachers
Natural Color Images or Photos	213	80
High Altitude Photography	202	76
Space Shuttle Imagery	197	74
False Color Imagery	130	49
Black-and-White Photography	85	32
Others	32	12

When asked what regions of the world they would like to see covered in future projects of this type, one hundred and three participants (32%) said they would prefer to see images of North America, particularly the United States. This supports Kirman (1977) who stated that teachers should begin by using regional images as a way to familiarize themselves, and their students, with remotely sensed images and concepts. Teachers usually know more about the local region and are more likely to teach about this area. One hundred (31%) of the participants stated they would like to see all world regions covered to supply a global view. Eighty-seven (27%) indicated they would like to see images of Asia, particularly the Middle East. This response came as no surprise because the Persian Gulf War between the United States and Iraq was taking place at the time this survey was mailed and the Middle East was highly visible in the news. These and other results are presented in Table X.

TABLE X

REMOTELY SENSED WORLD REGIONS RESPONDENTS WOULD PREFER IN FUTURE ISSUES IN ORDER OF IMPORTANCE

Continent	No. of Teachers	Percent of Teachers
North America	103	32
All Areas	100	31
Asia	87	27
Africa	45	14
South America	42	13
Europe	32	10

Seventeen percent of the participants responded to the free response question concerning: How would (or did) they introduce the remotely sensed images to their students? Some of the selected comments for introducing students to remote sensing were:

> I use these images to supplement maps of various regions. It would be nice to have larger images or reproducible photos to distribute to the class.
>
> We used the Boston image to compare with road maps. I laminated the image and let my students use water color pens to label rivers, roads, buildings, etc..
>
> I would introduce remotely sensed images as another way of looking at our marvelous earth. The children found them very interesting and colorful.
>
> I started introducing the students to remote sensing with an aerial photo of our school campus (about 2,500 ft.) and with television reports of traffic in Southern California.
>
> I divided the class into teams/groups and let them examine an image. They were to write down what they thought the area was and what the colors represented.
>
> I placed the images on the bulletin board in our classroom. The kids were fascinated by the many colors. The false colors and infrareds looked "sexy" to them.
>
> I introduced the images by prefacing as a game "Where in the World...". I had my students examine the images and ask questions about the images. It was kind of like 20 questions.
>
> I gave the images to a group of students (5th grade) and asked them to figure out what the image is all about-how would you use it? Their response is shared in general class discussion. The images became part of our mapping center in the classroom.
>
> We were fortunate that there was an image from Pennsylvania. I allowed my students to examine the image of the Appalachians and then we took a field trip to look at this region from a ground level perspective.

I introduced the images as part of our map skills/mapping unit.

I displayed some of the images that correlated with regions we had recently studied and asked the students if they could identify the area. These images are excellent in that they introduce students to a new perspective of looking at earth.

I created a 12th grade elective course entitled "Physics in Geography".

My students and I have compared these images with political maps of the same areas. We discussed natural and political borders and reasons why cities thrive in certain geographic areas (i.e. immediate access to transportation, climate, soils, etc..).

I have been using satellite images for years. We laminated the images from the Journal to prolong their useful classroom life and so students can use water color pens to write in the images for identifying features.

I have been very interested in remote sensing for secondary student for many years. I recently applied for a Christa McAuliffe Fellowship to help develop a teacher training program in remote sensing applications for grades 7-12.

I recently acquired a 30x30 inch image of the Eagle River area of Alaska. It immediately caught the attention and interest if my students since some of them could find their homes. I explained what all the colors represented first so they would be able to identify objects. Later, I produced overlays with a grid system on them and used them with the color images from the Journal to introduce the idea of a grid system.

We began our mapping unit with topographic maps and moved to aerial photos. I then introduced remotely sensed images and explained they are all graphic representations of the same thing, just different techniques. All are very useful.

I began by relating explaining that 4 of their own senses were considered as being "remote sensors" (sight, touch, smell, hearing). We then looked at tools that can "see" or sense beyond human capabilities. Finally, we looked at how to translate false-color images into various understood features.

Nineteen percent of the participants responded to the free response question concerning: Did they have any innovative ideas as to how teachers can use remotely sensed images and materials in a classroom situation? Some of the selected innovative ideas included:

> Supply the students with different types of maps of the areas and have them match the map with the corresponding imagery.
>
> Have the students study their neighborhood from different aspects (i.e. ground level, air photo, satellite image)
>
> Use the images as a "Detective" game. After teaching the various regions in a more traditional way, divide the class into Detective Agencies. Each agency must use all they have learned, researched, etc. to identify as many areas as possible. The agencies will be scored on the number of photos/images correctly identified and their reasons for making that selection.
>
> No, I could use some myself!!
>
> Make boxes that children must feel items in and describe what they feel. Blindfold students and have them describe size, shape, colors of items with touch only. Then use red cellophane to "see" items printed in red on cards that have many shapes imbedded in red zones on the card. Items "magically" appear. Listen to whispers or items dropped across the room while the student is blind-folded and have them describes what the heard. Relate all of these activities and experiences to the tool of remote sensing.
>
> Compare the same place during different seasons.
>
> Have the students draw the room from a "birds-eye" view.
>
> It would be interesting to make an overhead and create an art simulation through lines, shapes, and figures. Each student would be given their own transparency to create an artistic rendering.
>
> Encourage university geography departments to establish active contacts with elementary and secondary school systems and vice versa.

> Use them in publications class as a terrific example of visual-color impact on people.
>
> Develop future landuse maps. Compare environmental changes by having images of the same area over several years.
>
> Students, acting as satellites, transmit a series of points verbally to other students, acting as receivers. If the students transmit and receive (plot) the points accurately, a picture is formed (comparable to satellite imagery)
>
> Include remote sensing in college teacher training. Maybe not an entire course but it should be discussed.
>
> Acquire photos/images of the local area. Students and teachers are usually more familiar with the local area than far-off regions.
>
> I would suggest using the nightly weather from a news channel. This is something that students have easy access to and are usually familiar with.
>
> Have your students attempt to make 3 dimensional models out of clay using these images. After they are fired they can be glazed using appropriate colors. This is very helpful in student comprehension of how landforms look and feel.

The fact that these teachers took the time to respond to how they introduced (or would introduce) remote sensing to their students and innovative ideas for how teachers can use remotely sensed images and materials in a classroom situation demonstrates a level of professionalism and concern about enhancing their knowledge on remote sensing and their ability to perform their duties.

The participants were given four prices for individual copies of images and were asked if they would pay for the images if the National Council for Geographic Education provided lesson plans for future images. The participants were asked to answer **Yes** or **No** to four listed prices for the images. Two hundred and seventy participants (84%) said they would be willing to pay .10¢/image while two hundred and eighteen participants (68%) said they would be willing to pay .20¢/image. One hundred and nine participants (34%) said they would be willing to pay .50¢/image. The drop off between .20¢/image and .50¢/image is attributed to the lack of school funding for purchasing class sets of remotely sensed images. Another reason may be that many teachers pay for materials from their own pockets and a .30¢/image increase is more than most educators can afford. A summary of the results to this question are presented in Table XI.

