The Geographic Information System
in a
Junior High School Environment

A Thesis
Presented to
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In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by

Malcolm H. Brown

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ABSTRACT

This study investigated the use of a computerized geographic information system in social studies instruction at the grade seven level. The students used for this research were divided into three equal groups according to their academic performance on previous social studies tests. Groups A and B were given the same instructional material, the only difference being that a computerized geographic information system was used as a teaching tool to present the information to Group B. Group C was used as the control group. A test consisting of three different segments was administered to all of the students of the three groups at the end of the study. These segments were designed to evaluate the students' retention of geographic facts, the understanding of spatial concepts and the ability to analyse and solve problems in geography.

The results showed that although the group that received instruction with the computer using the geographic information system software performed better on the post-test than the group that received conventional instruction, this difference was not statistically significant at the standard 0.05 level. This was true for all three segments of the post-test. There was ,however, a significant difference between these two groups with respect to lower-ability students. The lower-ability students of Group B scored higher on the post-test than their counterparts in Group A who received conventional instruction.

This study was not extensive enough to prove unequivocally that computerized geographic information systems can improve instruction in geography at the grade seven level. However, the results are significant enough to warrant further investigation.

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CHAPTER 1

INTRODUCTION

Acid rain, air pollution, deforestation and a rapidly expanding population are just a few of the major problems facing our planet at this point in history. The urgent need for a better stewardship of the earth's resources necessitates an improved educational program in our schools. The students of today must be made aware of where places are and how the global environment is influenced by man. The ability to read maps and to use them as an analytical tool is only part of the solution to these problems, but it is a part that is often overlooked (Bartz, 1970).

The objective of this study was to determine if a computerized geographic information system (GIS) has a role to play in junior high school education, particularly in the instruction of spatial concepts and regional geography. Such systems, in recent years, have become widely used in natural resource management but little or no research has been conducted on their potential as a tool for instruction. According to Piaget and Inhelder (1956), by the age of twelve, children have developed a degree of spatial awareness which allows them to understand spatial problems without having the visual stimulus present. If this is true, such children should be able to receive classroom instruction in geography through the use of a simple GIS. The supposition is that this is the case and that the information gleaned in this work will be of use to educators in geography as well as to the designers of such systems.

The Problem

A 1988 survey conducted by the Gallup Organization and the United States based National Geographic Society, indicated that Americans and Canadians display a remarkable lack of knowledge of world geography. Young people (18-24 age group) in particular did not fare well against their counterparts from eight other countries (Grosvenor, 1989).This survey, unfortunately, is not an anomaly. Numerous studies in recent years have identified the same problem. Some of these are outlined in the following paragraphs.

Tests conducted at the University of Wisconsin-Oshkosh in 1985 and 1986 showed a high level of geographical illiteracy among students enrolled in introductory level World Regional Geography and Cultural Geography classes (Cross, 1987).

A similar test was undertaken in 1983 at the University of Miami. The results identified a significant lack of geographic knowledge throughout the student population. The fact that 42.1 percent of the test group could not find London, England on a world map was particularly disconcerting (Helgren, 1983).

The crux of the problem identified in the above studies would appear to be the increasingly diverse curriculum in present-day North American schools and, accordingly, the limited amount of time allocated to each subject. A corollary is that geography, since the 1950s, has been taught less as an independent subject at the elementary school level.

In a 1987 article in The Professional Geographer, Andrew McNally notes that at the grade school and high school levels "... techniques need to be developed for teaching geography in a relevant and effective manner. Proficiency tests and standards of achievement in basic geographic principles, map skills, and geographic information also need to be developed and integrated into the social studies curriculum" (McNally, 1987).

Reason for the Study

Given that teachers today have less time to instruct their students in geographic skills and concepts, the computer and geographic information system software may prove a valuable tool to enable them to use this limited time more efficiently.

Michael Dove cites three significant reasons for using the computer in teaching geography (Dove, 1988). These are as follows:

- the fact that it increases student interest;
- it gives the capability of new approaches or strategies for teachers; and
- it allows certain goals to be achieved with an increase in efficiency.

Computerized learning, according to McNally (1987), could allow students to learn about geography as well as familiarizing them with an essential tool of the discipline. An added advantage of such alternative procedures is that students will discover that the learning process is not restricted to conventional educational methods. This latter point has been identified in a publication produced by the Ontario Institute for Studies in Education (Senathirajah and Weiss, 1971).

Although microcomputers have been used as a means of teaching map concepts and skills to elementary school students (De Leeuw, 1983), no research has been done on the use of geographic information system software in this environment. In the Rooze and Northup (1986) book on teaching social studies using computers there is, surprisingly, no mention of mapping packages or geographic information system software. The emphasis is totally on databases, spreadsheets, statistical analysis, and word processing. Such disregard of the map and mapping software as teaching tools was the prime reason why this study was undertaken.

Context of the Study

There are very few fields of human endeavour that have not been influenced in some way by the development of the computer. In Western society, in particular, it is an all encompassing and well documented revolution. Volumes have been written on the effects it has had and will have on our existence (Naisbitt, 1982; Levien, 1972). The disciplines of geography and education have not been immune from this upheaval.

In geography, the emergence of the computerized geographic information system (GIS) has altered dramatically the way in which geographers deal with spatial data. The capability of merging databases with maps has increased the analytical capacity of the discipline.

Computer Assisted Instruction (CAI) and Computer Assisted Learning (CAL) are two terms which have become commonplace in the educational field. They refer to computer programs which have been written to assist students in learning specific material. Computer Assisted Instruction is not a new concept in geographic education by any means. Authors such as Traberman (1983) and McQuade (1986) have dealt with the topic in great detail. Irmgard Penn, in a study undertaken at the University of Manitoba, has broken down CAI into six different categories. These are: drill and practice, exploration, games, problem solving, simulations, and tutorials (Penn,1987). A review of relevant CAI literature appears in the second chapter of this thesis. Educators in social studies, however, do not always make use of CAI techniques because there is not enough suitable software written for their tasks. This reflects the difficult task for programmers of outlining all possible real world situations in geography. It is in this environment that the geographic information system has a role to play. A GIS is specifically designed as a tool to solve spatial problems and as a result it is relatively free from the design biases and parameters which are generally present in CAI programs. It also differs from CAI in that it can be utilized in a group setting. Traditionally CAI has been a one pupil to one computer operation.

A final point regarding the context of this study is that computers have become commonplace in elementary and junior high school classrooms in recent years. As well, many Canadian schools now have computer laboratories. Access to computers, therefore, is no longer a problem for most classes. The development of technology to project, in real time, the image which appears on a computer monitor onto a large screen in front of the classroom is also a major development in bringing computers into everyday use in education. Moyer (1990) enthusiastically advocates such a projection panel system especially in a situation where there is only one computer for a class. The benefits he cites are that it makes the computer a more effective presentation device, it cuts down on preparation time for the teacher and it enhances learning for visual learners.

Definition of Terms

Some of the terms made use of in this study are specialized to the fields of geography, education or computer science. The most important of these are defined below.

Computer Assisted Instruction (CAI) - a program of instructional material presented using a computer.

Courseware - the instructional materials used in CAI. It refers to the computer software that presents the instruction via the computer (Hofmeister, 1984).

Database Management System (DBMS) - a set of computer programs for organizing the information in a database. Usually a DBMS would be made up of routines for data input, checking, storage and retrieval (Burrough, 1986).

Digitizer - a device for converting point locations on a graphic image to plane (x,y) coordinates for digital processing (Monmonier, 1982).

Drum Plotter - a plotter which makes use of a rotating drum or cylinder to move the sheet of paper on which the image is drawn.

Geographic Information System (GIS) - a computer assisted system for the capture, storage, retrieval, analysis, and display of spatial data (Clark, 1986).

Hard copy - a copy on paper or other material of a graphic or alphanumeric image as displayed on the computer screen.

Orthogenetic Principle - the idea that mental development evolves from a state of universality to states of increasing differentiation and awareness of individual spatial elements (Werner, 1948).

Overlay - the process of stacking digital maps (holding different thematic information) of the same area on top of each other so that each position in the map can be analysed in terms of these data (Burrough, 1986).

Polygon - a zone on a map having a unique characteristic and being delineated by lines.

Raster data - data in the form of parallel scan-line segments or grid cells (Monmonier, 1982).

Thematic map - a map that concentrates on the spatial variations of a single phenomenon or the relationship between phenomena (Robinson, 1978).

Topology - a branch of geometry dealing with properties which do not change under conditions of distortion.

Turnkey - an adjective used to describe a computer system which is ready for immediate use when purchased (Monmonier, 1982).

Vector data - data in the form of a list or lists of point coordinates (Monmonier, 1982).

