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ABSTRACT

A research project in Alberta, Canada, explored the ability of elementary school students to understand and interpret infrared false color Landsat maps. Landsat maps are representations of the earth's land surface produced by orbiting satellites. Infrared is used to delineate vegetation. Accuracy and timeliness of Landsat maps make them useful for studying urban and rural developments, pollution problems, and agricultural conditions. Sixty-nine students and three teachers representing third, fourth, and fifth grade classes in Edmonton participated in the study. None had previous exposure to Landsat maps. Teachers were given preliminary training in map interpretation and possible ways of using the maps in class. No specific teaching strategies were imposed during the six to 11 instruction periods. Students were posttested with nonuniform teacher-developed tests, and three students from each class were interviewed by a researcher. Results indicated that children can work with Landsat maps if instruction is provided, and that the teachers themselves need greater familiarity with the principles involved in producing the maps. Children had difficulty understanding the extent of territory covered by the maps and the role of radiation. Further research should explore male-female achievement trends and whether children in grades 3-5 can apply Landsat map data to given problems. (AV)

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THE USE OF INFRA-RED FALSE COLOR SATELLITE MAPS BY GRADES 3, 4, and 5 PUPILS AND TEACHERS[1]

This study is an exploratory one. It is an attempt to generate preliminary data with a limited sample of participants to determine the feasibility of further definitive research on the topic. In this case, to make an initial judgment whether or not elementary school children and their teachers in this project can deal with infra-red false color Landsat maps.

Introduction

Today, through the services of space technology maps of the earth's surface are made by orbiting satellites. These maps known as Landsat and Seasat maps (Land satellite and sea satellite maps respectively) formerly known as ERTS maps (Earth Resources Technology Satellite) were first obtained when ERTS-1 was launched, July 23, 1972.[2] A second such satellite was launched January 23, 1975.[3] These satellites are in a near polar orbit, 560 miles high, each one covering almost all of the Earth's surface every eighteen days.[4] These satellites follow each other on a nine day interval.[5]

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[1]This project was funded by a grant from the Alberta Advisory Committee for Educational Studies. The cooperation of Dr. Donald Massey, University of Alberta, as external examiner, and the Edmonton Separate School Board for its facilities is gratefully acknowledged.

[2]National Aeronautics and Space Administration, Photography From Space To Help Solve Problems on Earth, (Goddard Space Flight Center, Maryland: N.A.S.A., 1973?), p. 2.

[3]Cal D. Bricker (Coordinator) and Kenneth M. Campbell (Technologist) Alberta Remote Sensing Data Center, Edmonton, Alberta, Interview, Nov. 21, 1975.

[4]NASA, Photography From Space, op. cit. p. 2.

[5]Bricker, Campbell, op. cit.

Each satellite picture contains an area of 13,000 square miles, resolving features not smaller than 30 meters.[6]

The accuracy and timeliness of these maps, as well as their uses are of extreme value:

> Agricultural fields, surface water, types of land forms, patterns of urban development and other changes in the earth's surface from natural or man-made causes are now observed on a regular basis.[7]
>
> ERTS-1 also carries a Data Collection System (DCS) that acquires water quality, rainfall, snow depth and seismic activity information from remotely located sites in North America...[8]

The scale of the Landsat maps is 1:1,000,000; however, these maps can be enlarged without loss of detail up to a scale of 1:250,000.[9] Several images are produced in various visible and non-visible light spectrum bands both in black and white and in composite false color.[10]

In the opinion of this writer these maps are far more informative and accurate than any hand drawn maps based upon previous cartographic technology. Among possible uses of the maps are: comparative growth of communities, land use, nature of vegetation, evidence of pollution, examination of geologic patterns.

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[6]NASA, Photography From Space, op. cit. p. 2.

[7]Ibid.

[8]Ibid.

[9]Ibid. p. 12.

[10]Ibid. p. 2.

With a device called a density slicer, even more uses are presented, from the identification of specific mineral and vegetable surface features to ~~the height of trees and~~ the quality of the surface soil.[11] However, this latter item is a most expensive and sophisticated tool, presently out of financial reach of almost all elementary and secondary school systems.

Given the nature of these Landsat maps, and the potential for classroom instruction that might evolve, the following questions were raised:

1. Can elementary level children obtain data from Landsat maps?
2. How would elementary education teachers use Landsat maps, assuming children on these grade levels are capable of dealing with Landsat maps?