TABLE XI

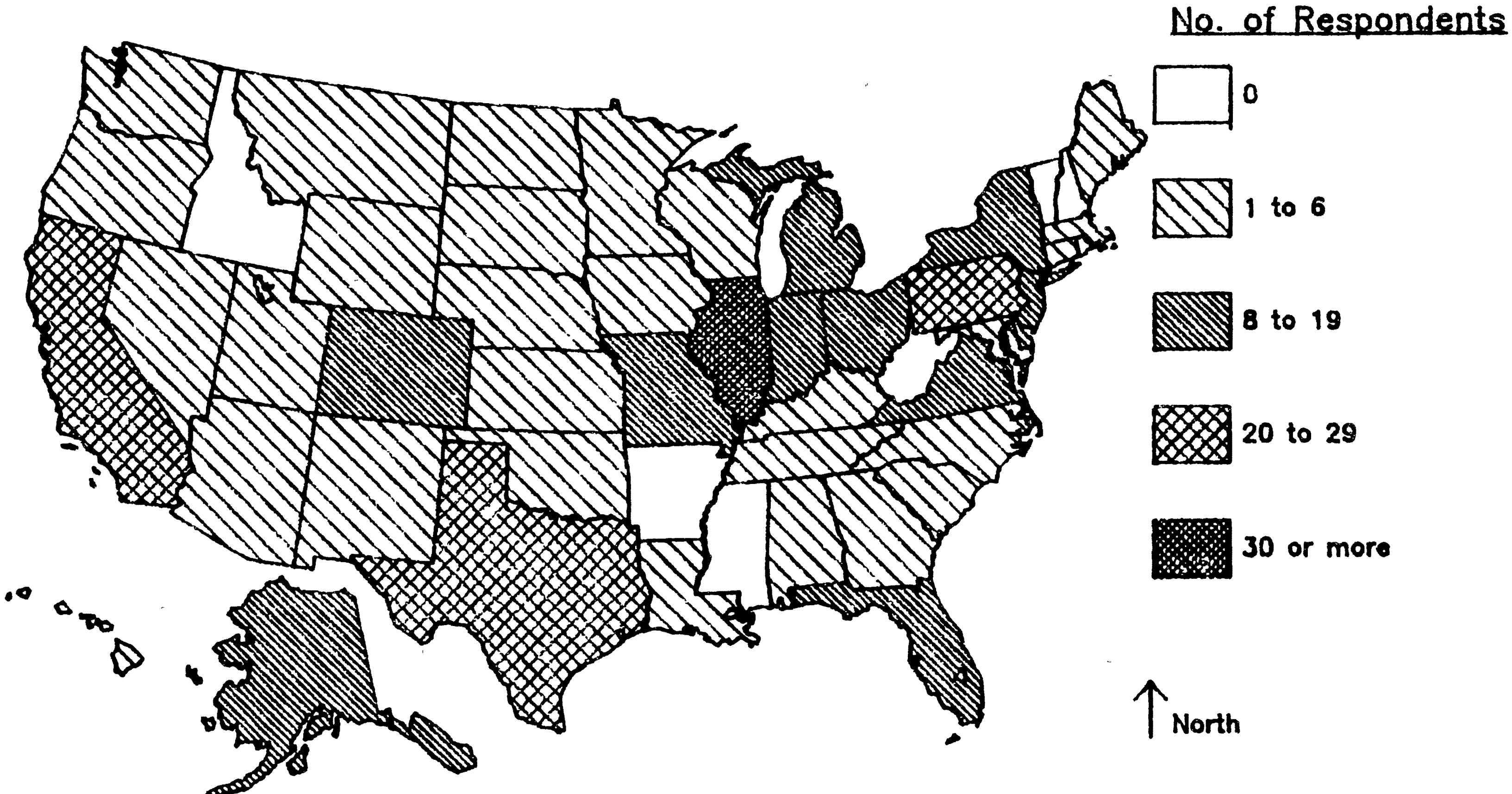
RESPONSES OF 1991 SURVEY PARTICIPANT WILLINGNESS TO PAY FOR INDIVIDUAL COPIES OF IMAGES

Cost	Yes	Percent of Teachers	No	Percent of Teachers
.10¢/image	270	84	51	16
.20¢/image	218	68	103	32
.50¢/image	109	34	212	66
$1.00/image	58	18	263	82

Demographic Information

Participants were asked to supply information concerning their state of residence. The largest numbers of returns came from Illinois (47), California (25), Pennsylvania (25), and Texas (21). These states have exceptionally active geographic alliances which may account for the high number of returns from these states. Having such active geographic alliance, the educators in these states may be more likely to adopt remotely sensed images into K-12 education if they are not already attempting to do so. The results of these and other states of employment of the research participants are presented in Figure 2.

Other returned data indicate that forty-seven percent of the participants are male and fifty-three percent are female. In relation to the grade level(s) in which the participants taught, the result show that the largest percentage of the respondents teach at the middle school level (42%), the high school level (41%), and at the junior high school (40%). The distribution of the above noted grade level was expected to be even. One reason for this assumption is that those educators receiving the Journal of Geography teach course in the social studies field (geography, social science, history, political science) and these courses receive more attention at these grade levels. Grade levels were separated into four categories to show where the sample population devoted their teaching efforts. The results of teacher responses are presented in Table XII. These percentages add up to greater than 100% because many teachers currently teach in more than one grade level.



Source: Fieldwork Completed 1991

Figure 2. States of Employment of the 1991 Survey Respondents

TABLE XII

GRADE LEVEL TAUGHT BY 1991 SURVEY RESPONDENTS

Grade Level Taught	No. of Teachers	Percent of Teachers
Elementary (K-5)	67	21
Middle School (6-7)	135	42
Junior High School (8-9)	128	40
High School (10-12)	132	41

When the participants were asked what subjects they taught, the largest percentage (55%) stated that they taught courses in geography. This response was expected because the population used in this study receive the Journal of Geography and are therefore most likely to teach courses in geography. The second most common response (27%) stated that they taught history courses. One aspect of remote sensing which has direct implications for educators is the data returned by the aircraft or spacecraft can be utilized to supplement and compliment classroom instruction in various disciplines. By its nature, earth observation from space is multi-disciplinary and no one academic subject has a monopoly such that it can serve as a vehicle for the dissemination of knowledge in this field (Becker, 1989). Satellite imagery holds promise as an educational tool for use in instructing students about the physical earth as well as the relationship between humans and the natural environment. The results of the teacher responses are presented in Table XIII. The percentages add up to greater than 100% and the number of teachers add up to greater than 321.

Many teachers currently teach more than one subject which contributes to a total that exceeds 100 percent.

TABLE XIII

SUBJECTS TAUGHT BY THE 1991 SURVEY RESPONDENTS IN ORDER OF IMPORTANCE

Subjects Taught	No. of Teachers	Percent of Teachers
Geography	177	55
History	87	27
Social Science	61	19
Elementary Education	58	18
Science (any)	22	7
Mathematics	13	4
Administration	7	2
Other Subjects	71	22

The majority of the respondents (32%) teach in schools that have more than 1,000 students for their respective grade level. This was followed by schools of 501-750 students (20%), and schools of 251-500 students and 751-1,000 students (19% each) (Table XIV). In a study of 10 junior high schools in a large metropolitan school district, Ashton (1986) reported that as school size increased, teachers impersonal treatment of students and their resistance to innovations increased. The research also showed a strong relationship between teachers sense of efficacy, teacher belief that they can be more effective with smaller classes, and implementation of innovations suggests that teacher perceived efficacy may moderate the relationship between school size, treatment of students and resistance to innovations. If the factors related to size of the schools affect teacher's perceptions of their effectiveness, then teachers will be less likely to try new approaches and ideas.