Overview of the Study

This study was designed to determine if a computerized geographic information system could be used as a tool to improve or enhance instruction in geography to grade seven students. This particular age group was chosen because, as outlined in Chapter 2, students at a younger age are not all able, according to the literature, to grasp such geographic concepts as scale, distance, direction and coordinate systems. Also the ability to analyse and solve spatial problems appears to develop to a significant degree by the junior high school level.

The twenty eight students in the grade seven class of the 1989-90 academic year at Saint John Brebeuf School in Winnipeg, Manitoba were the primary subjects used in this research. These pupils were divided into three academically equal groups according to their previous social studies marks. These marks were used as the pretest in the experimental design of the study. Groups A and B received 1.5 hours of identical instruction in geography, the only difference being that a computerized geographic information system was used as a teaching tool to present the information to Group B. Group C was used as the control group and received no instruction.

The instructional material consisted of a large scale neighbourhood map of the area close to Saint John Brebeuf School in Winnipeg, and a series of small scale thematic maps of Australia. The hard copy version of these maps used for instruction to Group A and for the post-test were produced using the PAMAP geographic information system and a drum plotter. The focus of the instruction was on spatial concepts and regional geography, the maps being used to display the geographic information and its relationships graphically.

At the conclusion of the study all three groups were given a test. This test was divided into three segments and designed to evaluate the student's retention of geographic facts, the understanding of spatial concepts and the ability to analyse and solve problems in geography. Also the affect of the instruction on lower-ability students was examined. The Kruskal and Wallis nonparametric analysis of variance by ranks statistical procedure was used to evaluate the results.

Hypotheses

Given three groups of grade seven students, where one group received instruction in geography in a conventional manner, another received instruction using a computerized geographic information system and the third acted as a control, the following null hypotheses were generated:

1) A computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the students' retention of geographic facts.

2) A computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the students' comprehension of spatial concepts.

3) A computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the students' ability to analyse and solve spatial problems.

4) A computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the students' comprehension of a geography lesson.

5) A computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the comprehension of a geography lesson by lower-ability students.

CHAPTER 2

LITERATURE REVIEW

There are two diverse areas of study which have literature relevant to this research. These are spatial awareness in children and computer assisted instruction (CAI). The examination of the former enabled the study to focus on students of a specific age group who would receive maximum benefit from the proposed instruction. The literature on CAI was examined in order to comprehend the problems and benefits of a field of research closely related to the topic of this thesis. There was no literature found which dealt directly with the use of the geographic information system as an instructional tool in an elementary or junior high school setting.

Spatial Awareness in Children

Robinson and Petchenik make the statement that the map is a form of space and that "...only by understanding the representations of space will we understand the percipient's ability to interact with maps" (Robinson and Petchenik, 1976, p. 89). The development of spatial awareness in children has been examined by a variety of scholars from a number of different disciplines. This section of the chapter will review the literature dealing with this complex topic and attempt to draw some conclusions relevant to the main study.

The medieval concept that the child was nothing more than a miniature and poorly informed adult at the fringe of society did not begin to disappear until the seventeenth century. The depiction of the Christ Child in European art of the middle ages confirms this belief graphically. It was only at the end of the Renaissance period that philosophers began to realize that childhood was a special period and that children possessed different psychological, educational and physical needs. The roots of present day developmental psychology can be traced to Charles Darwin's theory of evolution. His ideas on mental development were of immense interest to psychologists of his era (Silk, 1968). Developmental psychology is concerned with the examination of changes in behavior of humans throughout their life. Accordingly, it is the field where most studies on childrens' perception have taken place.

One of the first attempts at examining human spatial awareness was undertaken by C.C. Trowbridge (1913). In a 1913 article in Science, he suggests that children, like animals, use the "domi-centric" method of orientation. This means that they have no knowledge of the points of the compass and know only the area in which they have travelled. Through training, however, man learns to use the cardinal points to orient himself in space. Trowbridge refers to this as the "ego-centric" method.

In a 1932 study, Howe used over 1300 children below the grade seven level to evaluate their ability to use directions in space and on maps (Howe, 1932). He concluded that children could achieve a clear concept of directions in space by eight years of age if given the proper educational environment.

An elaboration of Howe's study was undertaken by Francis Everette Lord (1941). This work dealt with the measurement of the ability of children to master three phases of spatial orientation. The phases were as follows: (1) the ability to give directions in space; (2) the ability to describe the spatial configuration of known places; and (3) the ability to keep oriented by direction during travel. The students studied were from grades four through eight and the conclusions reached indicated that, in general, children do not have a clear concept of the cardinal directions. They can, nevertheless, point out the correct directions to known points. Also, they appear to possess two frames of reference, a conventional map frame for distant locations and a direct experience frame for local places.

The first all-encompassing theory dealing with spatial awareness and using experimental techniques was put forward by Werner (1948). He identified three main periods of development connected to the concept of orthogenesis. The orthogenetic principle is the idea that mental development evolves from a state of universality, where there is a lack of differentiation among objects in a child's spatial environment, to states of increasing differentiation and awareness of individual spatial elements. The periods are: progressive self-object differentiation, progressive constructivism and progressive perspectivism.

For example, in the first stage, a baby initially cannot differentiate between itself and its environment. However, by the age of two this has changed. Stage two, progressive constructivism, occurs between the ages of two and eight. It is here that the child begins the transition from egocentrism to perspectivism. There is also an increasing awareness of the various elements that make up his or her spatial environment. By the age of eight or nine, according to Werner, the child reaches a point where knowledge about the universe can be actively constructed. The ability to adopt the perspective of others is also mastered.

The definitive work on spatial awareness in children, however, was done by the Swiss psychologist Jean Piaget (Piaget and Inhelder, 1956). Arthur Robinson, the prominent American cartographer, refers to this study as "the most comprehensive experimentation and theory development in the realm of conceptual space..." (Robinson and Petchenik, 1976, p.87).

Piaget's initial work was done on his own children but later he and his associates conducted a variety of systematic studies on children of various ages and backgrounds. Individual interviews were used and an intricate theory emerged.

On the basis of his observations Piaget in his book, The Child's Conception of Space, argues that a child's cognitive development can be defined in terms of four chief stages: the sensorimotor stage (birth to two years); the preoperational period (two to seven years); the concrete operations stage (seven to eleven years); and the period of formal operations (eleven to adulthood). Distinct cognitive abilities can be identified in each of these stages.

The Child's Conception of Space focuses on three main headings: topological space, projective space and the transition from projective to Euclidean space. Piaget maintains that the child's acquisition of spatial knowledge evolves slowly from elementary topological relationships to the more complex ideas of projective and Euclidean space. For example, a child will know the space around itself and the relationship of items in this space long before distance values between the items can be given. The topological perceptions can be viewed in terms of proximity, separation, order, enclosure and continuity.

Projective space deals with the child's ability to perceive the interrelationships among objects in space from various perspectives. Euclidean space is the last stage in Piaget's model. It is here that children begin to organize space using distance and direction.

Piaget and Inhelder advocated that a child's activities and not perceptions are the most important elements in the development of spatial concepts and that the achievement of total spatial awareness requires a significant educational foundation. A recent study by psychologists in the United States confirms these points.

Rosanne Kermoian (1988), assistant professor of psychology at Reed College, reports that research at her institute has shown that the action of crawling by babies actually triggers a number of developmental changes. Apparently, crawling provides the child with new experiences and makes it necessary to concentrate on its location in space.

Piaget and Inhelder were the first to examine in depth the child's representations of space. This is the ability to deal with space in an abstract way, not having visual stimulation present. Their research, therefore, was not aimed at the child's knowledge of space but at the development of intelligence as it pertains to spatial relationships. They identified three stages in this evolution. These are: (1) synthetic incapacity; (2) intellectual realism; and (3) visual realism. In the first stage, children are unable to comprehend abstract spatial concepts. During the intellectual realism stage there is evidence that children reach a level of spatial awareness in which they begin to deal with measurement and representational space in an elementary manner. It is not until the age of eight or nine, however, according to Piaget, that the final stage of visual realism is reached. Children at this point appear to be able to deal with distance and can picture items in space from viewpoints other than their own.

Piaget's work has undergone some criticism as to the methods used and the handling of the data but to this point in time it is the most important study dealing with the spatial awareness of children (Hart and Moore, 1973). It has also had a significant influence on subsequent research in this field.

One study in Canada which focused on the verification of Piaget's conclusions was undertaken by P.C. Dodwell of Queen's University (Dodwell, 1963). After examining nearly two hundred children in the five to eleven year age group, he concluded that Piaget's beliefs regarding the development of spatial concepts were, in general, accurate. However, Dodwell viewed this development as a continuous progression and not the stepped process described by Piaget.