Definitions

Landsat Map - a representation of the land surface of the earth produced with the aid of an orbiting satellite.

Infra-red False Color - that portion of the spectrum corresponding to infra-red, and used to delineate vegetation (green) on Landsat maps.

Landsat - Land satellites, scanning the land surfaces of the earth.

Seasat - Sea satellites, scanning the ocean surfaces of the earth.

ERTS - Earth Resources Technology Satellite. Formerly the name of Landsat satellites.

Visible Light Spectrum - that portion of the light spectrum visible to the human eye.

Composite False Color - color produced on Landsat maps composed of data derived from different satellite spectrum scans of the same area.

Non Visible Light Spectrum - that portion of the light spectrum not visible to the human eye.

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[11] Bricker, Campbell, op. cit.

Polar Orbit - the orbit of a satellite where the path is over the earth's poles.

Vertical Aerial Photographs - photographs taken in an aircraft of the surface of the earth directly below the aircraft.

Rationale

The rationale for undertaking this study with elementary level children is that Landsat maps are a new social studies resource, and the prime researcher was curious as to whether or not it could be used by young children.

In addition, while it might be presumed that secondary level students would probably be able to cope with many aspects of Landsat maps, no such presumption can be freely made for the elementary level, given the magnitude of the scale involved. Hence, if such relatively young children could cope with these new maps, the potential for early introduction of them might be discerned.

Implications of this Project for Social Studies

The ability to work with Landsat maps provides a new dimension of study. The Landsat maps being continually made of the same areas every nine days can provide timely, accurate data on urban and rural development, pollution problems, agricultural conditions, as well as comparative examinations of almost any surface area of the planet.

In such studies, economic, sociological, and political as well as geographic implications of these maps can be discussed with visual accuracy. Over a period of time, an historical examination of areas might be undertaken with a chronological series of maps.

To reiterate, the important chracteristic of Landsat maps for social studies is their accuracy and timeliness. Presently, there are no other

materials that can do the same or better.

Related Literature

An examination of the literature shows no studies of the use of Landsat maps with elementary level children.[12] However, studies have been made with elementary level children and aerial photographs.

B. E. Kingston used aerial photographs with children in grades one, two and three. The maps uses on each grade level were to a scale of 1:6,000, 1:12,000, 1:31,800.[13] Correlation was found between the children's uses of the maps and Piaget's opinion of classification being on a grade three level.[14] It was noted that the children considered the most difficult aerial photograph to be the low urban one.[15]

Kingston found that:[16]

1. Children of grades one, two and three can read vertical photographs.

2. Interpreting vertical aerial photographs seems to present some difficulty without any previous teaching.

3. Grade one children seem more interested in single features than groups of features.

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[12]An ERIC computor search (CIJE, and RIE) was made using the following search code: Elementary Education, Map Skills, Location Skills, Social Studies. In addition a search was made using the RESORS system - (Canada Centre for Remote Sensing Computor Based On-Line Document Retrieval System), the Canadian Education Index and Education Index.

[13]B. E. Kingston, Reading and Interpreting Vertical Aerial Photographs In The Primary Grades, Unpublished M.Ed. Thesis, University of Calgary, 1969. p. 82.

[14]Ibid. p. 84.

[15]Ibid.

[16]Ibid. p. 85.

K. G. Dueck, in a study similar to Kingston's, utilizing aerial photographs of the same scale with children in grades four, five and six, found that:[17]

1. Chronological age and map-reading ability were not significantly correlated with the ability to read and interpret vertical aerial photographs.

2. Scale did not interact significantly with any variable.

3. Children at each of grades four, five and six tended to classify features without direction, rather than identify single features.

4. The average performance of grade five subjects in reading aerial photographs was better than that of either the grade four or grade six subject.

5. The subjects performed significantly better in identifying and classifying features than in the covariation and synthesis of features.[18]

6. The subjects seemed to exhibit no preference between cultural and physical features.

7. As a result of the above findings and the fact that all children were able to make sense out of the aerial photographs, it can be stated that aerial photographs can be read by children in grades four, five and six.

Concerning the capacity of elementary level children to deal with maps, Brown and others in a study in schools in the areas of Glouster, London and Nottingham examined boys and girls ages eight to fifteen years old. Some suggestive results were that conventional signs and direction questions are

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[17]K. G. Dueck, Reading and Interpreting Vertical Aerial Photographs In The Primary Grades, Unpublished M.Ed. Thesis, University of Calgary, 1969, pp. 86-88.