The average class size was 26 students per class. Twenty percent of the respondents stated that their class sizes were to large to effectively introduce remotely sensed materials. Teachers have traditionally insisted that class size affects their ability to be effective instructors. To examine the changes that occur in the classroom when the number of students decrease, Ashton (1986) conducted a meta-analysis that gave empirical support to teachers long-held assumption that class size is related to student achievement. The relationship between class size and student achievement was "clear and strong". The relationship was somewhat stronger for the high school data than the elementary grades and was unaffected by demographic variables such as school subject and pupil IQ. Ashton concluded that "the difference in achievement resulting from instruction in groups of 20 pupils and groups of 10 can be larger than 10 percentile ranks in the central regions of the distribution". No attempt was made to determine class size according to grade level taught or school size.

TABLE XIV

SCHOOL SIZE IN WHICH THE 1991
SURVEY RESPONDENTS TAUGHT

School Size	No. of Teachers	Percent of Teachers
less than 100 students	10	3
100-250 students	22	7
251-500 students	61	19
501-750 students	64	20
751-1,000 students	61	19
more than 1,000 students	103	32

The largest percentage of the respondents received their undergraduate major degree in social studies (65%), including social science, political science, geography, and history. The second most common response (20%) stated they received their major degree in a field of education. These and other undergraduate majors are listed in Table XV. Information in Table XVI shows the undergraduate minor degrees that the respondents possess. The majority of the respondents (35%) have a minor degree in social studies. The second most common response (31%) have a minor degree in some field other than those listed in the table. The responses for undergraduate major and minor degrees were expected because the population used for this study received the Journal of Geography and are therefore more likely to teach courses in social studies than other subjects. By its nature earth observation is multi-disciplinary and no one academic subject can serve as the sole vehicle for the dissemination of knowledge in this field. The cooperation of the teachers in physical science and geography are necessary to introduce these materials to students at the secondary level, the former to cover the underlying scientific principles, the latter to interpret the Earth surface features displayed (Gathercole, 1987).

TABLE XV

COLLEGE UNDERGRADUATE MAJOR FOR THE 1991 SURVEY RESPONDENTS IN ORDER OF IMPORTANCE

Undergraduate Major	No. of Teachers	Percent of Teachers
Social Studies	207	65
Education	65	20
Science (any)	10	3
Other Major	39	12

TABLE XVI

COLLEGE UNDERGRADUATE MINOR FOR THE 1991 SURVEY RESPONDENTS IN ORDER OF IMPORTANCE

Undergraduate Minor	No. of Teachers	Percent of Teachers
Social Studies	113	35
Science (any)	22	7
Education	16	5
Mathematics	6	2
Other Minor	100	3
No Minor	64	20

The participants were asked to supply information concerning the highest educational degree that they earned. The highest degree attained response was separated into three categories: Bachelor's, Master's and Doctorate degrees. Credit earned information was not considered while evaluating this question. Of the 321 responses, 238 (74%), as data in Table XVII shows, had completed advanced educational degrees. The results of this study indicate that teachers possess a high level of educational training and a strong knowledge base as evidenced by the 74% of the respondents possessing an advanced educational degree. The results support a conclusion that most teachers have the expertise to teach.

TABLE XVII

HIGHEST EDUCATIONAL DEGREE ATTAINED BY THE 1991 SURVEY RESPONDENTS

Highest Degree Attained	No. of Teachers	Percent of Teachers
Bachelor's	83	26
Master's	225	70
Doctorate	13	4

Analysis of Degree Attained on Selected Research Questions

To obtain a better understanding of the effects of highest degree attained with the research questions used in this study, the chi-square test was used to evaluate if any significant differences occurred among those participants that possessed a Bachelor's degree and those with Master's degrees. Of the 321 educators that participated in this research, 83 had received Bachelor's degrees and 225 had received Master's degrees. For the chi-square statistical tests, the levels of significance were set at the .05 level. Previous studies concerning remote sensing with elementary or secondary level teachers and/or students utilized the .05 level of significance, therefore, this level of significance was chosen for consistency. Critical values were obtained from the standard chi-square tables with appropriate degrees of freedom. The research questions evaluated were #2-5, 8 and 12-14. No significant differences were expected to occur between responses of educators with B.S. and M.S. degrees for any of the research questions evaluated.

Chi-Square for Question Number Two

Were the written descriptions of these images easy to understand? The majority of those teachers with B.S. (68) and M.S degrees (178) agreed that the written descriptions were easy to understand.

Findings showed that no significant differences occurred between the educational degree attained and the ease of understanding of the image descriptions. The results from this survey reflect a high level of understanding by the study participants concerning physical geography, physical geology and geomorphology regardless of the educational degree attained. A summary of these results are presented in Table XVIII.

Chi-square for Question Number Three

Have you had any training in remote sensing? This would include college courses in remote sensing, workshops or any college course in which remote sensing was covered. The majority of educators with B.S. (70) and M.S. degrees (191) have had no training in remote sensing.

Findings showed that no significant differences occurred between the educational degree attained and the level of training in remote sensing. Regardless of the educational degree attained by the survey participants, remote sensing technology is not being transferred to teachers and students in the elementary and secondary levels of education. A summary of these results are presented in Table XIX.

TABLE XVIII

CHI-SQUARE VALUES REFLECTING RELATIONSHIP BETWEEN HIGHEST EDUCATIONAL DEGREE ATTAINED AND EASE OF UNDERSTANDING WRITTEN IMAGE DESCRIPTIONS

Degree Attained	Yes	No	Unsure	X^2	DF	Critical Value	Level of Sig.
Ques. #2							
B.S.	68	5	10				
				.36	2	5.99	N.S.
M.S.	178	14	33				

TABLE XIX

CHI-SQUARE VALUES REFLECTING RELATIONSHIP BETWEEN HIGHEST EDUCATIONAL DEGREE ATTAINED AND THE LEVEL OF TRAINING IN REMOTE SENSING

Degree Attained	Yes	No	X^2	DF	Critical Value	Level of Sig.
Ques. #3						
B.S.	13	70				
			.01	1	3.84	N.S.
M.S.	34	191				

Chi-square for Question Number Four

If you had access to numerous types of remotely sensed images, would you use them as an educational tool? The majority of educators with B.S. (55) and M.S. (142) degrees would use remotely sensed images in their classrooms if the they had access to materials of this type.

Findings showed that no significant differences occurred between the educational degree attained and if educators would use remotely sensed images as educational tools. Educators who responded to the survey expressed interest in remote sensing and indicated they would use remotely sensed materials to enhance their classroom activities. Level of degree attained has no effect on educators interests in using these materials in their classrooms. A summary of these results are presented in Table XX.

TABLE XX

CHI-SQUARE VALUES REFLECTING RELATIONSHIP BETWEEN HIGHEST EDUCATIONAL DEGREE ATTAINED AND WILLINGNESS TO USE REMOTELY SENSED IMAGES AS EDUCATIONAL TOOLS

Degree Attained	Yes	No	Unsure	X^2	DF	Critical Value	Level of Sig.
Ques. #4							
B.S.	55	4	24				
				.45	2	5.99	N.S.
M.S.	142	15	68				

Chi-square for Question Five

Do you believe your school administration would be receptive to acquiring remotely sensed images as a tool to facilitate understanding many aspects of planet earth? Of the educators with B.S. degree, 30 responded that their administration would be receptive to acquiring these materials while 42 were unsure. Ninety-nine of the participants with M.S. degrees believed their administrators would be receptive while 95 were unsure.

Analysis revealed that no significant differences occurred between the educational degree attained and the educators perceived willingness of school administrators to acquire remotely sensed images as educational tools. Given in Table XXI is a summary of these results.