Research in the field of spatial awareness in children has come from such diverse disciplines as education, psychology and geography. Of particular relevance to this study are the research works which deal with when and how children acquire map skills.

Another Canadian study by Towler identified and examined four spatial concepts needed by elementary school children to enable them to read and interpret maps (Towler, 1965). These were:

(1) the concept of a reference system;
(2) the concept of distance;
(3) the concept of direction; and

(4) the concept of scale.

Towler designed and administered a series of tests to school children in grades one to six inclusive. His goal was to identify the stages of conceptual development which are reached in the process of acquiring the above mentioned concepts. His results indicated a general agreement with Piaget's model although the development of the concepts of a reference system and scale occurred at a later age in his work.

In an article entitled "Map Skills Instruction and the Child's Developing Cognitive Abilities", Judith Meyer gives a different perspective to spatial awareness research (Meyer, 1973). She has reviewed the existing literature related to this field and outlined the relevant abilities needed by children in order to effectively read a map. These include the development of a frame of reference, spatial orientation, measurement, manipulative ability and symbolization. The terms "manipulative ability" and "symbolization" have not appeared in the previously quoted literature dealing with spatial awareness. She notes that various studies have indicated that children in early primary school understand the principles of symbolization. However, there is a lack of research related to their manipulative abilities. The few studies which have been done seem to indicate that primary school children are weak in such tasks.

The development of a child's spatial reference system was the focus of research reported on in 1973 by Pufall and Shaw (1973). They examined children in the four, six, and ten year old age bracket in Piagetian type experiments.

In general, they concluded that as a child grows older there is a transition from a self-centred reference system to an objective system. Two phases were identified in the self-reference system. The first was when the two components (near-far, left-right) function independently not forming a system. The second phase was when these same components interact. Even after an adult has achieved an objective system this egocentric reference system is retained.

The Pufall and Shaw study supports the findings of Piaget in that the child must reach the period of "concrete operational thought" before the concept of the two-dimensional reference system is achieved.

One of the most significant reviews and analysis of the research dealing with spatial awareness was done by R.A. Hart and G.T. Moore (1973). They identified three main reference systems which evolve through childhood. These were the egocentric system, the fixed system, and the coordinated system. Much of their work was influenced by Piaget.

In general, they note that children gradually emerge from their egocentric system of reference at about seven or eight years. It is at this stage that the fixed system is achieved. A limited number of routes and landmarks provide the basis of spatial awareness at this point. With the onset of what Piaget refers to as the concrete operations stage (seven to eleven years) the uncoordinated representations of the child's space begin to become more coordinated. The concepts of Euclidian geometry are achieved and an "x" and "y" reference system can be comprehended.

Another model which essentially paralleled that of Piaget was put forward by Siegel and White (1975). They proposed that landmarks in space are the primary components of the cognitive map. Such landmarks are remembered by the individual and paths or routes linking them are formed. Lastly, these routes become part of an individuals' spatial framework. This development process, according to the authors, is the same for adults as it is for children.

The concepts that children must develop in order to interpret maps was the focus of the work by Jane Thake (1976). Dealing with children in the seven to nine year old range she found that map communication was impossible if children had not developed basic mapping ideas. These include direction and spatial orientation, scale, symbolization, and a grid reference system. Although she admits that the child may have some innate ability to use maps, most skills needed to read a map effectively must be introduced in the classroom. Children in this age group may not be capable of completely understanding all of these mapping concepts. For example, the use of scale, she suggests, cannot be totally comprehended until the age of ten or eleven years. However, work can and should begin in the seven to nine year age bracket to teach children these skills and thus give them the building blocks for future graphic literacy.

Thorndyke and Hayes-Roth investigated the differences which occur in spatial knowledge when it is achieved from two different sources: navigation experience and maps (Thorndyke and Hayes-Roth, 1982). Although their research concentrated on adults, the results are relevant to the discussion on spatial awareness in children. The experiment devised involved adult volunteers who became familiar with a restricted spatial environment either through memorizing a map or by navigation. They were then tested on their knowledge of this space.

Thorndyke and Hayes-Roth refer to the spatial knowledge gained from navigational experience as procedural knowledge and that obtained from maps as survey knowledge. In the latter, extensive topological relationships are established and the objects in the spatial environment can be defined in terms of a "x-y" coordinate system. Navigation does not enable a person to establish such a mental reference system for an area until he or she has spent an extended period (over one year) in the spatial environment.

Computer Assisted Instruction

The earliest use of Computer Assisted Instruction (CAI) can be traced to the Massachusetts Institute of Technology in the 1950s. It was here that a specialized computer was designed to provide training for combat pilots (Hofmeister, 1984). The first case of CAI being used in an elementary school took place in 1959 in New York state when researchers for the IBM company used school children to test techniques being developed to train company staff (Baker, 1978). One of the earliest academic studies into the use of Computer Assisted Instruction in elementary schools occurred in California in 1965 (Suppes and Macken, 1978). This took the form of drill and practice sessions in mathematics for grade four students. The program was expanded as an aid to reading instruction the following year. Although Stanford University initiated research into CAI in education, other universities became involved in the 1960s. These included the University of Illinois and Florida State University.

Three categories of CAI can be identified (Atkinson, 1968). The first is the drill-and-practice instruction program. An example of this would be a program matching countries with their capital cities. The second category is the tutorial. This software allows students to interact with the computer to a greater degree. Accordingly they can provide different responses and follow different paths through the material. The final class of CAI described by Atkinson is the dialogue program. Here total interaction with the computer is possible. This could be described as an artificial-intelligence-based CAI.

The Stanford CAI project of 1965 was a tutorial program conducted using first-grade students. The reading portion of the project compared students taking reading via CAI with students taught reading in a conventional manner. The results on post-tests showed that those receiving instruction from the computer were at a more advanced skill level (Atkinson, 1968). According to Hofmeister (1984), by the end of the 1960s there were many private companies in the United States developing their own CAI software. Also, progressive states such as Minnesota began to take leadership roles in producing educational computer programs. Educational institutions such as Stanford and MIT continued their activities in CAI development as well. The premier version of Logo was produced in 1966 at MIT and in 1970 work began with Turtles (this would develop later into Turtle Graphics software). The most important development in the late 1960s, however, was the introduction of the minicomputer. The lower cost of this machine allowed more researchers to become involved with CAI. In the early 1970s the MITRE Corporation began development on the Time-shared, Interactive, Computer- Controlled, Information Television (TICCIT) system of CAI (Suppes and Macken, 1978). The motivation behind this major project was to use minicomputer technology to administer educational programs for English and mathematics.

Possibly the most important event in the history of CAI was the emergence of the microcomputer in the 1970s. The low cost, portability and ease of use allowed more educators to become involved with CAI, both in its utilization and development.

The evolution of computer assisted instruction has not always been constant or positive. Educators from time to time have questioned its usefulness. In the early 1980s such questions arose concerning the quality of courseware. Due to the proliferation of microcomputers at this time a cottage industry emerged which was producing computer assisted instruction material at a rapid rate. Although some of these programs were good many were not and the enthusiasm for CAI in the schools was reduced.

The next stage of CAI which followed put the development back on course. This was its adoption by some of the large publishing companies in the United States. Their interest stemmed from a concern that CAI would eventually replace conventional textbooks.

The abundance of CAI programs that have been produced in the last decade has been staggering. Although many of these have been written for the fields of mathematics and languages other disciplines such as geography have also been well represented. The March-April 1985 issue of the Journal of Geography listed 21 different educational software programs for geographers. However, a common complaint from teachers noted throughout the literature was the lack of quality software for computer assisted instruction (Turner, 1982). What is more relevant, however, than the number of programs that exist is whether CAI is effective and efficient as a teaching tool.

Kulik, Bangert and Williams (1983) evaluated 51 different studies concerned with computer-based teaching in grades 6 through 12. Their results indicated that students who were taught with the aid of the computer improved their performance scores and developed positive attitudes toward the computer. Also the CAI reduced the amount of time that pupils needed for learning. One specific study reported on by Traberman (1983) involved eighth grade social studies students who were taught abstract and complex lessons using the microcomputer. The results were completely positive indicating that students improved their problem solving skills in social studies and developed an attitude that they were in control of their learning environment.

The literature related to CAI also indicated that such instruction was more effective for low ability students than for middle or high ability students (Edwards et al., 1975). There were few articles found, however, that dealt with this phenomenon.

On the negative side of computer assisted instruction there is some evidence that retention of information may not be as great with CAI techniques as with traditional instruction.