[18]Dueck defined covariation as "the act of comprehending relationships among earth features which vary together in space." Ibid. p. 5.

understandable by eight year olds; at about nine or ten years of age, contour line relief can be visualized; comprehension of scale and other more difficult items began beyond age eleven; physical feature interpretation and discussion of "settlement problems" required the students to be "fourteen or older."[19]

In a study by Blaut of children aged three to twelve dealing with "mapping and free environmental behavior, "among other items,

> ...The main finding has been that mapping behavior is so highly developed before school-entering age that formal map skills and theoretical concepts in geography, social science, etc. are easily and eagerly grasped...[20]

The Kingston, Dueck and Blaut studies appear to confirm that elementary level children are capable of dealing with aspects of aerial photographs and maps. While the Brown study does not sepcifically deal with aerial photographs, the conclusions drawn from it do not appear to suggest ease of comprehension of certain aspects of maps by elementary level children. However, items such as the types of maps and the nature of the research may enter into the difference between this study and the aforementioned ones. As well, the socio-economic level of the children may have had a bearing on the differences as well as the nature of the social studies curricula that can be found in England in comparison with those of North America.

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[19] T. W. Brown, et. al., "An Investigation into the Optimum Age at which Different Types of Map Questions May Best Be Set To Pupils In The Teaching of Geography," International Geographical Union, 1970, Clearinghouse Accession Number: So002755. descriptor

[20] J. M. Blaut, "Studies of Place Perception in Elementary and Pre-School Education. Vol. I. Final Report." Clark University, 1971, Clearinghouse Accession Number: PS005603. descriptor

Instruments

Three instruments were used in this exploratory project: teacher made tests for each class; an "Interview Questions For Children on Landsat Maps" administered and prepared by the prime researcher; teacher questionnaire prepared by the prime researcher.

The instruments are subject to the following:

1. No validated instrument has been found that can test the abilities of elementary level school children to read infra-red false color Landsat maps.

2. No previous studies have been found utilizing Landsat maps with elementary level school children in order to provide a comparative study to extrapolate testing tools for this study.

3. The purposes of the study are to determine if the participating elementary level school children are capable of deriving information from infra-red false color Landsat maps, and if their participating teachers can teach about them.

Thus, the teacher made instruments would necessarily be:

1. Tentative rather than definitive.

2. Specific to this study, rather than general.

3. Designed to elicit a response unique to the teaching procedures of each class, and the information taught.

4. To elicit responses to Landsat map questions considered correct by each teacher.

Under these circumstances, the teacher made instruments may be considered valid for their particular classes. Since these instruments are unique to these teachers and children and are not to be used again, the element of reliability appears not to enter into this consideration.

The "Interview Questions For Children On Landsat Maps," administered by the prime researcher is to elicit responses to questions based specifically on Landsat maps. The object is to determine if children of varying abilities

using different area infra-red Landsat maps than those used in their class are able to derive information from them, and answer questions about them.

This instrument was designed specifically to generate tentative data on the ability of a select number of children of varying abilities to answer specific questions about infra-red Landsat maps (vegetation and snow cover maps). Since the questions were specific to the Landsat maps in question, and since the children appeared able to understand the questions and respond to them, it may be tentatively considered that this tool was valid for the purposes stated.

Since the questions are such that they may be applied to any infra-red false color Landsat map, the instrument may be tentatively considered as reliable for the purpose stated.

The teacher questionnaire being subjective for each teacher, elements of reliability appear not to be germane to it. Since it deals with matters related to teaching with Landsat maps designed to generate data for this study, these instruments tentatively appear to be valid for this study.

Research Questions

In order to determine if children on the grade 3, 4, and 5 level were capable of dealing with Landsat maps, the following questions were formulated:

1. Can grade three, four and five teachers work with Landsat maps in their planning for classroom activities?

2. Can grade three, four and five children understand what Landsat maps are, by deriving information from them?

3. Will grade three, four and five teachers be able to teach their students about Landsat maps?

4. Will grade three, four and five teachers have to modify Landsat maps in order to use them with their students?

Study Design

Grade Level Rationale

The rationale for the use of Landsat maps with grades three, four and five is that the Alberta social studies curriculum calls for community studies in grade three, Alberta in comparison with other regions of the world in grade four, and regional studies of Canada in grade five. These topics can lend themselves to the use of maps for classroom activities.

