The Alberta Journal of Educational Research *Vol. XLVI, No. 2, Summer 2000, 134-148*

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The Ability of Grade 5 Students to Use Radarsat Satellite Images

This exploratory study examines the ability of grade 5 students to interpret selected elements of a Radarsat satellite radar image. The participants were provided with images of their neighborhood, downtown Edmonton, and the town of St. Albert for instruction. They were then tested with an image of Calgary similar to that of their own neighborhood. The participants were able to interpret successfully most elements of the image, but not as successfully as had as grade 6 students in an earlier study. Based on performance there is potential to use Radarsat satellite fine mode images for geography instruction at the grade 5 level. An attempt was also made to see if the grade 5 students were able to work directly with the Radarsat data CD-ROM. The CD-ROM proved difficult for the students to use, but the CD-ROM program tools allow teachers to produce hard copy images that can be customized for their students' use.

Cette étude exploratoire a analysé la capacité d'élèves de 5^e^ année à interpréter quelques éléments choisis d'une image satellite Radarsat. On a fourni aux participants des images de leur quartier – le centre ville d'Edmonton et la ville de St. Albert – pendant une session de formation. Par la suite, on leur a fait passer un test avec une image qui ressemblait à celles qu'ils avaient déjà vues mais qui représentait Calgary. Les participants ont réussi à identifier la plupart des éléments, mais pas aussi bien que les élèves de 6^e^ année qui avait participé à une étude préalable. En se basant sur ces performances, on affirme qu'il est possible de se servir d'images satellites Radarsat en mode haute définition pour enseigner la géographie en 5^e^ année. On a également tenté de voir si les élèves en 5^e^ année pouvaient travailler directement à partir du CD-ROM de données Radarsat. Même si les élèves ont éprouvé de la difficulté avec le CD-ROM, les outils de celui-ci permettent aux enseignants d'imprimer des images qui peuvent être adaptées pour mieux répondre aux besoins de leurs élèves.

This exploratory study addresses the question "Can grade 5 students interpret elements of fine mode Radarsat images?" The use of Radarsat satellite images provides a new tool for grade 5 geography instruction. This study also deals with the geographic topic of remote sensing, in particular, using images produced by the Canadian Radarsat satellite.

Remote sensing means being able to examine something without being in direct contact with it. For example, our eyes are remote sensors, and by observing something we are remotely sensing it. Thus aerial photographs and satellite

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images are remotely sensed geographic products. The satellites that produce images for geographic purposes are earth resources technology satellites. They are not used for military purposes and differ significantly from military spy satellites. Military satellites have an equatorial orbit, high-resolution scanning devices, and can be maneuvered from earth. The earth resources technology satellites traverse a polar orbit, contain comparatively low-resolution scanning devices, and are not ordinarily maneuvered from earth.

The Radarsat satellite was launched in 1996 and scans the earth from a height of 800 km, circling the earth around the Poles in approximately 100 minutes. Previous remote sensing satellites were unable to provide images of the earth through cloud cover or of the dark side of the earth. The radar images produced by this satellite are not limited by these conditions, and the satellite can image a location every 24 days for continuous monitoring (Canadian Space Agency, 1994).

Radarsat images are a unique geography tool as the radar sensor allows images to be made without light, independent of weather conditions, and provides images that are geologically superior to other satellite images. Radarsat also produces images that can vary from 50 km^2 to 500 km^2 with resolution from 9 m^2 to 100 m^2. Radarsat images provide a unique and versatile geography tool where use is limited only by the imagination of the user.

National Geography Standards

Among North America's most respected associations for geography are the National Geographic Society, National Council for Geographic Education, American Geographical Society, and the Association of American Geographers. *Geography for Life: National Geography Standards, 1994* was developed on their behalf (Bednarz et al., 1994). Eighteen standards were noted that are divided into six areas: The World in Spatial Terms; Places and Regions; Physical System; Human Systems; Environment and Society; and the Uses of Geography.

The use of satellite images for classroom instruction in geography meets 10 of the 18 standards. They are:

> Standard 1: How to use maps and other geographic representations, to acquire, process, and report information from a spatial perspective
> Standard 3: How to analyze the spatial organization of people, places, and departments on Earth's surface
> Standard 4: The physical and human characteristics of places
> Standard 7: The physical processes that shape the patterns of Earth's surface
> Standard 8: The characteristics and spatial distribution of ecosystems on Earth's surface
> Standard 9: The characteristics, distribution, and migration of human populations on Earth's surface
> Standard 14: How human actions modify the physical environment
> Standard 15: How physical systems affect human systems
> Standard 17: How to apply geography to interpret the past
> Standard 18: How to apply geography to interpret the present and plan for the future. (pp. 34-35)