Most of the research done in the field of CAI has taken place in the United States. In recent years, however, countries such as Germany, Australia and Great Britain have made developments with regard to computer use in their schools. Dove (1988) in a study of schools in the state of Victoria in Australia cites three significant reasons why computers should be used to teach geography. These are:

1) it increases the interest of the pupil;
2) it provides teachers with an opportunity to develop new teaching strategies; and
3) it allows certain goals to be achieved with more efficiency.

He also lists reasons for not using computers for such classroom instruction. These include the time necessary to develop computer skills, inappropriate software, and lack of equipment. Two significant points are noted in his results. Firstly, he states that it may be necessary to change the common curriculum practice before microcomputers can have a significant impact on education. Secondly, emphasis must be kept on the goal of teaching and educators must not allow technological advances to overshadow this.

In Great Britain information technology has been a major concern in education in recent years. To assist teachers in introducing computer instruction into their classes an in-service pack entitled Learning Geography with Computers has been produced. It includes software and booklets to help the geography teacher (Davidson, 1989).

There have been numerous studies in Canada over the last decade investigating the use of CAI in mathematics or language studies but very few dealing with geography. One study relevant to this research, however, was undertaken at the University of Manitoba in 1987. Penn (1987) showed in her research that learning principles (e.g. immediate feedback, graphics, etc.) can be incorporated into a CAI package to improve students learning.

Discussion and Summary

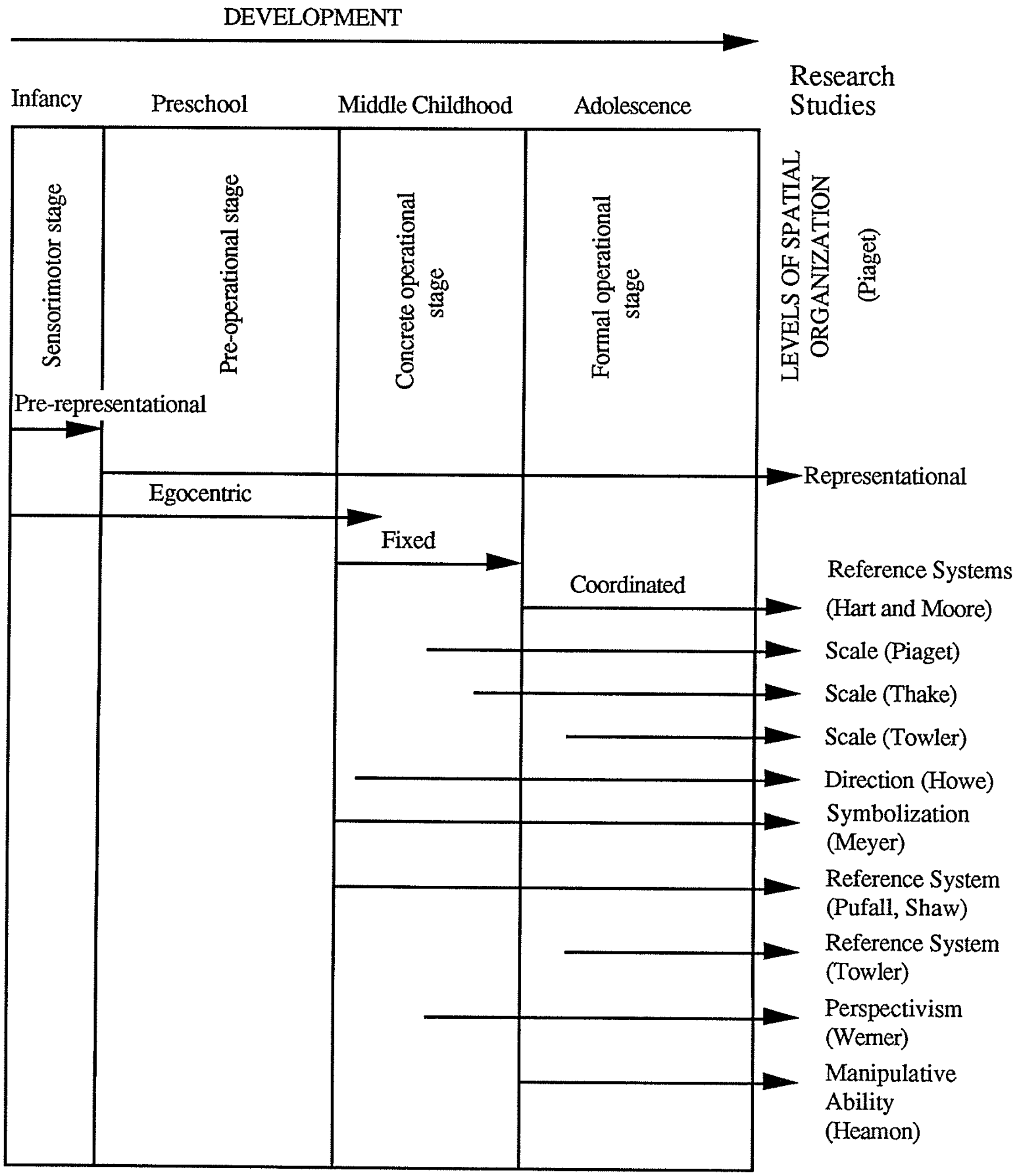
This chapter has outlined the literature of two areas of study germane to this thesis. It has attempted to justify through previous research the use of students in the 12 to 13 year old age group as the population for the study. It appears that until a child reaches this age he or she is unable to comprehend the full range of spatial concepts such as direction, distance, scale, and coordinate system. As well, the evolution and pertinent literature of computer assisted instruction has been summarized. The following paragraphs review and discuss the points most relevant to the research undertaken. It should be noted, however, that this thesis deals with the use of the geographic information system as a teaching tool, used by the teacher to demonstrate a geographic lesson. CAI, in general, involves little or no teacher interaction with the students, the computer being the prime instructor.

The preceding examination of the literature related to the development of spatial awareness in children is by no means all encompassing. As stated earlier, the topic under discussion has been approached by a variety of scholars from a number of different fields. The concept that the map is a form of space has influenced the choice of studies which have been reviewed. This emphasis has been taken in order to cast light on the topic of map use capabilities in elementary and junior high school children.

The most difficult part of any such literature review is to summarize and identify the most important elements. Figure 2.1 portrays the relevant information graphically. The various studies shown here identify the findings of the researchers who have dealt with the question of how old children must be to fully comprehend different spatial concepts. The middle childhood to adolescence boundary, 12 to 13 years, appears to be an important limit according to this diagram.

FIGURE 2.1

Schematic Representation of the Development of Spatial Awareness



The constants that can be identified in the literature include the fact that spatial awareness increases as a child grows older and that the concepts of spatial awareness are partly innate and partly learned. It appears that the achievement of a high level of such awareness requires a good educational base. Also the learning of many of these concepts is not possible until the child reaches a certain stage of mental development. In the studies portrayed in Figure 2.1 it is difficult to make a broad generalization as to when a child will completely comprehend all of these concepts. However, it would appear that this is the case by the age of 12 years. This latter point is vital to this study. The testing of students using a geographic information system requires that the age group under investigation understand the basic spatial concepts dealt with in this chapter. The effectiveness of using such an instructional tool cannot be judged accurately with students who may not have the appropriate level of mental development.

Research into Computer Assisted Instruction has in general concentrated on three areas. These are efficiency, cost of implementation, and the attitudes of the pupils and teachers. In terms of the efficiency of CAI the literature as a whole indicates that such instruction is more effective than conventional instruction when considering student performance; although the differences are not great. However, CAI has been shown to be effective in reducing the time needed by pupils to accomplish learning tasks.

The literature shows clearly that CAI has been investigated more in the fields of mathematics and languages than it has in geography and there is a general complaint among social studies teachers that there is not enough quality CAI material. Also the cost of purchasing individual programs to teach specific concepts is prohibitive for most schools.

In general, the literature dealing with the computer assisted instruction is positive about its usefulness.

There was no literature found which dealt with the use of geographic information systems as a teaching tool in the elementary or junior high school environment. The advantages of using a GIS in this milieu are unique. It would appear that the GIS can accomplish all that the canned CAI programs are capable of and more. The weak points of CAI noted in the literature reviewed earlier in this chapter can be overcome with a geographic information system. For example, the teacher does not have to purchase different programs to introduce different spatial concepts, the GIS can be used in a variety of ways to demonstrate such ideas. Also the complaint concerning the lack of appropriate CAI material in geography can be overcome as the teacher can custom design projects with a GIS. The geographic information system software is developing rapidly and is becoming easier to use. The trend is towards turnkey systems, menus and a total emphasis on ease of use.