Teacher Selection and Preliminary Training

In cooperation with the Edmonton Separate School Board, one teacher and class on each grade level were selected. The teachers and students had no previous exposure to Landsat maps. Prior to the classroom phase of this exploratory project, the teachers and research director met twice as a group. The first meeting was at the Alberta Remote Data Sensing Center in Edmonton for approximately one hour. There they were instructed in interpreting Landsat maps, and the technology involved in obtaining the map image.

A second meeting was held for approximately one hour at the Separate School Board Headquarters for a brain storming session on possible ways of using the Landsat maps in class. Teachers also received several National Aeronautics and Space Administration publications on Landsat maps.

At the first meeting it was determined that two Landsat maps would be used: one with snow cover, and one without. The teachers decided that infra-red false color might prove more effective with the children due to the attractiveness of the color, and the apparently greater contrast between earth surface features than any of the black and white maps. Landsat maps are not made in true color.

Classroom Materials

The maps selected by the teachers were of the Edmonton Region. One was a fall map without snow cover. The other was a spring map with snow cover. Both maps were of approximately the same area, with the spring map covering a more south-westerly area than the fall map. The maps' size was 18.2 cm x 18.4 cm each.

Enough prints of the maps were provided for two children to work on a single set. In addition some magnifying glasses were also provided. Each teacher had available an overhead projection size transparency of each map in infra-red false color, a class set of gasoline company maps that included the area of the Landsat maps, and an overhead projection transparency of the road map with the approximate areas of the Landsat maps marked on them. Black China markers to mark the surface of the maps were also provided for the children.

Teaching Strategies

Since there were no studies of the use of these types of maps with elementary school children, the teachers were asked to teach about these maps in the way they felt it was best for their classes.

Evaluation Procedures

In order to allow for complete flexibility of class instruction and to avoid teaching to a test no uniform written post test of all the children was given. The teachers were requested to prepare an examination and evaluate their students following the classroom instruction phase, and to determine prior exposure to these types of maps.

Following the classroom evaluation, the prime researcher orally interviewed three children on each grade level. Selected by the teachers, these children were considered above average, average, below average. The teachers also received a questionnaire on their participation in the project. All data was submitted to an external examiner for review.

Teacher Data

Elementary School Teaching Experience, and Professional Training

Grade 3 - Six years, B.Ed.

Grade 4 - One year, B.A., B.Ed.

Grade 5 - Six years, B.A., B.Ed. (equivalent), completing Graduate Diploma in elementary reading.

Class Data

Grade 3

Number 25 Male 15 Female 10

Reading Level: Mean 4.07 S.D. .800 I.Q.: Mean 108.5 S.D. 9.88 (Primary Mental Abilities Test)

Grade 4

Number 25 Male 16 Female 9

Reading Level: Mean 4.93 S.D. 1.21

I.Q.: Mean Verbal 106 S.D. 13.02 Non-Verbal 109.70 S.D. 14.01 (Lorge Thorndike)

Grade 5

Number 19 Male 12 Female 7

Reading Level: Mean 4.42 S.D. 1.00

I.Q.: Mean Verbal 91.31 S.D. 13.91 Non-Verbal 87.25 S.D. 14.19 (Lorge Thorndike)

Classroom Phase

Prior to starting the instruction phase of the project, the teachers were asked to check the medical records to ascertain if any of the children had vision problems, and to specially observe those who did.

Since there was no experience base concerning Landsat maps on the elementary level, the teachers emphasized different aspects of them. Thus, the grades three and four teachers emphasized radiation that allows images to be made, while the grade five teacher emphasized specific geographic features.

All teachers provided some background information on how the maps were produced. The grade three and four teachers prepared some ditto sheets of National Aeronautics and Space Administration materials for distribution to the children, and had the students prepare a special folder for the Landsat activities. It may be noted that the grade three and four teachers were both at the same school. There was virtually no prior exposure of the students to satellite maps, as determined by the teachers.

During the course of the project, the research director visited all classrooms a minimum of three times. Teachers were prepared and the students participated in an interested orderly manner. All classes were well organized. When not conducting a question and answer activity, the teachers moved among the students providing advice and guidance.