Educational Value and Relationship to the National Geographic Standards
Satellite images provide an astronaut's view of the earth. They are timely and up to date. Traditional cartographic products are hand-drawn and often require an on-site visit from the cartographer. Usually these are costly to produce, go out of date quickly, and it can be years until new ones are made. The continuous observation of the earth by imaging satellites allows students:

- to see changes as they happen: Standards 1, 3, 14, 15, 18;
- to compare before, during, and after images of construction and disasters: Standards 1, 7, 14, 18;
- to monitor land use: Standards 1, 3, 4, 9, 14, 15, 17;
- examine pollution trajectories and the effects of pollution: Standards 1, 9, 14, 18;
- to locate and track icebergs: Standards 1, 4, 7, 8, 15, 18;
- to view water flow and drainage patterns: Standards 1, 4, 7, 8, 15, 17;
- to see accurately surface geology such as glaciation: Standards 1, 7, 15, 17;
- to view historical items such as ancient roads and trails visible only from great heights: Standards 1, 3, 8, 9, 17;
- to obtain a new perspective for viewing locations: Standards 1, 3, 8, 14;
- to observe habitats and land structure from a local to a regional view: Standards 1, 3, 4, 8, 9, 14, 15, 17, 18.

Previous Research
No studies in the professional literature deal with the abilities of grade 5 students to use Radarsat satellite images or with their ability to use any type of geographic radar product. Recent research establishes that grade 6 students are capable of working with Radarsat satellite images (Kirman & Nyitrai, 1998).

Virtually all research dealing with satellite images on the elementary level have come from Project Omega[1] at the University of Alberta's Faculty of Education. This research has dealt mainly with Landsat satellite images. Specific studies range from assessing the abilities of grade 3 students to derive information from them (Kirman, 1977, 1981) to using Landsat images with infrared vertical aerial photographs (Gyan, 1984). A grade 6 unit to teach about a volcanic eruption has been developed (Smith, 1982), as well as a computer assisted instruction procedure to teach about Landsat images on the grade 6 level (Burke, 1983). The abilities of grade 6 students to understand the role of digital data in producing satellite images (Kirman & Unsworth, 1992) and to manipulate Landsat digital data with a computer program to derive information about a location have also been explored (Kirman & Jackson, 1993). Research at Project Omega is now focused on Radarsat images. The project (Kirman & Nyitrai, 1998) dealing with grade 6 students' ability to interpret Radarsat images was the first, and this study is the second.

Participant Group
This study was undertaken at an elementary school in Edmonton, Alberta, Canada with a grade 5 class consisting of 13 boys and 19 girls with an average age of approximately 11. Three girls and two boys are special needs students. This is defined as being below the average range IQ. Four of these students are about two grade levels below the class in reading and writing. The fifth is an "opportunity" student who is functioning at a grade 1 level in all areas. One

child in the class, also a special needs student, has a vision problem. This class and the grade 6 class in the earlier study were rated by their teachers as slightly below average.

Procedure

Our procedure involves teaching the students about locating selected items for Radarsat image interpretation, providing activities for them to apply this skill, observing them while they undertake these activities, examining them for these skills using a Radarsat image that they have not yet worked with, and asking for their comments about what they liked and did not like about the process (Kirman & Nyitrai, 1998). The students used the same images and received the same test as the grade 6 students in the previous study.

The students worked in teams of two to four, as earlier research on remote sensing in the elementary classroom found that a team approach lent itself to discussion by the team members and a cooperative attitude toward the activities (Kirman, 1977, 1981). Two students worked by themselves because they caused a discipline problem in their groups.

The students were provided with three 8 x 10 in. Radarsat prints. One print was of their neighborhood (Figure 1), the second was central Edmonton (Figure 2), and the third was the area of St. Albert (Figure 3), a city to the northwest of Edmonton. They were also provided with a road map of the locations and erasable liquid markers. Although magnifying glasses were available they were not used because the teacher felt that the students were able to examine the images and road maps without them. This appeared to be a correct judgment as none of the students reported having a problem in viewing the images and maps during the activities.