TABLE XXI

CHI-SQUARE VALUES REFLECTING RELATIONSHIP BETWEEN HIGHEST EDUCATIONAL DEGREE ATTAINED AND PERCEIVED WILLINGNESS OF SCHOOL ADMINISTRATORS TO ACQUIRE REMOTELY SENSED IMAGES AS EDUCATIONAL TOOLS

Degree Attained	Yes	No	Unsure	X^2	DF	Critical Value	Level of Sig.
Ques. #5							
B.S.	30	11	42				
				1.22	2	5.99	N.S.
M.S.	99	31	95				

Chi-square for Question Eight

Would you recommend additional inserts be added to the Journal of Geography? Seventy-four educators with B.S. degrees and 185 educators with M.S. degrees recommend that additional remotely sensed images be inserted in future issues of the Journal of Geography

Analysis revealed that no significant differences occurred between the educational degree attained and recommendations for additional images in the Journal of Geography. Teachers expressed much interest in additional inserts occurring in future issues of the Journal. The level of degree attained by the participants has no effect on educators interest in using remotely sensed materials to educate their student on planet earth. Given in Table XXII is a summary of these results.

TABLE XXII

CHI-SQUARE VALUES REFLECTING RELATIONSHIP BETWEEN HIGHEST EDUCATIONAL DEGREE ATTAINED AND RECOMMENDATIONS FOR ADDITIONAL REMOTELY SENSED IMAGES

Degree Attained	Yes	No	Unsure	X^2	DF	Critical Value	Level of Sig.
Ques. #8							
B.S.	74	0	9				
				4.07	2	5.99	N.S.
M.S.	185	9	31				

Chi-square for Question Twelve

If the NCGE provided lesson plans to accompany future images, would you adopt them if you could acquire individual copies for:

12 A: .10¢/image

12 B: .20¢/image

12 C: .50¢/image

12 D: $1.00/image

The majority of the educators with B.S. degrees were willing to pay .10¢/image (72) and .20¢/image (56). Conversely a majority would not be willing to pay .50¢/image (51) and $1.00/image (70). The majority of educators with M.S. degrees were willing to pay .10¢/image (189) and .20¢/image (155) but the majority would not be willing to pay .50¢/image (155) and $1.00/image (185).

Findings showed that no significant differences occurred between the educational degree attained and willingness of educators to purchase individual copies of images if lesson plans were provided by the NCGE. Test results indicate that educators, regardless of the level of educational degree attained, are unwilling to pay .50¢ or more per image. These results are attributed to the lack of school funding for remotely sensed images. Regardless of the level of educational degree attained by the participants, if school state education officials and school administrators are not familiar with remote sensing and its value in the classroom, funding will not be provided for remotely sensed materials. Another reason may be that educators often purchase materials with their own money and a .30¢ increase is more then they are willing to spend to purchase these materials. Given in Table XXIII is a summary of these results.

TABLE XXIII

CHI-SQUARE VALUES REFLECTING RELATIONSHIP BETWEEN HIGHEST EDUCATIONAL DEGREE ATTAINED AND WILLINGNESS TO PAY FOR IMAGERY

Degree Attained	Yes	No	X^2	DF	Critical Value	Level of Sig.
Ques. #12 A						
B.S.	72	11				
			.36	1	3.84	N.S
M.S.	189	36				
Ques #12 B						
B.S.	56	27				
			.06	1	3.84	N.S.
M.S.	155	70				
Ques. #12 C						
B.S.	32	51				
			.81	1	3.84	N.S.
M.S.	70	155				
Ques. #12 D						
B.S.	13	70				
			.19	1	3.84	N.S.
M.S.	40	185				

Chi-square for Question Thirteen

Would you be willing to attend a workshop on the principles of remote sensing and its integration into the classroom if such a course could be arranged within commuting distance from your home? Seventy of the educators with B.S. degrees and 186 educators with M.S. degrees would be willing to attend a workshop on remote sensing.

Analysis revealed that no significant difference exists between the educational degree attained and willingness of educators to attend a workshop on the principles of remote sensing and its integration into the classroom. Test results represent a level of professionalism on the part of the survey participants. These educators are concerned about enhancing their knowledge in remote sensing and are willing to take the time to learn how remote sensing techniques may be incorporated into the classroom. Many of the participants stated that college credit be used as an incentive for getting teachers to attend these workshops. Given in Table XXIV is a summary of these results.

Chi-square for Question Fourteen

How many of your colleagues would be interested in receiving remote sensing training? Eighty educators with B.S. degree stated that 0-5 of their colleagues would be willing to attend a workshop on remote sensing whereas 200 educators with M.S. degrees stated that 0-5 of their colleagues would attend a workshop.

Analysis revealed a significant difference exists between the educators with B.S. and M.S. degrees and perceived willingness of colleagues to attend a workshop on the principles of remote sensing and its integration into the classroom. Since few educators are using remotely sensed images in classroom instruction, no differences were expected between the responses of educators with B.S. and M.S. degrees. These findings may perhaps be attributed to an error in the wording of this question. Participants should have been given the choices of 0 and 1-5 colleagues instead of 0-5 colleagues willing to attend a workshop on remote sensing instead. Given in Table XXV is a summary of these results.

TABLE XXIV

CHI-SQUARE VALUES REFLECTING RELATIONSHIP BETWEEN HIGHEST EDUCATIONAL DEGREE ATTAINED AND THE WILLINGNESS TO ATTEND A WORKSHOP ON REMOTE SENSING

Degree Attained	Yes	No	Unsure	X^2	DF	Critical Value	Level of Sig.
Ques. #13							
B.S.	70	5	8				
				1.24	2	5.99	N.S
M.S.	186	9	30				

TABLE XXV

CHI-SQUARE EVALUATION REFLECTING THE RELATIONSHIP BETWEEN HIGHEST EDUCATIONAL DEGREE ATTAINED AND THE NUMBER OF COLLEAGUES INTERESTED IN ATTENDING REMOTE SENSING WORKSHOPS

Degree Attained	# of Colleagues 0-5	6-10	>10	X^2	DF	Critical Value	Level of Sig.
<u>Ques. #14</u>							
B.S.	80	1	2				
				6.44	2	5.99	05
M S.	200	20	5				

Summary

In this chapter the results of teacher responses to the study instrument are presented in the form of numerical responses and percentages. Based upon the purpose of this study, the results as raw data more effectively demonstrate the lack of remotely sensed data as educational tools. Findings indicate that although teachers at the elementary and secondary levels of education are interested in remotely sensed materials and their educational use, they are not knowledgeable in the principles of remote sensing. This lack of knowledge is the major reason teachers are not using remotely sensed materials as educational tools. The cost of imagery, along with budget cuts in most school systems across the nation, is also perceived as a major barrier to the incorporation of these materials into the classroom.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The following excerpt, entitled THE EARTH - A PERSPECTIVE, is from the NASA publication Earth System Science: A Closer View. This passage helps to convey my personal interest in this study as well as the desire for understanding our role on planet earth and need in transferring this knowledge on to future generations.

> The Earth is a planet, a captive of the sun and a mere speck in the universe. Yet, it is a very special speck - unique because we live upon it, because we can touch and feel it and examine its most detailed workings. It is the mirror against which we test our perceptions of things elsewhere - not because we expect them to be the same, but because we seek to understand why they should be different. The rocks and soil, the atmosphere, the ice all have counterparts on other planets.
>
> Only relatively recently have we recognized the Earth to be in continual flux and upheaval on timescales of hundreds of millions of years, the continents in slow but inexorable motion, the ocean widening and narrowing through the force of gigantic convection currents in the underlying mantle. We are no longer

astonished to find tropical coal seams in the Arctic or deep ocean trenches just offshore from mountain ranges; however, the specific mechanisms of plate tectonics are only now being thoroughly worked out, together with their implications for the assembly and evolution of the continents, the generation of mineral and petroleum resources, and the origin of hazards to human life, such as earthquakes and volcanic eruptions.