Class activities consisted of: basic factual instruction; questions and application of information to the maps at hand; examining a single Landsat map first, usually the fall one, for surface features; examining the second map for these surface features; checking for differences between the fall and spring maps; comparing the Landsat maps with gasoline company road maps (grade three did not use the gasoline company road maps, but examined

the overhead projector transparency of the road map-there was a road map displayed on the back wall of the classroom during the entire project.

Teachers began working with the fall map first. Then when the children were able to work with it, the spring one was introduced. After examining the spring Landsat map and becoming familiar with it, both maps were used for comparative purposes.

One aspect of the instruction was that the children were able to write and mark the surface of the Landsat maps with easily erasable China markers. When the overhead transparency projector was used, children were encouraged to come to the screen and point out features being discussed or newly discovered.

In all classes, children worked in teams of two. The reason for this was to minimize expenses for the maps. A second benefit was that each child was able to interact with a least one other child.

Grade	Hours of Teaching	Period Length	Instruction Periods
3	5	45 minutes	6 - consecutive with a double period later in the day, if necessary
4	4½	45 minutes	6 - consecutive
5	5½	30 minutes	11 - over a period of 16 days, with one lesson on any one day

Evaluations

Teacher Evaluations

The teacher made examinations differed greatly concerning content, number of questions, and manner of administration. However, specific questions in almost all tests could be designated either as interpreting the maps, or applying the maps to a problem. In this way a very rough measure could be obtained of the number of students able to interpret the maps or apply the

maps to a problem.

The following are the teacher made questions that may show the maximum number of students able to interpret the Landsat maps as determined by the teachers:

Grade 3

Question #6 - What types of land surface are seen on these maps? Name them.

Full Credit 14 Half Credit 9 Total Credit 23

Grade 4

Question #5 - What is the main thing to be seen when you look at any Landsat map?

Total Credit 13

Grade 5

Question #5 - (one among a series of interpretive questions) On this summer map, the large blue areas represent: (a) rivers (b) lakes (c) forests (d) mountains

Total Credit 19

The following are the teacher made questions that may show the maximum number of students able to apply Landsat maps to a problem, as determined by the teachers:

Grade 3

Question #9 - (a) What can these ERTS maps tell farmers?

Full Credit 14 Half Credit 4 Total Credit 18

(b) How can the maps help the Forestry Department or the lumberman?

Full Credit 20 Half Credit 3 Total Credit 23

Grade 4

Question #6 - Name three different groups who could use Landsat maps for their benefit?

Full Credit 8 Partial (2) 5 Partial (1) 3 Total Credit 16

Grade 5

Questions were mainly interpretive.

Scores for the teacher made tests were:

	Mean	Standard Deviation	Range
Grade 3			
Class	78.1	13.73	45-100
Males	78.2	14.76	45-100
Females	78	12.95	65-90
Grade 4			
Class	54.74	23.18	0-100
Males	57.5	22.61	30-100
Females	43.8	29.25	0-80
Grade 5			
Class	69.1	12.02	44-92
Males	69.8	15.20	44-92
Females	68.6	4.86	60-76

Interview Evaluation

Following the classroom phase of the project, the prime researcher interviewed three children on each grade level: above average, average, below average, for the class as determined by their teachers. Each child was asked a series of 15 questions, 13 of which had one or more responses that could be graded as correct or incorrect. Based upon these 13 questions, there was a possible total of 20 correct answers.

The questions were based upon a fall and a spring Landsat map, and one question was based upon the Landsat maps and a road map of the area. These

maps were of a different area than those used in the class. Question #10 of the series required the children to pick out a town on the Landsat maps. No child was able to do this due to the small size of the towns in the area, and this question may not constitute a valid measure of the children's capability to do this.

The following are the data of the interview examination:

A = Above Average B = Average C= Below Average

GRADE	AGE	SEX	I.Q.		READING	CORRECT RESPONSES	PERCENT	LESS QUESTION #10
Grade 3								
A	7.3	M	N/A		4.8	13	.65	.72
B	8.1	F	129		4.7	13	.65	.72
C	8.1	M	109		2.7	13	.65	.72
Grade 4			Verbal	Non-Verbal				
A	9.4	M	112	131	6.2	12	.60	.65
B	9.1	M	122	118	5.6	17	.85	.94
C	8.11	F	108	115	4.9	5	.25	.28
Grade 5								
A	10.3	F	114	111	5.8	13	.65	.65
B*	9.9	F	N/A	N/A	5.3	8	.40	.44
C	11.7	M	N/A	N/A	N/A	11	.55	.61

* Teacher noted child as nervous and inattentive with family mental health and marital instability.