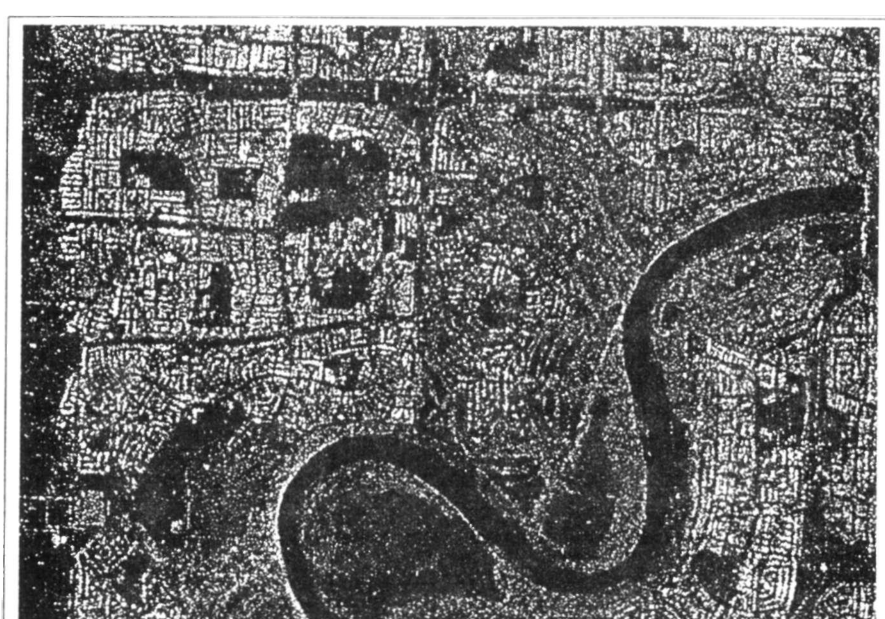

Figure 1.

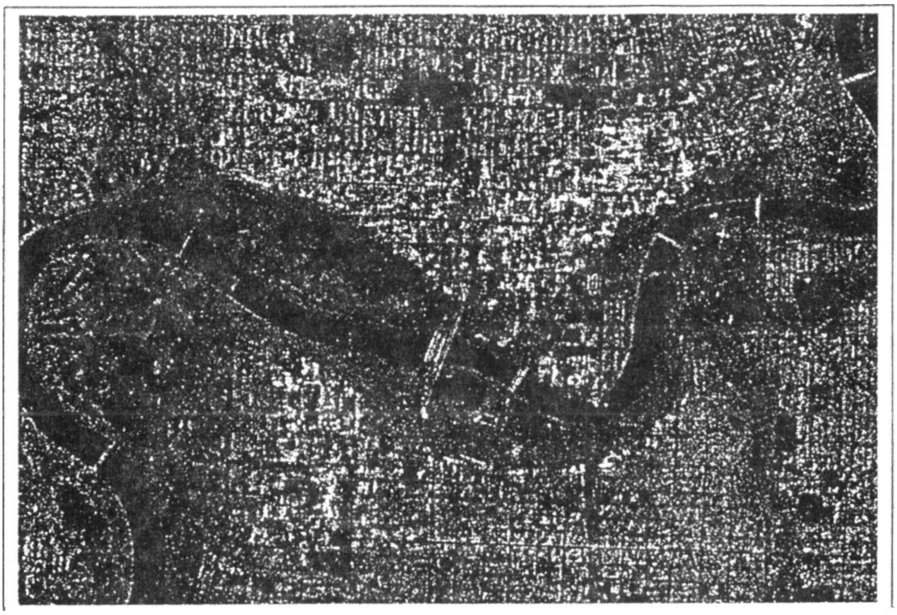

Figure 2.

The images were housed in clear plastic covers, and the students were encouraged to write on the covers. The images were at a scale of 1:25,000, and the road maps were at a scale of 1:40,000. All the images were made on October 22, 1996. The images are of a fine resolution beam with 9 m^2 resolution. This fine-beam image mode was selected because urban areas were to be examined and fine resolution would best show urban features.

The week before beginning classroom Radarsat image instruction the students had an approximately 45-minute introduction to the Radarsat satellite and images on the Internet[2] and approximately 45 minutes of map work with road maps of the cities of Edmonton and Calgary. They also received 160 minutes of classroom instruction about features found on Radarsat images ranging from 35 to 47 minutes each period. This took place over four days between February 17 and March 2. The time devoted to Radarsat, including the Internet activity and map work, was approximately 4 hours and 10 minutes. The class testing was on March 6.

In the grade 6 study the students had four consecutive afternoons of instruction totaling 3 hours and 43 minutes. They had no Internet activities or special map instruction. Two considerations account for the difference in class schedules and the total amount of instruction time between the grade 5 and grade 6 classes. First, the scheduling for the grade 5 class depended on the time for the Radarsat instruction that would not affect the regular teaching program and that could also fit the prime researcher's schedule. Second, the shorter time for Radarsat classroom image instruction (160 minutes for grade 5 and 223 minutes for grade 6) was related to grade 5 students' interest level and attention span.