Much of the so-called educational software in the field of geography fails to take advantage of the strengths that the computer has to offer. It is too restricted and too repetitive and very often the capability for student interaction is limited. A geographic information system as an educational tool, on the other hand, is limited principally by the teacher's imagination. It is this tool, the GIS, which is discussed in detail in the following chapter.

CHAPTER 3

GEOGRAPHIC INFORMATION SYSTEMS

The computer is becoming more and more a force in our society and, accordingly, there are very few fields of study which have not been influenced by it. Geography is no exception. Not since the quantitative revolution of the 1960s has the discipline been affected to such a great extent. The reason has been the emergence of the computerized geographic information system (GIS).

History

The computer is not new to geographers as they have been using it for several decades to process their data. It is only in the last decade, however, that the concept of a geographic information system has gained wide recognition. Given the tremendous interest in environmental problems and the fact that a high percentage of governmental and private databases have a significant spatial element, the growing importance of geographic information systems is not surprising.

The geographic information system as it is known at present can be traced back to the early stages of computer assisted drafting (CAD). The Massachusetts Institute of Technology and the General Motor Research Lab were two centres in the mid 1950s and early 1960s which were instrumental in the development of the field (Jenks, et al. 1969). The first computer mapping systems evolved from this CAD background, early efforts being merely automated map drafting systems. In the first part of the 1960s, both the Swedish and Canadian governments began work on computer applications in cartography (Wastesson et al., 1977). The British Ordnance Survey also was involved in such work later in the decade (Taylor, 1980), as was Harvard University in the United States (Chrisman, 1988).

Burrough (1986) notes that during the 1960s and 1970s a multi disciplinary approach to mapping emerged. This manifested itself in the merging of the concepts of computer assisted mapping and map analysis. Computer programs such as SYMAP were developed which allowed the analysis and manipulation of spatial data, and the production of crude lineprinter maps. The SYMAP program was created by Howard T. Fisher at the Laboratory for Computer Graphics and Spatial Analysis of Harvard University. It became extremely popular and by 1975 it was being used at more than 300 different sites (Taylor, 1980).

An essential component of the contemporary GIS is the database management system (DBMS). A GIS must store enormous amounts of data and have that data easily accessible. Database management systems were created independent of geographic information systems but were incorporated because of these characteristics. The development of such systems was, like GIS, also taking place in the 1960s. In 1965, C. W. Bachman of the General Electric Company developed the program IDS (Integrated Data Store) which introduced many of the concepts used in modern database systems. It was also the first full DBMS on a commercial scale (Parker, 1987). Originally developed for mainframe computers, DBMSs were initially very expensive. At present, however, microcomputer versions of this software are available at a low cost. Unfortunately, not all commercial systems are suitable for the needs of a GIS. Frank (1988) notes that some commercial systems cannot accommodate spatial data or deal with the retrieval of map graphics. An in depth discussion of such limitations is outside the scope of this chapter.

What is often referred to as the world's first geographic information system was developed by Environment Canada in the 1963-1971 period and was given the name of the Canada Geographic Information System (CGIS). The vast area of this country and the need to efficiently manage natural resources have been cited as reasons why Canadian scientists became early leaders in the GIS field. The CGIS, one of the few original systems that is still in use, is also the most extensive databank in the world on information related to agriculture, forestry, recreation and wildlife habitat (Harris, 1989).

The myriad of computerized geographic information systems that have been developed in the last decade have emerged from a wide range of disciplines. Cartography, geography, civil engineering, soil science, urban planning and surveying, are just some of the areas of study that have had an influence on the GIS field. The concept, by McLuhan (1962), that the introduction of new technology alters the human environment is especially valid when dealing with geographic information systems. As computer technology developed from the early years of the CGIS, new software was written to run on smaller and more economical computers. Government agencies were no longer the sole proprietors of the field. Private companies, such as the Environmental Systems Research Institute (ESRI) of Redlands, California, began to develop and sell their own systems.

Jack Dangermond (Dangermond and Smith, 1988), the president of ESRI, notes that as the 1980s began, GIS technology seemed to be a solution searching for a problem. However, by the middle of the decade users from a multitude of fields had emerged and

GIS became a growth industry. Today the number of companies and the diversity of geographic information system software is staggering.

The Definition of a Geographic Information System

The search for a proper, widely accepted definition of the term "geographic information system" is ongoing. This is mainly because such systems have been incorporated into a number of varied disciplines, as listed earlier in this chapter. The International Cartographic Association has formed a separate committee just to deal with how to define a geographic information system and terms related to the GIS field. The following are a list of some definitions which have been used in the literature.

A Geographic Information System (GIS) is a computer-assisted system for the capture, storage, retrieval, analysis and display of spatial data (Clark, 1986).

A GIS is a set of computer-based tools for the input, storage and analysis, and output of geographical information (Tomlinson, 1989).

A Geographic Information System is the integration of people, equipment and techniques for the purpose of translating spatially-related data into meaningful spatially-related information (Kinzy, 1977).

A Geographic information system is a system which uses a spatial data base to provide answers to queries of a geographical nature (Goodchild, 1985).

GIS refers to a system of computer programs that store, retrieve, manipulate and display spatial data (Watson et al., 1989).

A Geographic Information System can be viewed as a complex, communication system which provides requested information on geographic or land-related phenomena to a user (Miller, 1988).

Such a broad range of definitions for the same subject indicates that the GIS field is still in its infancy. It is outside the scope of this paper to debate the philosophy behind the topic of geographic information systems or to provide the quintessential definition for the topic. For the purpose of this thesis the Tomlinson definition is applied.

The Generic Geographic Information System

As would be expected in such a rapidly changing field the geographic information system has been developed in a variety of ways with influences from a number of diverse disciplines. This has lead to the situation where systems are based on different computers, using different data structures and performing different functions. Although this has taken place it is still possible to identify characteristics that are common to all geographic information systems. The term used to describe this common ground is the generic GIS.

The geographic information system can be described as a tool to perform three distinct jobs. It is a mapping tool, an analytical tool and, as well, a modelling tool. It order to accomplish these tasks it makes use of four diverse operations. These are data capture, data storage, analysis and manipulation of the data, and information output. The following paragraphs outline what such operations entail.

Data can be captured by the geographic information system in a number of ways. It can be digitized from a map or plan using a digitizing table (digitizer), input in an alphanumeric format from a computer keyboard or scanned in using automatic line following devices (e.g. LASERSCAN) or conventional raster scanners (Burrough, 1986). Even with the advent of scanning technology the input stage remains the most time consuming segment of all the geographic information system operations.

All GIS systems store and enable efficient retrieval of data that has been captured. According to Marble "a data storage and retrieval subsystem organizes the spatial data in a form which permits it to be quickly retrieved by the user for subsequent analysis, as well as permitting rapid and accurate updates and corrections to be made to the spatial database" (Marble, 1987). Two main types of data may be stored in a geographic information system depending on the data structure of the GIS. These are raster data and vector data. Depending on the type of data and the size of the system, space is a crucial factor in the storage of digital data. This has led to a recent emphasis on compact disc technology. Also the need to store attribute data, that is data which describes the spatial phenomenon, in addition to spatial data has led GIS developers to utilize database management systems (DBMS) external to the geographic information system software. For example, the PAMAP system makes use of dBASE IV as an external DBMS. Attribute data can be sent out to this external database, analysed and retrieved back into the main system.

The data analysis and manipulation operation is the most important element of any GIS. This is where the problems are solved and where raw data is turned into useful information. Data may be input, stored efficiently and output in a cartographically acceptable manner but if the analytical capabilities of a GIS are weak it is not a good GIS. These capabilities make geographic information systems unique from CAD or computer-assisted-cartography software packages.

The analysis operation can be viewed as having four distinct segments (Miller, 1988). These are: spatial query (e.g. where is a feature?), attribute query (e.g. what characteristic does a feature have?), polygon processing (e.g. over what area?), and network analysis (e.g. what routes are available?). The latter two could be used to overlay map layers in order to solve locational problems or to determine shortest route solutions.

The last operation common to all geographic information systems is the output capability. This is the display of the information that has been gained from the analysis subsystem. The output may take the form of a display on a computer monitor, a plotted map or even a printed table. This segment of geographic information systems has received the least amount of attention from system developers. As a result many commercial GIS software packages produce output that is poorly designed in terms of cartographic theory and therefore does not communicate effectively or efficiently the analysed information.