Research question two regarding grade three, four, and five children understanding what Landsat maps are, by deriving information from them, appears to be answered affirmatively. Both the teacher made tests and the

oral evaluation show that the children were able to derive information from the Landsat maps. Based on the data, it may tentatively be concluded that children at these grade levels have the capacity to work with Landsat maps. One notable discrepancy did occur. The mean of the teacher made test grades for the grade four girls with relatively high I.Q.'s and reading scores had scores that were comparatively low.

In discussing this with the grade four teacher, it was noted that the girls were generally less enthusiastic about the map activities than the boys as evidenced both by classroom response and the amount of outside literature brought to class. In attempting to seek an explanation for this, the means for the I.Q.'s for the boys and girls in grade four were examined in comparison with grade three and five to see if a male or female achievement trend was evident.

The following were the scores:

Grade 3			S.D.	
Male		108.58	9.2	
Female		108.43	11.71	
Grade 4	Verbal	S.D.	Non-Verbal	S.D.
Male	102.93	12.48	105.5	15.72
Female	111.11	12.97	116.22	7.74
Grade 5				
Male	86.9	14.10	82.3	12.0
Female	98.67	10.89	95.5	14.61

A definitive procedures would be to have many grade four classes on the same intellectual level in comparison with each other in order to discern differing

male or female trends.

In examining the above data, the comparative validity is subject to question since grade three received a different type of I.Q. test from grade four and five, and a comparison of grades four and five is subject to question since they are on different grade levels, and it appears that the grade four group may be intellectually superior to the grade five group.

Thus, from the above data no male-female achievement trend can be discerned or implied between the grade levels, but may possibly exist. The other variable that may have entered into the discrepency in the teacher made test scores between the girls and boys on the grade four level is that the grade four teacher had only one year of teaching experience. Classroom observations did not sustain a consideration that the teaching procedures were at fault.

It may be concluded that the girls in the grade four group had a higher I.Q. mean than the boys, but that they performed noticably poorer on the teacher made test. Given the comparatively more successful performance of the grade three and grade five girls, the performance of the grade four girls may have also been unique to that group of children.

The teachers reported that children with visual problems (which ranged from wearing glasses to color blindness) showed no difficulties in dealing with the maps.

Although the children were able to work with the Landsat maps, the teachers felt that without their instruction they could not have. The grade three teacher reported that the children were able to identify "lakes, rivers, mountains, clouds, cities and parts of farms," on their own, but that there was a problem in comprehending the distance involved in making the image.

The grade four teacher reported that some children had difficulty in realizing the extent of territory covered by the maps, but this was overcome with instruction. Also, that children had difficulty understanding how the map was made, especially regarding the role of radiation, was also reported.

No difficulty was reported by the grade five teacher other than a belief that his lack of knowledge about the relationship of the infra-red color to vegetation hampered the children.

The data generated by this exploratory project appear to answer affirmatively research questions one and three regarding grade three, four and five teachers' ability to work with the Landsat maps and if they will be able to teach their students about Landsat mpas. However, because: two teachers, grade four and grade five, were observed in class to be unclear about infra-red color;[21] because of the answer of the grade three teacher to question 6 of the Landsat Map teacher Questionnaire, that more background information was needed; the answer to question 10 of that questionnaire by the grade four teacher concurring on the need for more background information; the answer to question 11 of the same questionnaire by the grade five teacher suggesting inservice sessions on the use of the Landsat maps, it may be concluded that a more extensive preparatory program than that used for the project is necessary to train teachers to work with Landsat maps.[22]

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[21]The inability of grade 5 students to distinguish plant life on the interview evaluation was apparently due to this.

[22]It may be noted that the teacher made tests contained an abundance of low level questions. Perhaps this was due to the background weakness of the teachers as may be inferred by these replies.

The teachers reported no difficulty in using the maps as is. Thus, research question four, that the teacher would have to modify Landsat maps in order to use them with their students is answered negatively. The grade three teacher noted that larger maps would have enabled the children to do more with them, since they enjoyed working right on the maps.