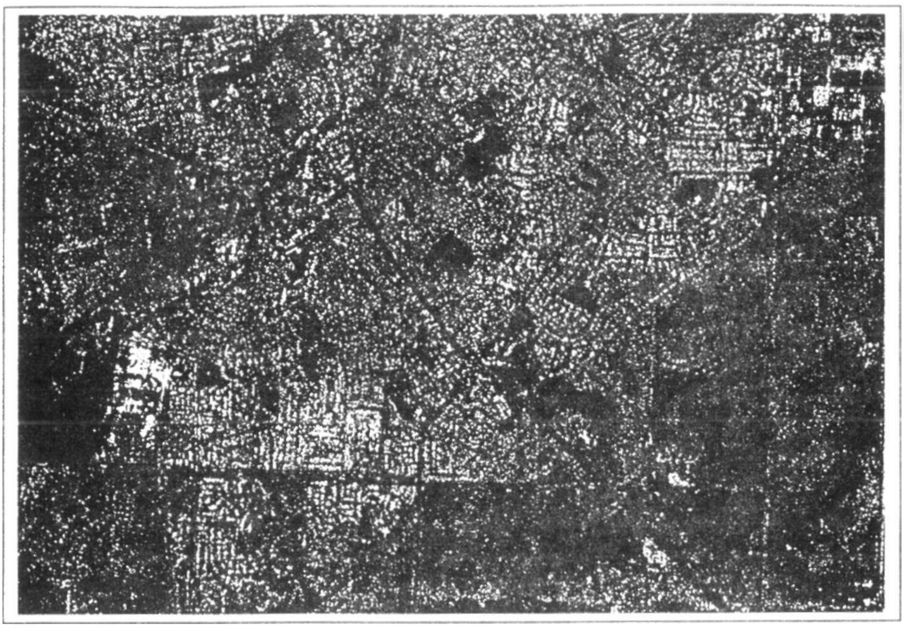

Figure 3.

Instruction Activities

Period 1, Tuesday, February 17. Students examined road map overhead projections of the school area, downtown Edmonton and its river valley, and the area of St. Albert. They then examined overhead projections of the Radarsat image showing the school area and downtown Edmonton previously seen on the road map projection. The students took turns finding the school and local streets. They also identified cars and the North Saskatchewan River. When the instruction period ended the students then noted what was done in their journals; this activity concluded all Radarsat activity periods.

Period 2, Friday, February 20. Students received the school area Radarsat image print. They circled the school with their felt-tipped pens. They were asked to find where they lived. The teacher asked what would help them find locations. The class suggested major roads. They then looked for them on the image. One student described how she found her home on the image. They then looked for West Edmonton Mall, although this feature was not on the image. When the class was asked what would help them find places on the image they answered "road maps." These were then distributed. The students found West Edmonton Mall on the road map and then discovered that the image area was too far south and west of the Mall. The school image was collected and the downtown Edmonton image was distributed. The students oriented the image with the road map and marked the cardinal compass directions on the image. They then looked for and found various bridges over the North Saskatchewan River, looked for roads with cars, and noted the locations on the board. No problems were noted.

Period 3, Monday, February 23. The St. Albert image and then the road map were distributed to the class, but they were not told the location (St. Albert is

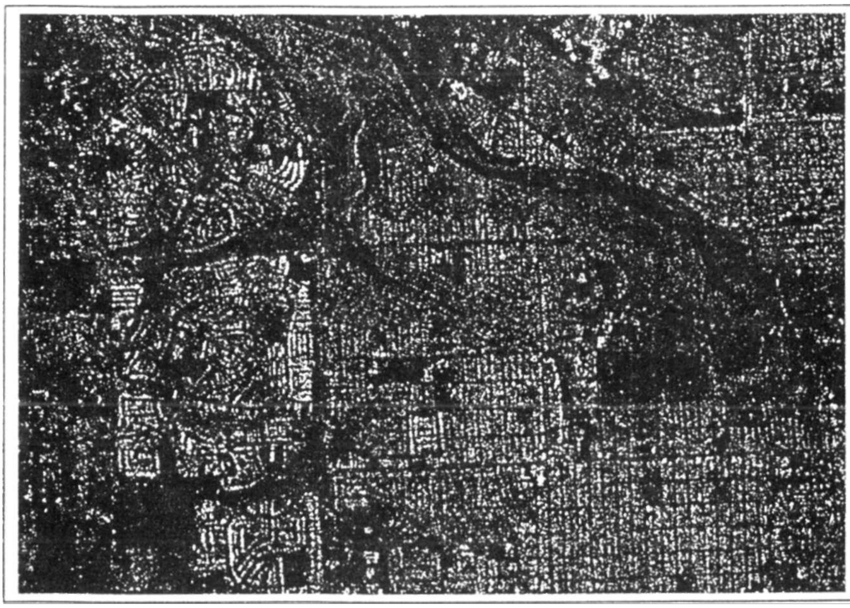

Figure 4.