GIS Applications

Although the GIS revolution has been largely technology driven the practical applications must be useful and cost effective if the field is to continue to develop. This appears to be the case as noted by Dangermond and Smith (1988) earlier in this chapter. A number of real-world applications which have been identified in the literature are outlined below:

1. Facility and asset inventory: locating, counting, and analyzing distributions (for example: timber stands, land parcels, infrastructure networks);

2. Geographic data collection and production. (for example: land surveys, digital map compilation, remote sensing);

3. Map and chart publishing;

4. Resources allocation: analysis of human and non-human resources as defined by political, economic, or social criteria. (for example: target marketing, sales territory planning, service force distribution);

5. Route and flow optimization (for example: transportation network analysis, school bus routing);

6. Route selection and navigation: selection of optimal paths in response to imposed criteria (for example: emergency vehicle dispatch);

7. Site location planning. (for example: siting fire and police stations, shopping centres, hazardous waste sites);

8. Surface and subsurface assessment: analysis of physical phenomena to understand, preserve, or utilize the availability of natural resources (for example: topographic, geologic, hydrologic modelling);

9. Tracking and monitoring (for example: crime tracking, traffic accidents, environmental analysis, elections).

Future Trends

O'Donnel (1989) states that only the surface of potential applications of GIS has been touched and that awareness of this field is increasing rapidly. He predicts that geographic information systems will dissolve the boundaries between many disciplines, the end result being improved problem solving.

On a less grandiose level, it can be safely predicted that computer technology and geographic information system software will continue to develop and improve. The growing trend is toward the operation of such packages on microcomputers and work-stations. The ease of use will also continue to improve, making GIS more accessible to a variety of potential users. Hardware developments in the areas of compact disc technology and scanners will continue, altering the GIS field as they do so.

Dangermond and Smith (1988) note that GIS technology provides an effective method of dealing with the tremendous complexity of the real world and that through the use of modelling, forecasting can be done and the appropriate human decisions made. This point is particularly relevant in terms of environmental protection.

CHAPTER 4

EXPERIMENTAL DESIGN AND PROCEDURES

The purpose of this study was to examine the effects of using a computerized geographic information system to assist in the instruction of geography at the grade seven level. It was anticipated that the computerized instruction would lead to improved results on the post-test.

This chapter outlines the design of the experiment and the methods used to undertake the study. Included as well are a description of the sample group and of the geographic information system being used.

Experimental Design

It is almost impossible in educational or psychological research to conduct a perfect experiment which uses a totally random sample. Often researchers in these fields make use of sample groups, such as school classes, which they have easy access to. This does not, however, make their research any less valid. Such experiments are termed quasi-experimental and if the limitations of this type of research are taken into consideration the results, at least when human subjects are involved in the testing, approach the reliability of true scientific experiments.

One of the most common quasi-experimental designs used in educational research is termed the Nonequivalent Control Group design or the Nonrandomized Control-Group Pretest - Post-test design (Campbell and Stanley, 1963). This involves an experimental group and a control group which are both given a pretest and a post-test. The sample, however, is not drawn at random from a population. Figure 4.1 demonstrates the procedure graphically.

FIGURE 4.1

Nonequivalent Control Group Design

Pretest	Treatment	Post-test	
T	X	T1	Experimental Group
T		T1	Control Group

The experiment undertaken for this study used the Nonequivalent Control Group Design with two experimental groups receiving treatment. The design is also compatible with the statistical procedure being employed. The Kruskal-Wallis analysis of variance by ranks, which is discussed further on in this chapter, can be used when the underlying design is quasi-experimental.

Instructional Material

The most difficult task in creating instructional material for this study was to establish a valid framework of objectives. A computerized geographic information system is a tool which can be used in a variety of ways in order to accomplish most, if not all, the general objectives of geographic education.

In a 1978 study done in England and Australia, Slater and Spicer (1978) identified a comprehensive list of objectives which geography teachers in those two countries strived to achieve. The following are some of the items of that list which are relevant to this research:

1. Promoting an interest in the discipline;
2. Developing the ability to make judgements and solve problems;
3. Developing initiative with respect to research and independent study;
4. Developing an understanding of basic concepts, e.g. distance and scale; and
5. Developing an ability to read and interpret information from maps.

Geography is a discipline, possibly because it spans the gap between art and science, which can be taught in a variety of ways. It is outside the scope of this study to elaborate on the variety of teaching methods used by educators in geography. However, the following paragraphs outline some of the major points taken into consideration when putting together the instructional material for this project.

Drill and practice, most educators in geography agree, is an essential element of classroom instruction. However, such exercises are only effective if the need for knowledge of the subject matter is demonstrated to the students. Related to this point is the concept that in teaching problem solving, the problems dealt with should be of a real world nature and, therefore, have a relevance to the students. The problem solving approach in teaching geography is highly advocated because it forces students to use their thinking skills and memory.

Castner (1990) in an innovative approach to geographic education, suggests that by going through the process of mapping, students can gain enormous educational benefits. His definition of mapping involves the graphic description, analysis, and presentation of data in a problem solving context.

The idea that subject material should have real world relevance for students supports the approach advocated by some educators that local maps and data should be made use of to teach certain geographic concepts such as direction and scale.

Chapter 2 has dealt with the literature concerning spatial awareness in children. The conclusion drawn from the various studies, in general, is that not until the grade seven level are students completely capable of understanding spatial concepts such as direction, distance, scale and orientation system.

The actual lesson which was developed for this project was divided into two distinct sections. The first dealt with the previously mentioned spatial concepts and made use of a neighbourhood map of the area adjacent to Saint John Brebeuf school as a vehicle for instruction. The map was created using the PAMAP geographic information system. Paper copies for the conventional instruction part of the study were produced by a drum plotter. The map displayed such features as streets, railways and and buildings. A small database was created with information concerning the price of products at certain stores. This was printed in tabular form for the conventional classroom instruction. The instructional material used for this study is found in Appendix A.

The second part of the lesson took the form of a regional geography of Australia. Australia was chosen as the subject matter because, although it is included in the grade seven curriculum in Manitoba, it had not been taught to the Saint John Brebeuf class previous to this study. Different thematic maps of Australia (e.g. Temperature, Rainfall, Mineral Resources, etc.) were generated using the GIS and again, hard copies of these were produced and used in the conventional instruction. Written instructional material was also prepared and presented with the geography lessons.

The consideration of the previously mentioned methodology was reflected in the building of the geography lessons for the study. Another factor which influenced the choice of material was the goal of making the study relevant to the grade seven social studies curriculum in Manitoba. The focus of geography at this level is on the relationships and interdependence of the physical and social environments on earth. More specifically, the purpose of this part of the curriculum in the schools is to help students examine and better understand the earth and its resources, to make them aware of patterns of land, water, soil, minerals, etc. throughout the world, and to make them think about the interdependent nature of the earth's landforms, climate, population and natural resources.

The Sample

The importance of proper sampling procedure in any realm of behavioural science cannot be over emphasized. Sample size is often a topic for debate in such research. A discussion pertaining to the sample size for this study is found in Chapter 6.

The subjects of this study were seventh grade students, aged 12 to 14 years, attending Saint John Brebeuf School in Winnipeg, Manitoba, Canada. The class size totalled 28 at the time of the study, with males outnumbering females 3:1. The experiment was conducted over a three month period in the early part of 1990.

Saint John Brebeuf School is located in a predominantly middle class residential neighbourhood in Winnipeg and its students could be described as coming from families of middle to upper middle class socio-economic status.

The 28 students were divided into three academically equal groups. This was done using their social studies class marks for the 1989-90 school year. These marks constituted the pretest in the experimental design of this project. The grade 7 teacher was consulted to ensure that the groups were, in fact, equally balanced. Groups A and B were the experimental groups and Group C acted as the control group. Detailed information on the subjects can be found in Table 5.0 in Chapter 5 of this study.

Procedure

As stated previously, the students of Group A in the study were given instruction in a conventional manner. Group B students were instructed with the assistance of a computerized geographic information system and Group C acted as the control or reference group. The conventional instruction was undertaken in a classroom situation at Saint John Brebeuf School. The students were presented with information on geographical concepts and the geography of Australia using the instructional material described earlier in this chapter. This material is available in Appendix A of the thesis. Students were asked to work in pairs to examine the maps and text presented to them and to answer questions related to the subject matter. The total teaching time amounted to ninety minutes.

Group B was provided with the same information as Group A but it was presented to the students using a computerized geographic information system. The logistics of undertaking this teaching method were more complicated than for Group A. In order to get access to the computer and the GIS software being utilized it was necessary to transport students to the University of Manitoba. This was done after school hours with the permission of the parents of the students involved. Parents were invited to attend and observe the lesson. An effort was made to keep the lessons presented to both groups as identical as possible.

After completion of the instruction all three groups were administered a post-test which was designed to evaluate the students' retention of geographic facts, the understanding of spatial concepts and the ability to analyse and solve problems in geography. The results of these tests as well as the results of the pretest, the gender of the student and the group that each student belonged to were loaded onto a spreadsheet in preparation for statistical analysis (Table 5.0). At the request of the school, students were identified on the pretest and post-test by an identity number. This system maintained the students anonymity.