In answer to the question, What is your general feeling about the capacity of children on the grade level you teach to use Landsat maps?, the following answers were given by the participating teachers:

> Grade 3 - My feeling is that with proper preparation and knowledge the average grade three class should be able to grasp the simplest concepts involved. They do enjoy the manipulative aspects of locating familiar places and labelling them with grease pencils, also hunting for places with a magnifying glass appealed to them (they told me so).
>
> Grade 4 - It is not an easy concept for them to grasp, but an introduction to this type of map definitely gives the student a new and broader idea about maps.
>
> Grade 5 - Enthusiastic!

The youngest child in the project was 7.3 years old. Also of interest was that the only children to obtain correct responses to question 9 on the Interview Evaluation "Can you find any farm land on both of these maps?" were the below average child for grade three and the average child for grade four. The other children were unable to identify farm land on either of the maps. The possibility exists that these correct answers may have been good guesses; however, that correct responses were obtained with both spring and fall maps raises the presumption the answers may have been based upon knowledge.

One item of data that could have been derived from this project was which of the two maps were easier to work with: the vegetation cover or the snow cover? This was not done since any data would be misleading. This

is due to the variation in observation of specific features because of the intensity of the infra-red false color and contrast with non-vegetation varying from region to region, and whether or not inhabited areas or roads are cleared of snow in the winter. Thus, each region's Landsat maps varying from season to season must be examined on their merits. However, it appears that greater contrast between ground cover and items of interest can promote easier identification of these items.

The data seemed consistent with Kingston's findings that youngsters in grade three can read vertical photographs, and that without previous teaching there was some difficulty in vertical aerial photograph interpretation.[23]

The data also appears to be consistent with Dueck's findings that there was no significate correlation between chronological age and map reading ability.[24] Although due to the variation in class ability, experience of the teachers and the differing approaches taken by the teachers in this project this consistency may not be valid.

Since there appeared to be no problems concerning map scale, the project data seems consistent with Dueck's similar findings. While Dueck found grade five subjects to perform better than grade four or grade six subjects, [25] the grade three subjects in this project appear to have performed better on their evaluations than the grade four or grade five children. This may possibly not be considered a valid comparison for the reasons noted above.

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[23]Kingston, op. cit. p 84.

[24]Dueck, op. cit. pp. 86-88.

Conclusions and Recommendations

Research questions 1, 2, and 3 appear to be answered affirmatively for the participants in this project. Research question 4 appears to be answered negatively for the participants in this project.

Since children on the grade three, four and five level seemed to be able to work with infra-red false color Landsat maps to obtain data from them, it may be tentatively concluded that such Landsat maps can be used on these levels. However, the extent to which children can apply Landsat map derived data to problems remains to be explored.

Teachers of grade three, four and five children in this project appear to be able to teach about Landsat maps to their students. However, the level of instruction appeared related to the background knowledge of the teacher. It may be concluded that a more extensive program of instruction is necessary to provide teachers with Landsat map background information than was provided in this project.

Suggestions For Further Research

A more definitive project allowing greater scope for claims of effectiveness of using Landsat maps with elementary school children might be undertaken with the following considerations:

1. A larger selection of students on each grade level. A minimum of three classes, or as many as needed to reach 100 students on each grade level.
2. All students to be as nearly as possible within the range of "average." If not, then as intellectually comparable as possible.
3. All students to be as nearly as possible within the same socio-economic level.
4. All students to have "normal" reading levels. That is, no students with serious reading problems in the sample, if possible.

5. Participating teachers to be as comparable as possible to each other as to professional training, teaching experience, ability, and interest.

6. Participating teachers to follow specific teaching procedures on each grade level.

7. Teaching objectives to be specified before classroom phase is to begin.

8. All children to be pre and post tested, using uniform examination for all grade levels, and uniform examinations on specific grade levels where special circumstances relating to that grade level merit such examinations.

9. A thorough training program for participating teachers in teaching about Landsat maps, and how these maps are produced and used. Five hours is suggested for this phase, as a minimum.

10. External evaluation at all phases of the project.

New Questions

1. Is there a sex related difference between grade 4 students' interest and achievement with Landsat maps?

2. Can children on grade three, four and five levels work with the black and white Landsat maps? If so, which types?

3. Can children on the grade one and two levels deal with Landsat maps?

4. To what extent can children on the grade three, four and five levels apply data from a Landsat maps to given problems?