This speck in the universe is also a cradle of life, that remarkable phenomenon that has evolved to marvelous levels of intricacy and specialization amid the seeming disorder and violence of the cosmos at large. The development of life has, in turn, helped to give the Earth its special character. Some three and a half billion years ago, primitive living cells evolved the process of photosynthesis, drawing on energy from the sun to manufacture food and transforming the atmosphere into one dominated by free oxygen. The subsequent story, which may be read in fossil records and the rocks in which it is imbedded, is a humbling one. It tells of dinosaurs and of ice ages, of mass extinction and the emergence of yet other life forms, such as mammals. Biochemistry and molecular biology are now revealing the genetic character of such variations over tens of millions of years. There remain, however, the grand questions of the origin of life remain, especially the capacity of life processes to adapt to the different environmental conditions over the Earth.

Now we, the peoples of the world, have become collective participants in these global designs, contributing in barely perceptible but significant ways to the evolution of this special

> speck in the universe. In our effort to achieve a higher standard of living for an expanding population, we are spreading advanced technology to every region of the Earth and are making steadily increasing demands on natural resources. These actions have begun to alter the atmosphere, ocean, lands, and life forms of our planet in ways that have no precedent in human history. Responsibility, therefore, dictates that we seek to understand more fully our role upon the Earth and the consequences of global change for humanity (NASA, 1988b).

The purpose of this study was to determine if educators in grades K-12 had access to remotely sensed images, would they use them in instructional projects. This assessment was made via a Remote Sensing Survey (Appendix A) designed by the author. The research survey was bisectional, with the first portion containing 14 questions concerning the level of use of remotely sensed data in elementary and secondary levels of education. The remaining portion was comprised of 9 questions concerning demographic information.

The subjects of this research were teachers in grades K-12 who receive the Journal of Geography. The names and addresses of the participants were obtained from the National Council for Geographic Education. The questionnaire, accompanied by a letter of explanation, was mailed to 951 teachers on February 7, 1991 with a return deadline of April 1, 1991. A total of 321 participants returned questionnaires which were suitable for data interpretation.

Upon receipt of the completed questionnaire at Oklahoma State University, the questionnaire was coded and entered into a computer database. By the use of computer, frequency counts were tabulated for each question and percentages were made for the total returned questionnaire population. The results of participant responses are presented in number of responses and percentage form. Based upon the purpose of the study, the results in the form of raw data better demonstrates the lack of remotely sensed data as an educational tool in elementary and secondary education. Chi-square statistical tests were performed to determine if there were any significant relations between the level of educational degree of the participant on selected research questions.

The Remote Sensing Survey was designed to collect data on the use and limitations of remotely sensed data in classroom instruction by the participant and demographic information of the participant. If the questionnaire revealed that educators would use these materials in educational projects, the study was designed to assess what types of training are necessary for educators to effectively use these materials as educational tools. Another purpose of this study was to acquire an understanding of what limits the use of remotely sensed data in K-12 education and to make recommendations as to how this problem may be resolved.

Conclusions

The analysis of the data have produced evidence to substantiate several conclusions relative to the level of remotely sensed data being used for educational instruction in grades K-12. Eighty percent of the respondents answered affirmatively that the written descriptions of the images inserted in the *Journal* were easy to read and understand. This response is attributed to the fact that two hundred and seven of the respondents (65%) received their undergraduate major degree in one of social studies fields, while one hundred and thirteen of the respondents (35%) have a minor degree in one of the social studies fields. The field of social studies includes social science, political science, geography, and history. With the exception of earth science teachers, educators receiving degrees in one of the social studies fields are more likely to possess a higher level of understanding regarding physical geography, physical geology and geomorphology than those receiving degrees in other educational fields. The ease of understanding the written description may also be attributed to the fact that seventy-four percent of the respondents had completed advanced educational degrees. This high response suggests that teachers possess a high level of educational training and a strong knowledge base in their respective educational field.

The majority of teachers who completed the survey have had no educational training in remote sensing. Only fifteen percent responded that they have received formal training in remote sensing. Formal training would include college courses in remote sensing, college courses or workshops in which remote sensing was covered. Twenty-three percent of the participants perceive the lack of teachers knowledge concerning remote sensing to be a major barrier to the adoption of these materials in the classroom. These results confirm Kirman's (1981) and Walsh's (1984) findings that the lack of teacher knowledge in the principles of remote sensing and its integration into the classroom is the major reason that this techniques is not being utilized as an educational tool in elementary and secondary schools. Although the survey results indicate a lack of training in remote sensing by the participants, sixty-three percent responded that they would use remotely sensed data for educational instruction if they had access to necessary materials.

Greater than forty percent of the teachers believe that their school administration would be receptive to acquiring remotely sensed images as tools to facilitate understanding many aspects of planet earth. Fourteen percent did not believe their administration would be willing to acquire these types of materials for educational purposes while forty-four percent were unsure about the receptiveness of their administration.. Before teachers can acquire knowledge of remotely sensed images and their educational applications, school administrators must be made aware of this new technology and be willing to provide training for educators and provide financial support for purchasing remotely sensed materials for classroom use.

The cost of remotely sensed images and additional equipment was perceived by teachers to be the largest barrier for not adopting these materials as educational tools. This is a common problem for many school systems nationwide because of budget cuts and funding problems. At the time the surveys were mailed to the teachers, it cost approximately $300.00 for a standard color image and $95.00 for a black and white image (1:1,000,000) . Shortly after the surveys were mailed the Director of the U.S. Geological Society (USGS) announced that approximately 600,000 Landsat scenes, all those acquired by multispectral scanners (MSS) aboard Landsat satellites more than two years in the past, are now available at reduced prices from the Earth Resources Observation Systems Data Center (EROSDC). The new prices for the historic MSS data are substantially lower than the prices for more current data and images that are less than two years old. For example, a 1:1,000,000 black and white paper print of an historic Landsat image sells for $10.00 from EROSDC, compared with $95.00 from EOSAT for an images less than two years old (NASA, 1991). Even with these substantially lower prices, most school systems across the nation will be unable to acquire these types of materials without financial assistance from outside funding sources, such as educational grants or educational discounts from the remote sensing industry .

Analysis of teachers suggestions revealed that fifteen percent of the teachers suggested workshops on the principles of remote sensing be conducted to help incorporate these materials into the classroom. Fifteen percent also suggested that in-service programs on remote sensing be provided. Two hundred and sixty-six (83%) of the respondents indicated that they would be willing to attend a workshop on the principles of remote sensing and its integration into the classroom. Of the two hundred and sixty-six respondents that indicated they would attend a workshop on remote sensing, all two hundred and sixty-six stated they would attend a weekend workshop while one hundred and seventy (64%) indicated they would be willing to attend a one week workshop on remote sensing. Workshops and in-service programs covering the principles of remote sensing are two ways of facilitating the education of teachers on the value of remotely sensed materials as educational tools (Kirman 1981; Lillesand 1982; Walsh 1984). These workshops and in-service program should not be the sole responsibility of the educational community. There must be a cooperation between industry and education to provide remotely sensed materials to teachers and students. Once industry employees understand the basic needs of the educational community and the classroom teacher, they will be able to assist in training school administrators and teachers in remote sensing technologies and its educational applications (Becker, 1989).