also located on the Edmonton map). When the Radarsat images were distributed one child asked for the road maps ("hard maps") realizing that the road maps were needed for orienting with the Radarsat images. They were asked to determine the location of the image. One student thought it was Calgary because of a particularly angled road. Another correctly determined that the image was of St. Albert because of several matching roads on the Radarsat image and the road map. Yet another student also determined it was St. Albert because the Sturgeon River, which runs through the city, was located on the Radarsat image and the student had observed the similar shape of the river on the map and image. The class began to look for farmland, parks, and pastures noted as darker areas. The students also located the Riel Business Park, an industrial site. Students looked for major roads going to Edmonton, while some looked for the teacher's home in St. Albert and traced how the teacher would leave St. Albert to get to the school. Students looked for different routes from St. Albert to Edmonton and also for cars. The overhead projection image of the Radarsat image was shown to the class, and they were informed that on a radar image tall grass has a speckled appearance whereas mown grass appears black.

Period 4, Monday, March 2. The class examined the road map of Calgary, especially the area that is shown on the Radarsat test image. The teacher used an overhead projection of the Calgary road map of the Radarsat area. This activity was done to see if such map work would improve the ability of the grade 5 students to find locations on the Radarsat test image. This was of concern because the students were not as familiar with the Calgary map as they were with that of Edmonton.

Testing

The process of the test was identical to that of the grade 6 class (Kirman & Nytrai, 1998). Each student received a china marker, a road map of the city of Calgary, and a Radarsat image of a residential area in the city of Calgary (Figure 4) comparable to the neighborhood image they had worked with in class. This scene was made on the same day as the other images used. The scale of the Calgary image was 1:24,000, and the road map scale was 1:37,000. China markers were used because the mark is more durable and observable than the felt-tipped nonpermanent markers used during the instruction periods. One male student was absent.

Questions 1-8 were administered orally and are as follows:

1. On your Radarsat image find what appears to be houses or buildings. Draw a small circle around them. Next to the circle write the number 1.
2. On your Radarsat image find a road or a street. Draw an arrow with the point touching the road or the street. Next to the arrow write the number 2.
3. On your Radarsat image find a river. Draw an arrow with the point touching the river. Next to the arrow write the number 3.
4. On your Radarsat image find a car. Draw a small circle around the car. Next to the circle write the number 4.
5. On your Radarsat image find a bridge. Draw a small circle around the bridge. Next to the circle write the number 5.
6. On your Radarsat image find a place where plants may be growing. Draw a small circle around the place where plants may be growing. Next to the circle write the number 6.
7. Find a place on the Radarsat image that could be farmland or undeveloped land. Draw a circle around the place that could be farmland or undeveloped land. Next to the circle write the number 7.
8. Open your road map to the City of Calgary. Find 17 AV SW located between I and J, and 4 and 5 (these letters and numbers are grid indicators on the map) on the west side of the map. You can find it fast by looking for the SW on the left side of the map. Now find where 17 AV SW crosses SARCEE TR SW. (Show overhead image road map of the area. Wait for all the children to find the location on the road map and assist any with the road map who cannot find it. When all children have found the location on the road map remove the OHP map.) Now find this location on your Radarsat image. When you find 17 AV SW and the SARCEE TR SW on your Radarsat image draw a circle around it. Next to the circle write the number 8. Fold your maps.

Questions 9 and 10 required a written response:

9. What did you like best about these Radarsat images?
10. Was there anything you did not like about these Radarsat images?

Grade 5 Class Results of The Testing for Questions 1-8

Twelve boys and 19 girls were tested. Five of the students were classified as special-needs. The frequency of the scores and their percentages for the class are as shown in Table 1.

Table 1

Scores	Class	Boys	Girls
100%	5 (16%)	3 (25%)	2 (11%)
88%	10 (32%)	4 (33%)	6 (32%)
75%	7 (23%)	2 (17%)	5 (26%)
63%	5 (16%)	1 (8%)	4 (21%)
50%	2 (6%)	1 (8%)	1 (5%)
25%	1 (3%)	1 (8%)	0
13%	1 (3%)	0	1 (5%)
Mean	76%	78.3%	74.6%[1]
SD	20.6	21.8	19.6
(Grade 6)			
Mean	(85.9%)	(86.5%)	(84.1%)
SD	(14.6)	(15.2)	(12.8)

[1]If the three grade 5 special needs girls' scores of 63%, 50%, 13% are removed, the girls' average rises to 80.75%, SD 11.6. If the special needs boys' scores of 100% and 50% are removed the boys' average declines to 79%, SD 21. But if only the 50% is removed, the boys' average rises to 80.9%, SD 20.9.