Post-test Design

The assessment process in education is used for a number of reasons. One of the most important of these is to assist in determining appropriate teaching strategies. Needless to say the assessment procedure is difficult to design. Relevant questions must be asked and the results must be evaluated correctly.

The prime goal in establishing an assessment test is to make it valid in content. Salvia and Ysseldyke (1988) identified three factors which are relevant to content validity. These are:

1) the appropriateness of the items on the test for the age of the student;

2) the completeness of the test (e.g. does it measure a wide variety of tasks and knowledge?); and
3) the appropriateness of the test style to gain information about the student (e.g. true or false, multiple choice, etc.).

There are various other factors which can bias a test but if the above points are taken into consideration the test should be reasonably objective.

The post-test for this study was divided into three separate elements. The first part was designed to evaluate the students' ability to retain or remember factual information about the geography lessons undertaken. The second part sought to examine the students' understanding of basic geographic concepts such as direction, distance, scale and orientation system. The third and last segment of the post-test had the goal of evaluating the ability to analyse and solve spatial problems.

A combination of true or false questions, multiple choice and written responses were used in the test. The three parts of the post-test are found in Appendix B of this thesis.

Software

Chapter 3 provided a detailed description of geographic information systems and the increasing role they are playing in geography. The specific GIS used for this project was PAMAP, a Canadian system developed in British Columbia.

The PAMAP geographic information system was developed by PAMAP Technologies Corporation of Victoria, British Columbia, Canada. It is a stand-alone GIS which can be implemented on a number of different platforms, including the IBM PC (or compatibles) and the VAX. This study made use of a Compaq 386 microcomputer to run the software. Originally designed for the resource management field PAMAP has now been expanded to serve a wide range of disciplines. These include: agriculture, landuse planning, property assessment, surveys, etc. PAMAP is being used professionally in a variety of government, university and private agencies throughout Canada. The following paragraphs outline some of the characteristics of the software.

The PAMAP geographic information system is a vector based system which has a raster capability to perform analysis functions. It is menu driven and, therefore, easy to learn for new users. This latter point made its use attractive for this study. The complete system is made up of several individual modules. These include MAPPER, ANALYZER, PLANNER, TOPOGRAPHER and INTERPRETER. The most recent version of the software (Version 2.22) also contains MODELLER and NETWORKER modules or subsystems. It is not necessary to purchase each module and the user can customize their own system by choosing the modules that are needed for his or her applications.

The MAPPER subsystem is used to input new maps or to edit existing ones. Line styles, colours and type styles are controlled from this module. Sixty-four different layers or levels of graphic information can be handled in the MAPPER module.

The ANALYZER module of PAMAP is the other main element of the software used in this study. ANALYZER performs the analysis operations in the geographical information system by converting vector elements into raster or grid-cell format. This means that it can take polygons in line form and transform them to raster automatically, computing their areas and storing them in a database as it does the operation. PAMAP is one of the few geographic information systems that makes use of this efficient technique. ANALYZER also provides the user with a number of effective analysis tools. The most important of these being the capacity to overlay map layers. The capability of altering the colours of elements on the computer screen and to have a database of attributes, which can be used to answer questions, attached to these elements are two important components of a GIS in an educational environment.

There are a number of similar, moderately priced commercial geographic information systems capable of performing the same operations as PAMAP. This research used the PAMAP system because of the system's ease of use and its availability for the study. Technical information on PAMAP can be found in Appendix C.

The Statistical Procedures

The first statistical work in this research involved the establishment of the three study groups from the grade seven class at Saint John Brebeuf school. The criterion used to do this was the students' social studies course marks for that year. Pupils were shifted between groups in the planning stage until three academically equal groups (groups with approximately the same average mark) were created. The social studies teacher was consulted at this stage to ensure that these assemblages were indeed balanced. The social studies course scores thus constituted the pretest for the experiment.

The results of the pretest and of the three segments of the post-test were recorded in tabular form as was the total post-test score and the final percent (Table 5.0). The pretest and post-test average scores were calculated by group (Table 5.1).

Due to the nature of the pretest - post-test experimental design it was possible to analyse several factors in this research. In real world situations it is often difficult to know if the distribution of a population is normal in character. Such situations lend themselves to the use of nonparametric or "distribution-free" tests. One such test is the Kruskal-Wallis one-way analysis of variance by ranks. In addition to being "distribution-free", it is simple to calculate, quick, suitable to be used with small samples, and capable of dealing with experimental groups of an uneven size (Hammond and McCullagh, 1978). It is a nonparametric technique which means that it is not influenced by the form of the underlaying probability density distribution of the variables. This eliminates the situation of having to prove normality of the variables in either their original or, if necessary, transformed state. This is extremely important since the small sample size precludes such proof and it would be necessary to proceed with unverified and unverifiable assumptions if a parametric test was utilized.

The parametric alternative to the Kruskal-Wallis test is Analysis of Variance (ANOVA) or Analysis of Covariance (ANCOVA) (essentially the two tests are the same, differing only in preparation to performing the test). In the statistical literature all available distribution free tests have been evaluated for their effectiveness in correctly accepting the null hypothesis. In such evaluations the nonparametric test is compared to the most similar parametric test available. The asymptotic relative efficiency (A.R.E.) is most commonly used and is considered the best expression of the robustness of a nonparametric test (Bradley, 1968). The A.R.E. measure is also often made use of to compare alternative distribution-free tests.

The term "asymptotic" means that the test statistics are compared repeatedly as the known probability density functions depart from extreme abnormality and approach normality. "Relative" refers to the fact that the result is expressed as the ability of the distribution-free test to distinguish correctly, divided by the ability of the competitor to do the same.

The Kruskal-Wallis test is one of the most powerful, if not the most powerful, distribution-free test. Compared to ANOVA its A.R.E. can never be lower than 0.864 (Hodges and Lehman, 1956) and may be as high as infinity. When the underlaying distributions are normal and all other assumptions are met the A.R.E. is 0.955 (Bradley, 1968, p. 132). In general, for small samples, distribution-free tests are more discriminating (Bradley, 1968, p. 18) and are in most cases preferable. When compared to other distribution free tests the A.R.E. of the Kruskal-Wallis test ranges from 1.5 to 3.0.

Its use as a statistical technique spans such divergent disciplines as geography, education, psychology and medicine and, in recent years, it has been used in a number of research projects which have been conducted in semi-controlled environments and have been characterized by small sample sizes (Johnson and West, 1989; Brunswick et al., 1988; Ross and Smith, 1990).

The statistical software package used to produce the dot plots shown in Chapter 5 was Data Desk from the Odesta Corporation of Northbrook Illinois, U.S.A.

CHAPTER 5

RESULTS AND ANALYSIS

The results of the study and a cursory analysis of these results are put forward in this chapter. The null hypotheses were tested individually and their validity ascertained from the results. The data for each null hypothesis are displayed in Table 5.0. As stated earlier, the social studies mark acted as the pretest for the study. The column labelled "TEST PERCENT" in Table 5.0 displays the post-test scores in percentage form and the results of the three parts of the post-test are listed in columns four, five and six under the headings of Part A, Part B, and Part C.

The five null hypotheses that underwent testing were outlined previously in this thesis and are listed again below:

H_o1: A computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the students' retention of geographic facts.

H_o2: A computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the students' understanding of spatial concepts.

H_o3: A computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the students' ability to solve spatial problems.

H_o4: A computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the students' comprehension of a geography lesson.

H_o5: A computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the comprehension of a geography lesson by lower-ability students.

TABLE 5.0
DATA SHEET

ID NUMBER	GENDER	GROUP	TEST PART A	TEST PART B	TEST PART C	TEST TOTAL	TEST PERCENT	PRE-TEST
1	M	A	26	10	29	65	89	76
2	M	A	22	10	24	56	77	97
3	M	A	23	8	24	55	75	85
4	M	A	13	7	7	27	37	64
5	M	A	16	7	14	37	51	67
6	M	A	8	8	7	23	32	50
7	F	A	11	5	15	31	43	57
8	F	A	24	9	21	54	74	95
9	F	A	21	6	21	48	66	82
25	M	A	18	8	22	48	66	92
10	M	C	15	4	12	31	43	52
11	F	C	10	3	8	21	29	54
12	M	C	15	4	10	29	40	71
13	F	C	13	6	22	41	56	95
14	M	C	10	3	3	16	22	62
16	M	C	13	5	5	23	32	71
29	M	C	13	6	14	33	45	91
28	M	C	22	8	24	54	74	95
17	M	B	21	8	20	49	67	85
18	M	B	17	9	24	50	68	70
19	F	B	17	5	15	37	51	81
26	M	B	26	10	24	60	82	65
21	F	B	23	8	16	47	64	82
22	M	B	20	6	25	51	70	86
23	M	B	21	9	25	55	75	86
24	M	B	25	9	21	55	75	93
27	M	B	18	8	18	44	60	60
30	M	B	22	9	21	52	71	90

The statistical procedure used to evaluate the results of this study was the Kruskal and Wallis analysis of variance by ranks. As stated previously, it is a nonparametric technique which is "distribution free". Figure 5.1 provides the formula used for the calculations. A chi-square table was used to find a value equal to H.