Greater than eighty percent of the participants recommended that additional remotely sensed images be inserted in the *Journal* . The major formats that participants indicated they would be interested in for future issues were natural color images or photos, high altitude photos and space shuttle imagery. Forty-nine percent of those wishing to see additional inserts suggested false color imagery. These observations support Kirman (1981) who believes teachers are more likely to use natural color images or photographs rather than false-color because of their lack of familiarity with false-color images. It is difficult for a teacher used to hand-drawn maps with colors and symbols to suddenly have to work with a new "map" with strange colors not necessarily corresponding to their natural colors.

Analysis of teacher interest in images being included in future issues of the *Journal* revealed that greater than eighty percent of the respondents would like to see additional images distributed by the NCGE. More than thirty percent of the participants indicated that they would like to see images of North America in future projects of this type. Greater than seventy-five percent of the teachers who indicated they would like to see images of North America would like to see images that "highlight" regions near their school or hometown. These results reaffirm Kirman (1977) who believed that teachers are more likely to begin 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. Twenty-seven percent of the participants indicated they would like to see images of Asia, especially the Middle East. This response came as no surprise because the Persian Gulf War between the United States and Iraq was taking place at the time this survey was mailed and the Middle East was highly visible in the news.

The participants were given four prices for individual copies of images and were asked if they would be willing to pay for the images if the NCGE provided lesson plans for future images. Eighty-four percent of the teachers indicated they would be willing to pay .10¢/image, while sixty-eight percent were willing to pay .20¢/image if the NCGE provided lesson plans with future images. Thirty-four percent of the participants were willing to pay .50¢/image while only eighteen percent would pay $1.00/image. The drop off between .20¢/image and .50¢/image may be attributed to the lack of school funding for purchasing remotely sensed images. Another reason is that educators and school administrators are not familiar with remotely sensed materials and their educational potential and, therefore, are not willing to spend money on these materials.

Middle school teachers (grades 6-7) comprised forty-two percent of the participants while forty-one percent teach high school (grades 10-12) and forty percent teach at the junior high level (grades 8-9). The distribution of the above noted grade levels were expected to be even. This assumption was made because educators receiving the Journal of Geography most likely teach courses in the social studies field (geography, social science, history, political science) and social studies courses receive more attention at these grade levels.

In response to the question concerning school size, thirty-two percent of the respondents teach in schools that have more than 1000 students for their respective grade level. This was followed by twenty percent who teach in schools of 501-750 students, and nineteen percent of the respondent teach in schools with 251-500 students and 751-1000 students. The average class size calculated from all respondents was 26 students per class. Twenty percent of the respondents stated that their class sizes were to large to effectively introduce remotely sensed materials. In a previous study by Ashton (1986), it was reported that as school size and class size increase, teachers become more resistant to implementing new educational innovations and ideas. If the factors related to size of the schools and class size affect teacher's perceptions of their effectiveness, then teachers will be less likely to try new approaches and ideas.

Findings from chi-square statistical tests on selected research questions revealed that no significant differences occurred in the responses between the educators with B.S. and M.S. degrees. One exception to these findings was the question concerning the number of the participants colleagues that would be interested in receiving remote sensing training. Analysis revealed a significant difference exists between the educators with B.S. and M.S. degrees and the number colleagues they perceived as willing to attend a workshop on the principles of remote sensing and its integration into the classroom. Since few educators are using remotely sensed images in classroom instruction, no differences were expected to occur between the responses of educators with B.S. and M.S. degrees. These findings may be attributed to an error in the wording of this question. Participants should have been given the choices of 0 and 1-5 colleagues instead of 0-5 colleagues willing to attend a workshop on remote sensing instead. The way the question was worded, it was impossible to separate the number of participants that selected 0 colleagues from those that believe 1-5 colleagues would be willing to attend a workshop on the principles of remote sensing.

Recommendations

The data indicate the educators possess a high level of interest in remote sensing and its integration into the classroom but are not using these materials at the present time for a variety of reasons. The education of teachers and school administrators is the most important phase concerning the integration of remotely sensed data in the classroom because these are the individuals who work directly with the students. Walsh (1984) stated that teachers must receive instruction about applications and uses of remote sensing before this technique can be an effective instructional tool. If the school administrators that set up and develop pre-service and in-service teacher training lack expertise in remote sensing, teachers will not acquire the knowledge to use remotely sensed materials in the classroom. In order for teachers to acquire knowledge of satellite images and applications, school administrators must learn about this new technology (Kirman, 1981). Therefore the primary step concerning the the integration of remotely sensed data into the curricula is to educate teachers and school supervisors of the curriculum values that remotely sensed data has to offer. Compensation for the lack of remotely sensed being integrated into the classroom might best be realized by implementation of the following recommendations.

The best way to accomplish this task is to develop regional remote sensing educational resource centers at major universities and colleges throughout the nation. The universities and colleges selected as educational centers should be those that prepare individuals for careers in teaching, administration or research in the professional field of education either in the common schools or in institutions of higher learning. These centers should be a cooperative effort among schools, colleges or universities, government agencies, and private industry. It would be beneficial if the schools selected as resource centers also included a geography department with a strong remote sensing curriculum. In this way, professors from the education and geography departments could work together to develop lesson plans and curriculum ideas for elementary and secondary level teachers and students.

The primary responsibility of the educational centers would be the organization of workshops or mini-courses on the integration of remotely sensed data into the curricula. Walsh (1984) believes that workshops or mini-courses should provide teachers with a competent understanding of remote sensing through lectures and related exercise such as "hands on" experiences in the analysis of remotely sensed and digital data. Workshops are also beneficial for demonstrating specific educational applications of remote sensing and to suggest ways to integrate these ideas into the classroom. The development of micro-computer programs would also be necessary to provide a realistic approach to teacher training and student use of automated systems for digital remote sensing and image processing. These resource centers would also have the responsibility of developing and disseminating literature, activities, and audio-visual materials to provide teachers with a working knowledge of the fundamentals of remote sensing. The centers would be invaluable in keeping teachers current in the educational applications of new remote sensing equipment and technologies.

A method of information dissemination that has grown dramatically in recent years has been educational television and videoconferences, commonly referred to as "distance education". Educational resource centers would be responsible for cooperating with school districts for developing a series of remote sensing activities for educational television. New innovations or integration ideas could be transmitted to teachers and students through distance learning techniques. Many advantages and capabilities exist concerning the use of distance learning techniques. Distance learning provides equity and increased quality for smaller or isolated schools where there may not be enough students or qualified teachers to support advanced or specialty courses offered by larger or less isolated schools. This technique provides access to subject matter experts or career role models not available in the local community. Students are able to interact and work on joint activities with students in other school, states or countries. Distance learning allows increased access to information and instructional resources and also provides opportunities for staff development and in-service training. The major disadvantage of distance learning is that it removes the personal aspects of education, especially one-on-one student teacher relations.

A common problem for many school systems nationwide has been budget cuts and funding problems. The recent announcement by the Director of the USGS to release approximately 600,000 Landsat scenes more than two years in the past, at substantially lower cost, all images acquired by multispectral scanners (MSS) aboard Landsat satellites. These lower costs may be a beginning step in the incorporation of satellite imagery into classroom utilization. The cost of purchasing imagery can become even more feasible if teachers from different grade levels and disciplines could agree on specific images that are suitable for the subjects they teach. This type of cooperation would also cut down on the number of images required for effective instruction.

Dissemination of the materials that are presently available should also be of top priority. Materials, such as instructional ideas by Kirman, Becker, Hall, Herzer, Marks; Walsh's book with its already designed lesson plans; visual aids such as Francis' and Jones'; and the images distributed by the NCGE are the types of efforts necessary for integrating remotely sensed images and concepts into the classroom. Although the images used in these educational efforts may be older and dated, the principles behind them are still relevant.