APPENDIX A

INTERVIEW QUESTIONS FOR CHILDREN ON LANDSAT MAPS

1. What are these? (Pointing to both Landsat maps)
2. How were they made?
3. What are the differences between these two maps?
4. Can you tell if there are any growing plants on these maps? How?
5. Can you find a lake on both of these maps?
6. Can you find a river on both of these maps?
7. Can you find a road on both of these maps?
8. Can you find any clouds on both of these maps?
9. Can you find any farm land on both of these maps?
10. Can you find a town on both of these maps?
11. Here is a regular map of the land shown by the Landsat map. Find the town of High Level on this map. Now find High Level on a Landsat map.
12. What could people use these maps for?
13. Can you tell me anything else you know about these maps?
14. What else would you like to learn about these maps?
15. If you were in the lumber business, could Landsat maps help you? How?

APPENDIX B

GRADE 3 TEACHER'S CULMINATING EXAMINATION

1. What was it that took the photos (ERTS maps)[1] you have been studying?

2. Can you tell me how high up these pictures were taken?

3. Are these photographs like the ordinary photos your parents take? Yes or No, then explain your answer.

4. What does all the pink stand for on the two maps you have?

5. Why are there so many shades of pink on the maps?

6. What types of land surface are seen on these maps? Name them.

7. Draw and color for me a small square on your paper, showing what a field of wheat would look like on the ERTS maps.

8. Did the two ERTS maps that you have seen show exactly the same areas of land? Explain your answer.

9. What can these ERTS maps tell (a) farmers? (b) How can the maps help the forestry department or the lumbermen?

10. What has interested you the most about this unit on the ERTS maps? Is there anything else about what we have studied that you would like to know?

GRADE 4 TEACHER'S CULMINATING EXAMINATION

1. What is the main thing needed for these types of maps?

2. Why is it possible to make maps from space?

3. Give two advantages of Landsat maps.

4. Give two disadvantages of making Landsat maps.

5. What is the main thing to be seen when you look at any Landsat map?

6. Name three different groups who could use Landsat maps for their benefit.

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[1]N.A.S.A. information publication given teachers contained older name for Landsat maps. This publication was produced prior to name change.

GRADE 5 TEACHER'S CULMINATING EXAMINATION

1. This picture map was taken from:
   (a) the top of a high building
   (b) an airplane
   (c) a satellite

2. This picture map was taken from an altitude of about:
   (a) 1 mile
   (b) 10 miles
   (c) 100 miles
   (d) 1000 miles

3. Is this map (a) more or (b) less accurate than the Alberta Road Map?

4. On the summer map, the area at the bottom left (reddish-brown area) is made up mostly of:
   (a) mountains
   (b) hills
   (c) low, flat lands

5. On this summer map, the large blue areas represent:
   (a) rivers
   (b) lakes
   (c) forests
   (d) mountains

6. The rectangular regions on the eastern (right) side of the summer map represent:
   (a) lakes
   (b) fields
   (c) buildings

7. The blue lines (summer map) represent:
   (a) highways
   (b) valleys
   (c) rivers
   (d) lakes

8. In one word, tell what the white matter is at the bottom left hand corner of the summer map.

9. Why isn't the top of the summer map very clear?

10. What explains why there is a body of water on the winter map?
    (a) powerhouse
    (b) lake
    (c) field
    (d) forest

11. The tiny criss-crossing lines on the eastern (right) side of the winter map represent:
(a) streets
(b) rivers
(c) fences
(d) roads

12. Which map shows lakes more clearly? Summer or winter map?

13. Which map shows highways more clearly?

14. Which map shows fields more clearly?

15. Which map shows cities more clearly?

16. How is the overall shape of Gull Lake different on the Alberta Road Map as compared to the summer Picture map?

17. Name this lake. (ans. Buck Lake)

18. Name this lake. (ans. Lake Wabamun)

19. Name this major river on the summer map. (ans. North Saskatchewan River)

20. Name this town at the very top of the winter map. (ans. Leduc)

21. Name this major river on the south-eastern (bottom-right) corner of the summer map. (ans. Red Deer river)

22. Name the town that is located just north of the biggest lake in the lower left-hand corner of the summer map. This town is near where this major river veers off suddenly toward the north and slightly west. (ans. Rocky Mountain House)

23. Compare the location of Bittern Lake in relation to Pigeon Lake on the summer map as opposed to the Alberta Highways Map.

24. Do you think that this Landsat picture map unit was:
(a) easy
(b) just right
(c) too hard

25. Can you suggest any way in which you or anyone else could use these maps?