Question Number	Class Percentage Correct (Grade 6 Scores)
1	81% (96%)
2	84% (81%)
3	87% (96%)
4	87% (100%)
5	84% (96%)
6	84% (81%)
7	58% (81%)
8	39% (52%)

Analysis and Discussion of Questions 1-8

The lower class average of the grade 5 compared with the grade 6 class may have been due to three factors. First, the grade 6 class had 63 minutes more classroom instruction time regarding features on a Radarsat image than did the grade 5 class. Second, the grade 6 class had four consecutive days of instruction, but the grade 5 class had four days over a period of 14 days. Third, the grade 6 class was tested the day after instruction ended, whereas the grade 5 class was tested four days after instruction ended. Each question was examined to determine the nature of the incorrect answers.

As noted above, five students, two boys and three girls, had special needs. The scores for these students are: boys 100%, 50% (vision problem), girls 63% (the opportunity student) 50%, 13%. One student received an inverted test image, which invalidated his answer for question 6. In the data below the percentages refer to the students' scores on questions 1-8.

Question 1. On your Radarsat image find what appears to be houses or buildings. Draw a small circle around them. Next to the circle write the number 1.

Wrong responses: 5 wrong and 1 not answered (boy 25%; girls 88%, 88%, 75%, not answered—girl 13%). All five tended to demarcate areas with low-cut vegetation showing some black. The students seemed to be unaware of street patterns to help demarcate built-up areas.

Question 2. On your Radarsat image find a road or a street. Draw an arrow with the point touching the road or the street. Next to the arrow write the number 2.

Wrong responses: 4 wrong and 1 invalid (boy 50%; girls 75%, 63%, 13%; invalid girl 75%). All four placed their arrows in areas with streets and roads, but the placement was not accurate in demarcating a road or street. The invalid response was to circle two cars in an intersection.

Question 3. On your Radarsat image find a river. Draw an arrow with the point touching the river. Next to the arrow write the number 3.

Wrong responses: 4 wrong (boy 25%; girls 63%, 63%, 25%). All four placed their arrows in the vicinity of the Bow River and were pointed toward the river, but the arrows were not touching the river. The distance between the arrow placements and the river varied between .4 cm and 1.65 cm. Three of the arrows were less than 1 cm from the river. This may be a more a matter of accuracy in positioning the arrows rather than not knowing the representation of a river on a Radarsat image.

Question 4. On your Radarsat image find a car. Draw a small circle around the car. Next to the circle write the number 4.

Wrong responses: 3 wrong and 1 not answered (boys 63%, 50%; girl 75%; not answered boy 88%) All three appear not to know what to look for to find a car. The unanswered item had only a number 4 but no circle around a car.

Question 5. On your Radarsat image find a bridge. Draw a small circle around the bridge. Next to the circle write the number 5.

Wrong responses: 5 wrong (boy 25%; girl 75%, 63%, 50%, 13%). Two students placed their circles on the Bow River but not around a bridge. Three students appeared not to know what to look for to find a bridge.

Question 6. On your Radarsat image find a place where plants may be growing. Draw a small circle around the place where plants may be growing. Next to the circle write the number 6.

Wrong responses: 5 wrong (boys 75%, 25%; girls 63%, 50%, 13%). Two students placed their circles to include places where plants might be growing, but also included substantial areas that would not be so designated. In one case it was a built-up area and in the other case a wide road and some built-up area. Three students selected built-up areas.

Question 7. Find a place on the Radarsat image that could be farmland or undeveloped land. Draw a circle around the place that could be farmland or undeveloped land. Next to the circle write the number 7.

Wrong responses: 13 wrong (boys 75%, 75%, 63%, 50%, 25%; girls 88%, 75%, 75%, 63%, 63%, 63%, 50%, 13%). Compared with the first six questions the students did poorly. The grade 6 class scored 81% on this item. Built-up areas were chosen by 11 students. A more irregularly shaped built-up area was chosen by two students. The same location was selected by both. Built-up areas were selected by 42% of the class. This calls into question the validity of their answers to question 1, that of identifying houses or buildings.

Three students in the above group were marked wrong for question 1, two were credited for question 1 because their choices could be a house although it was not as distinct a shape as the most obvious selections. One student received credit although some undeveloped land was in the circle. The seven remaining correctly circled locations with houses or buildings. Compared with question 7, five students circled larger areas for than for question 1 and two circled smaller areas than for question 1.

There was no pattern to the incorrect answers to question 7. Either the students knew what the return is for a house or building and incorrectly guessed the answer to question 7, or they did not know the difference between a house or building and farmland or undeveloped land. We believe it is the former, because they dealt extensively with the locations of their school and homes and their street locations, but did not spend as much time with farmland and undeveloped land.