Studies and ideas, such as Kirman (1977, 1981), Marks (1978), Walsh (1984), Hall (1986), Herzer (NASA, 1988a), Becker (1989), Allen (1989), the NCGE's (1991) and this study may act as a catalyst towards the integration of remote sensing techniques into classroom use. The benefits that remotely sensed materials have to offer are well documented. We, as teachers, must first educate ourselves on the principles of remote sensing and its classroom value. We are responsible for introducing students to this information so that they may receive a better understanding of this marvelously complex planet that we live on with its intricate interrelationships and the ways in which we are changing it, and we need to devote our best efforts to the task. Future studies are needed to look at the most effective method(s) for instructing educators and students in the principles of remote sensing and ways in which they may effectively work with these materials. Further studies should include methods for developing remote sensing instructional modules or packages and the costs involved with developing these types of materials. It is also recommended that future studies involving remotely sensed materials and its use in grades K-12 be expanded in scope, in sample size, and in geographic distribution.

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VISUAL AIDS (SLIDE KITS)

Francis, Peter , and Pat Jones. Shuttle Views the Earth: Geology From Space. Planetary Image Center, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058

Francis, Peter , and Pat Jones. Shuttle Views the Earth: Clouds From Space. Planetary Image Center, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058

Francis, Peter , and Pat Jones. Shuttle Views the Earth: Oceans From Space. Planetary Image Center, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058

Jones, Pat. Shuttle Views of the United States. Pat Jones P.O. Box 590853, Houston, TX 77259-0853

APPENDIX A

REMOTE SENSING QUESTIONNAIRE

NASA AEROSPACE EDUCATION SERVICES PROGRAM
and
NATIONAL COUNCIL FOR GEOGRAPHIC EDUCATION

Beginning with the May-June 1990 issue, the Journal of Geography started inserting a series of eight color images that provide a synoptic view of our planet. This initial series come from a variety of sensor platforms (i.e., airplane, SPOT©, LANDSAT). These images demonstrate the capability of the sensor system as well as provide classroom instructors with visual examples of interesting and relevant geographic phenomena.

This survey will help the NASA Aerospace Education Services Program and the National Council for Geographic Education evaluate their joint effort in identifying and describing remotely sensed images for the purpose of introducing teachers and students to the benefits that these materials have to offer as an educational tool.

Did you examine the images that were inserted in the Journal of Geography? (Circle One)

A. Yes B. No

Were the written descriptions of these images easy to understand? (Circle one)

A. Yes B. No C. Unsure

Have you had any formal training in remote sensing (i.e., college course or college course in which it was covered)? (Circle One)

A. Yes B. No

If you had access to numerous types of remotely sensed images, would you use these as an educational tool? (Circle one)

A. Yes B. No C. Unsure

If **Yes**, please identify those classes in which you would use these images

____

____

If **No**, please indicate why you would not use these materials

____

____

Do you believe your school administration would be receptive to acquiring remotely sensed images as a tool to facilitate understanding many aspects of planet earth? (Circle One)

A. Yes B. No C. Unsure

What do you perceive to be the greatest barrier(s) to adopting remotely sensed images in your classroom?

____
____
____
____
____
____

Do you have any suggestions or ideas that may facilitate teacher acquisition of remotely sensed images?

____
____
____
____

Would you recommend additional inserts be added to the Journal of Geography? (Circle one)

A. Yes B. No C. Unsure

If **Yes**, what types of images/photos would you be interested in? (Check all that apply)

______ false color infrared
______ natural color
______ black-and-white
______ high altitude photography
______ space shuttle imagery

What regions of the world would you like to see covered in future projects of this type?

____
____
____
____

How would (or did) you introduce remotely sensed images to your students?

____
____
____
____
____
____
____
____

Do you have any innovative ideas as to how teachers can use remotely sensed images and materials in a classroom situation?

____
____
____
____
____
____
____
____

If the National Council for Geographic Education provided lessons to accompany future images, would you adopt them if you could acquire individual copies of the image for:

.10¢/image	Yes	No
.20¢/image	Yes	No
.50¢/image	Yes	No
$1.00/image	Yes	No

Would you be willing to attend a workshop on the principles of remote sensing and its integration into the classroom if such a course could be arranged within commuting distance from your home? (Circle One)

A. Yes B. No C. Unsure

If **Yes**, what length of time would you be willing to devote to attend this type of workshop?

______ weekend workshop
______ one week workshop
______ two week workshop

How many of your colleagues would be interested in receiving remote sensing training free of charge (or for a minimal fee)? (Check One)

_____ 0 - 5
_____ 5 - 10
_____ more than 10

What state do you live in? ______________ **County** ___________

Gender ____ Male ____ Female

What grade level(s) do you teach? (Circle all that apply)

A. elementary
B. middle school
C. junior high school
D. secondary

What subjects do you teach? ________________________________

What is the size of the school you currently teach in? (Check one)

_____ less than 100 students
_____ 100 - 250 students
_____ 251 - 500 students
_____ 501 - 750 students
_____ 751 - 1000 students
_____ more than 1000 students

What is the average number of students in your classes? _________

What was your college undergraduate major? _________________

What was your college undergraduate minor? _________________

What is the highest degree you have attained? _________________

APPENDIX B

EDUCATIONAL MATERIALS CONCERNING REMOTE SENSING DEVELOPED FOR GRADES K-12

1973

NASA. Earth Resources: Workshop Activities and Information by Harry Herzer, Washington, DC: GPO (1973)

----. Skylab Experiments: Volume 2 - Remote Sensing of Earth Resources EP-111. Washington, DC: GPO (1073)

1976

----. ----. What's the Use of Land By A.J. Petrillo; Ed.. NASA EP-103. Washington, DC: GPO, (1976b)

1978

The following topics were individually released during 1978 in Educational Topics, an Educational Publication of the National Aeronautics and Space Administration

Students Can Identify Coastline Concepts Using Landsat Images

NASA's Landsat to Monitor Timber Resources

Water Resources and Satellite Imagery

Coastal Geology

Constructing a Fault Map From Space

Environmental Geology From Space

Geomorphology #1: Differentiating Physiographic Regions - Appalachian Folds, PA

Geomorphology #2: Studying Glacial and Coastal Features and Landforms - Cape Cod and Islands, MA

Determining the Dates and Times of Landsat Passes Over the USA

Determining Forestation

Lake Michigan Shoreline

Snowpack Monitoring

Using a Landsat Imagery to Make a Mosaic of Kansas by Dr. Steven K. Marks. College of Education - Oklahoma State University; Stillwater, OK

Using a Landsat Imagery to Make a Mosaic of Oklahoma by Dr. Steven K. Marks. College of Education - Oklahoma State University; Stillwater, OK

Using a Landsat Imagery to Make a Mosaic of the United States by Dr. Steven K. Marks. College of Education - Oklahoma State University; Stillwater, OK

NASA. Educator's Guide for Mission to Earth: Landsat Views the World by Margaret Tindal. NASA SP-360. Washington, DC: GPO, (1978)

----. Using the Geographic Grid with Landsat Images by Margaret Tindal. Washington, DC: GPO, (1978)

----. Constructing a Landsat Photomosaic Using Latitude and Longitude by Margaret Tindal. Washington, DC: GPO, (1978)

----. Identification of Gross Surface Features from Landsat Imagery by Margaret Tindal. Washington, DC: GPO, (1978)

----. Observing and Studying Temporal and Seasonal Variations Using Landsat Images by Margaret Tindal. Washington, DC: GPO, (1978)

----. Photointerpretation of Landsat Images by Margaret Tindal. Washington, DC: GPO, (1978)

----. Using Scale to Compute Distances and Measure Discernible Features on Landsat Imagery by Margaret Tindal. Washington, DC: GPO, (1978)

1986

Hall, Dorothy K. "Get Close to Glaciers With Satellite Imagery." The Science Teacher (Nov. 1986): 23-28

1988

NASA. Observing The Earth From Space: Information and Activities by Harry B. Herzer, III, Washington, DC: GPO, (1988)

1990-1991

National Council for Geographic Education. Journal of Geography Eight remotely sensed images and photographs distributed in Vol.89, No.3 through Vol.90, No.2

APPENDIX C

PRETEST/POSTTEST QUESTIONS FROM 1990 OSU

AEROSPACE SUMMER ACADEMY

REMOTE SENSING UNIT

1. Remote sensing satellites can record data concerning ....

   A. water
   B. air
   C. land
   D. all of the above

2. An active system remote sensing platform ....

   A. senses naturally available energy
   B. supply their own source of energy to illuminate features of interest
   C. absorbs and re-emits signals
   D. all of the above

3. A passive system remote sensing platform ....

   A. senses naturally available energy
   B. supply their own source of energy to illuminate features of interest
   C. absorbs and re-emits signals
   D. all of the above

4. Clear water appears what color on a false-color satellite image?

   A. blue
   B. green
   C. red
   D. black

5. Healthy vegetation appears what color on a false-color satellite image?

   A. blue
   B. green
   C. red
   D. black

6. Man-made objects most commonly appear as....

   A. straight lines
   B. "jagged" lines
   C. irregular patterns
   D. all of the above

7. Remote sensing can be used to study ....

   A. weather patterns
   B. environmental problems
   C. cultural features
   D. all of the above

8. The frequency used for remote sensing satellites must ....

   A. penetrate the atmosphere
   B. reflect signals from the atmosphere
   C. be absorbed by the atmosphere
   D. all of the above

9. Remote sensing is ....

   A. the art of obtaining reliable measurements and maps from photographs
   B. experimental manipulation of an object
   C. identifying objects seen on an aerial photograph
   D. gathering information without touching the object

10. Identical Landsat images are repeated every ....

   A. 90 minutes
   B. 18 days
   C. 3 weeks
   D. 1 year

ANSWERS TO REMOTE SENSING TEST

1. D
2. B
3. A
4. D
5. C
6. A
7. D
8. A
9. D
10. B

APPENDIX D

QUESTIONS CONCERNING REMOTELY SENSED IMAGES USED DURING THE 1990 AEROSPACE HIGH SCHOOL SUMMER ACADEMY

SOUTHERN IDAHO

1. Which of the lava flows do you think is the youngest? Why?

2. The lake on the extreme east side of this image is man-made. Where is the dam located and which way does the river flow?

3. What climatic feature do you notice on the extreme northern edge of this image?

4. In the SE portion of this image there are several circular red patterns that occur. What do you think is the cause of these patterns?

U.S. - CANADIAN BORDER

5. What causes the distinct linear feature that dissects this image?

6. What are the white features that occur in the NE portion of this image?

7. In the southern portion of this image there are several rectangular patterns that occur. What do you think these feature are? Why are some of them white and others red?

8. In what direction was the sun located when this image was taken? Why do you think this?

BASIN AND RANGE

9. What do you think causes the alluvial fans in this image?

10. Is there any evidence of man's intervention in this image? If so, where?

11. What are the large white circular features that occur in the center and NW corner of this image?

12. On the southern edge of the large white circular pattern mentioned in question 11 there appears to be "ripples" of some nature. What do you think these are?

BLACK BUTTES, WYOMING

13. Is this a natural color or false-color image? Why?

14. What is taking place in the two white rectangular features in this image?

15. What are the narrow black lines that occur in these rectangular features?

16. What is the dark black line that runs from the NW to the SE?

NATURAL AND FALSE-COLOR IMAGES OF EASTERN KANSAS

17. Of these two images, which is easier to distinguish vegetation? Why?

18. In this scene, Topeka is on the west (left) edge and Kansas City is on the east (right) edge. What are the linear features located to the south of Topeka and to the north of Kansas City?

19. What is the cause of the "square" features that dominate almost the entire southern half of both images?

20. What would cause the lake NE of Topeka to be in two different colors?

HIGH AERIAL PHOTOGRAPH OF BOSTON HARBOR

21. On the northern edge of this photo there are several white circular features. What do you think these might be?

22. What are the white objects that occur in the harbor channel?

23. How would you designate the runway that is situated from NW to SE?

24. What are the white, "cottonball" like features in the NW portion of this photo?

FOLDED APPALACHIANS

25. How was the river in the center of this image able to cut through the mountain ridges?

26. Why do you think there are so many cities and towns located where the rivers cut through the ridges?

27. Can you find evidence of any roads in this image? What makes you think these are roads?

28. Where was the sun located when this images was taken?

APPENDIX E

NASA REGIONAL CENTER EDUCATIONAL OFFICES

NASA Regional Center Education Offices

If you live in		Write to the Education Office at	Teacher Resource Center
Alaska Arizona California Hawaii Idaho Montana	Nevada Oregon Utah Washington Wyoming	NASA Ames Research Center Moffett Field, CA 94035	NASA Ames Research Center Attn: Teacher Resource Center Mail Stop: 204-7 Moffett Field, CA 90435
Connecticut Delaware Dist. of Columbia Maine Maryland Mass. New Hampshire	New Jersey New York Pennsylvania Rhode Island Vermont	NASA Goddard Space Flight Center Greenbelt, MD 20771	NASA Goddard SFC Attn: Teacher Resource Room Mail Stop: 130-3 Greenbelt, MD 20771
Colorado Kansas Nebraska New Mexico North Dakota	Oklahoma South Dakota Texas	NASA Johnson Space Center Houston, TX 77058	NASA Johnson Space Center Attn: Teacher Resource Room Mail Stop: AP-4 Houston, TX 77058
Florida Georgia Puerto Rico Virgin Islands		NASA Kennedy Space Center Kennedy Space Center, FL 32899	NASA Kennedy Space Center Attn: Teacher Resource Room Mail Stop: ERL Kennedy Space Center, FL 32899

NASA Regional Center Education Offices

If you live in		Write to the Education Office at	Teacher Resource Center
Kentucky North Carolina South Carolina Virginia	West Virginia	NASA Langley Research Center Langley Station Hampton, VA 23665-5225	NASA Langley Research Center Attn: Langley Teacher Resource Room Mail Stop: 146 Hampton, VA 23665-5225
Illinois Indiana Michigan	Minnesota Ohio Wisconsin	NASA Lewis Research Center 21000 Brookpark Rd. Cleveland, OH 44135	NASA Lewis Research Center Attn: Teacher Resource Room Mail Stop: 8-1 Cleveland, OH 44135
Alabama Arkansas Iowa	Louisiana Missouri Tennessee	NASA Marshall Space Flight Center Marshall Space Flight Center Huntsville, AL 35807	Alabama Space and Rocket Center Attn: Teacher Resource Center Tranquility Base Huntsville, AL 35807
Mississippi		NASA Stennis Space Center Stennis Space Center, MS 39529	NASA Stennis Space Center Attn: Teacher Resource Room Building 1100 Stennis Space Center, MS 39529

VITA

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Doctor of Philosophy

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