Question 8. Open your road map to the City of Calgary. Find 17 AV SW located between I and J, and 4 and 5. Now find this location on your Radarsat image. When you find 17 AV SW and the SARCEE TR SW on your Radarsat image draw a circle around it. Next to the circle write the number 8.

Wrong responses: 17 wrong, 1 not answered, 1 invalid (boys 88%, 88%, 75%, 50%, 25%; girls 88%, 88%, 88%, 88%, 75%, 75%, 75%, 63%, 63%, 63%, 50%, 15%; not answered boy 88%; invalid boy 63%). An intersection to the north of the correct location was selected by five students. Five were close to the correct location, of which three circles touched it, and two were about 1 cm away. Other locations were selected by seven. The student with the inverted image had the invalid response.

Because special attention was given to the Calgary road map of the Radarsat image area the results for question 8 are disappointing. Thirty-nine percent of the grade 5 students found the correct location compared with 52% of the grade 6 students who had no Calgary road map instruction

Discussion of the Results of Questions 9 and 10

Question 9. What did you like best about these Radarsat images?

Responses fell into three broad categories: everything (one student), finding things (24 students), and other (6 students). Example of other items are: "That it made my mind work harder," "That it is cool and look [sic] like there's lots of lights on." Six students used the word *fun*. Six students who had also mentioned finding things also noted other items.

Question 10. Was there anything you did not like about using these Radarsat images?

One student did not answer the question, but noted in question 9 that it was "fun to do." Thirteen students noted that there was nothing that they did not like. In this group there were six boys and seven girls. The scores of these students on questions 1-8 were: boys 88%, 88%, 88%, 75%, 75%, 63%; girls 100%, 100%, 88%, 88%, 88%, 75%, 75%.

Seventeen students responded with something negative. These 17 comments fall into six categories:

1. Hard to find some things: five students (2 boys 100%, 50%, 3 girls 88%, 63%, 13%);
2. The image quality is not sharp enough: four students (2 boys 100%, 100%, 2 girls 75%, 75%);

3. Initial difficulties with Radarsat, but now it is all right: three students (2 boys 88%, 25%, 1 girl 75%);
4. Difficulty distinguishing between items: one student (girl 88%);
5. Did not like working with Radarsat image without a road map: one student (girl 50%);
6. Items not related to Radarsat: three students. These items were that the road maps were so big they were difficult to use (girl 63%); the markers used (girl 50%); and writing about the project "because we don't know about what we did" (girl 50%).

Gender Differences

An examination of the grade 5 class results of the testing for questions 1-8 shows that the boys have a higher mean then the girls, although this is not necessarily significant. A larger percentage of the boys also have scores in the higher ranges then the girls. This difference has been observed in earlier remote sensing research with elementary-age students (Kirman & Goldberg, 1987, 1990). It is unclear why this happens, but as in the previous research, there are too few participants to draw any conclusions. Perhaps a large-scale study might provide some insight into this occurrence.

The Radarsat CD-ROM

The Radarsat data was provided by RSI (Radarsat International) on CD-ROMs and hard copies of the areas examined were derived from these CD-ROMs. It is worth mentioning these CDs because they come with a built-in tools program that is of value to geography instructors. The Radarsat data for the fine-mode images on the CD-ROMs cover an area of approximately 50 km^2. The tools program has the following of value for elementary classroom instruction: image drag up, down, sideways; cursor-click zoom-in and zoom-out from 1:32 to X32; measurement of straight line distances and square area (measurement may be in metric, imperial, nautical, or pixel); scale bar measured in metric, imperial, nautical, or off; specific locations can be pinpointed for latitude and longitude or line or sample using the cursor; the screen can be split with only one half of the image being worked with; full screen grid showing optional latitude-longitude lines.

We attempted to see if the students were able to use some of the tools in the CD-ROM. A road map and Radarsat image of Halifax were examined by the class, after which they were given instructions about the CD-ROM tools. Nine students, three each of average, above average and below average (Kirman, 1977) were selected to try to use the tools. Each child had to find locations on the road map and then find the locations using the CD-ROM. They had to determine latitude and longitude and distances between locations. The exercise was too difficult for the students. Some of them could find latitude and longitude and measure distances, but they all became disoriented when they had to find off-screen locations by dragging the image.

Educational Implications

The grade 5 students in this project were able to make some sense of fine-mode Radarsat images. Many were able to distinguish streets, houses, cars, rivers, and bridges. However, they had difficulty in locating farmland, undeveloped land, and finding locations on a Radarsat image using a road map without specific guidance from their teacher.

It is interesting to note that both question 8 and the CD-ROM activity involved multistep processes. In question 8 students had to find a location on a road map, orient the Radarsat image to the road map, then find similar patterns on the Radarsat image that would match the patterns on the road map. In addition they had to cope with a different scale between the road map and the Radarsat image. With the CD-ROM activity, students again had to find a location on a road map, orient the on-screen Radarsat image to the road map, and again match patterns on the road map to the Radarsat image involving a different scale. Students also had to manipulate the CD-ROM tools. The implication of this is that where students must deal with a multistep process, additional time must be spent to review and reinforce the skills needed to accomplish the task. This also means that where there are differences in scale between the Radarsat image and any map being used with it, the teacher should deal with the question of proportion and provide examples of proportion using other maps prior to the use of Radarsat images. This would also be of value for geography instruction in general because different maps of a location and different scales of maps are often used and may even be a curriculum requirement.

The Radarsat images appear to be of value as a geographic resource at the grade 5 level, but would not be used for designing a geography unit around them. For example, they could be used as follow-up material when studying maps of urban areas. After examining the maps of the urban location, Radarsat images of the area could be provided either as overhead projection overlays on the map being studied or as hard copies for groups with locations noted on the copies either by name or by number. Students could then determine the ground conditions of the location including land use, note any changes made since the street map was published, and hypothesize about future land use.

At the grade 5 level a more explicit space-age map-like product such as a Landsat image might be of more use than a Radarsat image because of Landsat's comparative clarity and option of color. Presently Landsat images do not have the high resolution that Radarsat fine-mode images have. Landsat images have a $30m^2$ resolution, whereas fine-mode Radarsat images have a $9m^2$ resolution. However, high resolutions can be obtained if Landsat images are combined with the Russian KVR 1000 satellite images of the same location (*EOSAT Notes*, 1995, cover, p. 10). These images would be ideal for grade 5 students, especially as they can be produced in natural color. The resolution is so high that these combined images resemble overhead aerial photographs and are ideal for classroom work, especially as special instructions for their use are not required. Unfortunately, these hybrid images are not readily available. Other hybrid images have been produced combining Landsat images with radar images, which provide much information about both ground cover and surface geology. But again, they do not have the resolution of Radarsat fine-beam mode.

Radarsat Resources

When we began work on this article, we hoped that standard Radarsat CD-ROMS would be available to teachers at reasonable prices, but the product remains expensive. However, Radarsat International (RSI) has produced low-cost and free Radarsat images for classroom use, some of which are CD-ROMs with the tools noted above for working with the images. RSI will send teachers information about these products.[3] A comprehensive list of these items and Internet sites related to Radarsat can be found in the April 1999 issue of *Social Education* magazine (Kirman, 1999).

Additional Research Questions

1. Are grade 5 students capable of working with fine-mode Radarsat images of nonurban areas?
2. Can grade 5 students interpret elements of smaller-scale Radarsat images?
3. Would grade 5 students be able to work with both Radarsat images and Landsat images of a given area?

Application

An application would be the development of a heuristic science or social studies urban studies teaching unit for grade 5 using Radarsat fine-beam mode images that would incorporate the findings of this study.

Conclusions

The results of this study show that some elements of fine-mode Radarsat images of urban areas can be interpreted by the students. These Radarsat images can be used in a limited manner when studying about urban areas. Overhead projector acetates or duplicated prints with selected information printed on them are possible ways of using Radarsat images as instructional materials. Teachers should provide additional time to review and reinforce skills requiring multistep processes and provide instruction about the use of different-scale maps of the same location prior to the use of Radarsat images.

Elementary social studies textbook and media authors can include fine-beam mode Radarsat images and street maps when writing about urban areas, and social studies and science curriculum developers can consider including Radarsat images in the teaching of geography and in earth science studies. Radarsat fine-beam mode images in studies of urban areas can be included in teaching activities even if the students have had no classroom instruction about Radarsat images. Such images should have specific items and locations clearly labeled so that these can be recognized and their locations plotted on a street map. The classroom phases of the above study have shown that once the location is demarcated on the Radarsat image, the students are able to orient the Radarsat image and a street map.

Notes

1. Project Omega for Research in Remote Sensing and Aerospace Education is the only educational facility that conducts research in remote sensing education on the elementary level.
2. The Canada Centre for Remote Sensing has an excellent Internet site for Radarsat located at: www.ccrs.nrcan.gc.ca/ccrs/tekrd/satsens/satsense.html.
3. RADARSAT International Client Services is located at 3851 Shell Road, Suite 200, Richmond, British Columbia, Canada, V6X 2W2. Telephone 1-604-244-0400, Fax 1-604-244-0404, e-mail abursey@rsi.ca.

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