The first step was to determine if there were any significant differences among the three study groups. Table 5.1 gives the sample size and the mean scores for each group in the pretest and post-test. Although the groups were reasonably well balanced in terms of their pretest marks the differences that remained necessitated the use of the Kruskal-Wallis analysis of variance as a statistical procedure to determine if the differences among the groups were statistically significant. A .05 level of significance was used for this research. The testing showed no statistically significant differences between the the three groups (Table 5.2).

FIGURE 5.1

KRUSKAL-WALLIS TEST

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \left(\frac{R_i^2}{n_i}\right) - 3(N+1)$$

where

n_i = number of observations in sample i

N = total number of observations

R_i = sum of ranks for sample i

To apply this test all the observations for k samples are ranked

TABLE 5.1

Sample Size and Average Scores

Group	Size	Pretest Average	Post-test Average
A	10	76.5	61.0
B	10	79.8	68.3
C	8	73.87	42.6

TABLE 5.2

The results of the Kruskal-Wallis test to evaluate if Groups A, B, and C are academically equivalent (Pretest marks)

Group Combinations	Df	χ^2 Value of .05	Calculated H value	Result *
A, B, C	2	5.991	- 0.06	Accept
A, B	1	3.841	0.206	Accept
A, C	1	3.841	0.146	Accept
B, C	1	3.841	0.146	Accept

* The null hypothesis is that there is no significant difference between the groups.

More precisely, the null hypothesis, that before the lesson there was no difference between the three groups, cannot be rejected.

Hypothesis One

Part A of the post-test evaluated the students' retention of geographic facts after undergoing the previously described geography lesson. Testing was done in order to evaluate the four separate group combinations. The combinations tested were Groups A, B, and C, A and B, A and C, and B and C. It was necessary to reject the null hypothesis of no difference between the three groups (line 1 of Table 5.3). The more detailed pairwise analysis shows this rejection to be principally the rejection of the similarity of the group receiving GIS instruction compared to the control group. The group receiving conventional instruction (Group A) obviously occupies an intermediate position. The null hypothesis cannot be rejected comparing this group to either of the other two. Obviously they benefit from the instruction but not as much as the GIS instructed students. The results indicated that there was a statistically significant difference among the three groups as a whole and also a significant difference between Group B and Group C. However, in comparing Group A students with Group B, no level of significance was discovered. Also no significant values were discovered when Group A was compared to Group C. The relationship is graphically displayed when dot plots are compared for the pretest and Part A of the post-test (Figure 5.2). An obvious improvement is visible on this graph for the lower ability students of Group B. On the basis of the comparison of Group A with Group B it is necessary to accept the null hypothesis. A discussion on the use of 0.05 as an appropriate level of significance for this type of study is found in Chapter 6. Testing results for Part A of the post-test are shown in Table 5.3.

FIGURE 5.2

DOT PLOTS: SOCIAL STUDIES (PRETEST) AND PART A (POST-TEST)

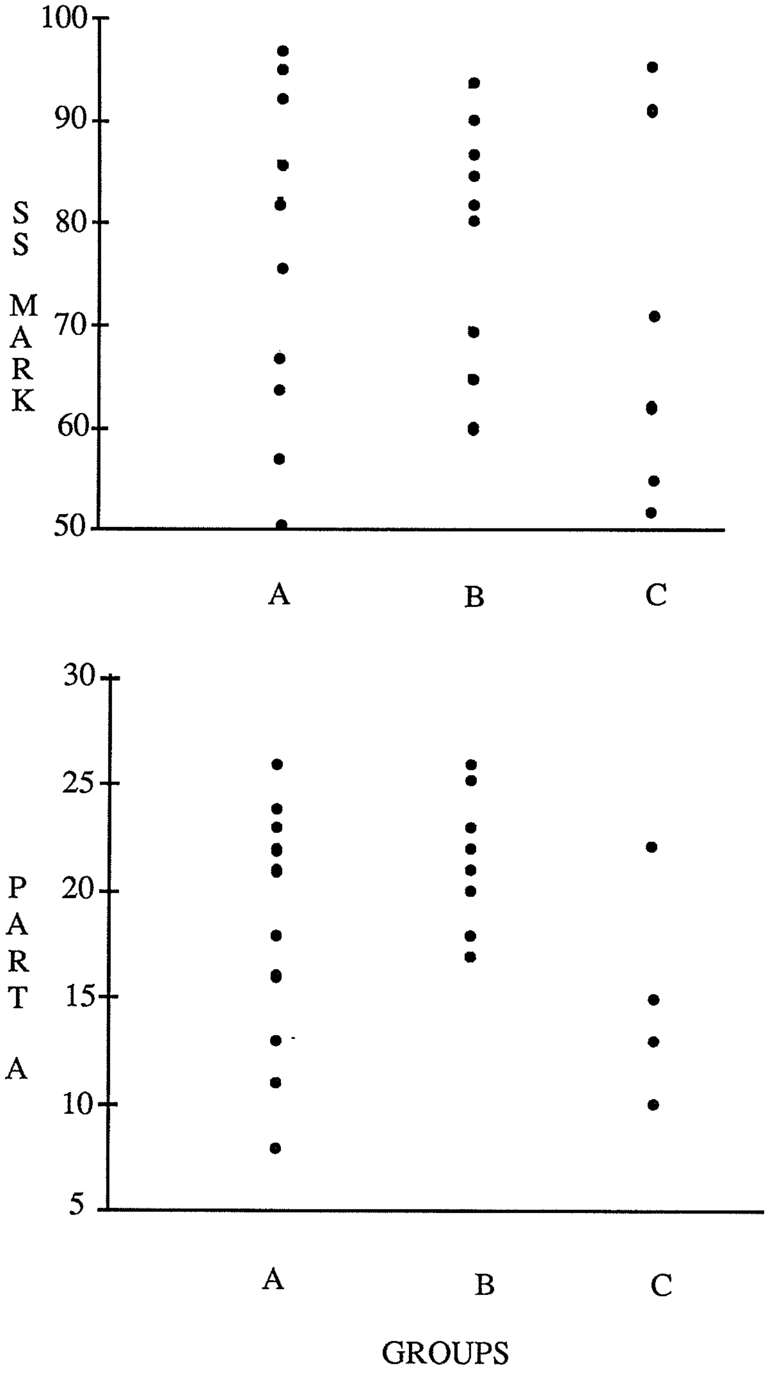


TABLE 5.3

PART A - RESULTS

Group Combinations	Df	χ^2 Value of .05	Calculated H Value	Result *
A, B, C	2	5.991	7.983	Reject
A, B	1	3.841	0.694	Accept
A, C	1	3.841	2.579	Accept
B, C	1	3.841	8.883	Reject

* The null hypothesis is that there is no significant difference between the groups.

Hypothesis Two

Part B of the post-test evaluated the students' understanding of spatial concepts. Again, testing was done using the Kruskal-Wallis procedure to evaluate differences among the three groups with respect to their scores on this section. The first test was to determine if the three groups scored differently from each other. Table 5.4 shows that there was a significant difference among the groups in this regard. Significant differences were also noted in comparing Group A with Group C and Group B with Group C. It can be concluded, as in Hypothesis One, that Group A occupies an intermediate position, with the students receiving benefit from the instruction but not to the extent of Group B. However, on the basis of the comparison of the two key groups, A and B, no statistically significant values were discovered at the standard 0.05 level. Accordingly, this null hypothesis was accepted. Dot plots display these results graphically in Figure 5.3. The literature related to spatial awareness in children which was examined in Chapter 2 indicates that by the age of 12 to 13 years the spatial concepts dealt with in this work should be comprehended by the students. Therefore, it would be expected that this null hypothesis would be accepted. However, the fact that any difference at all was present among these three groups would seem to indicate that the literature may not be completely accurate. An elaboration of this point is made in the following chapter.

FIGURE 5.3
DOT PLOTS: SOCIAL STUDIES (PRETEST) AND PART B (POST-TEST)

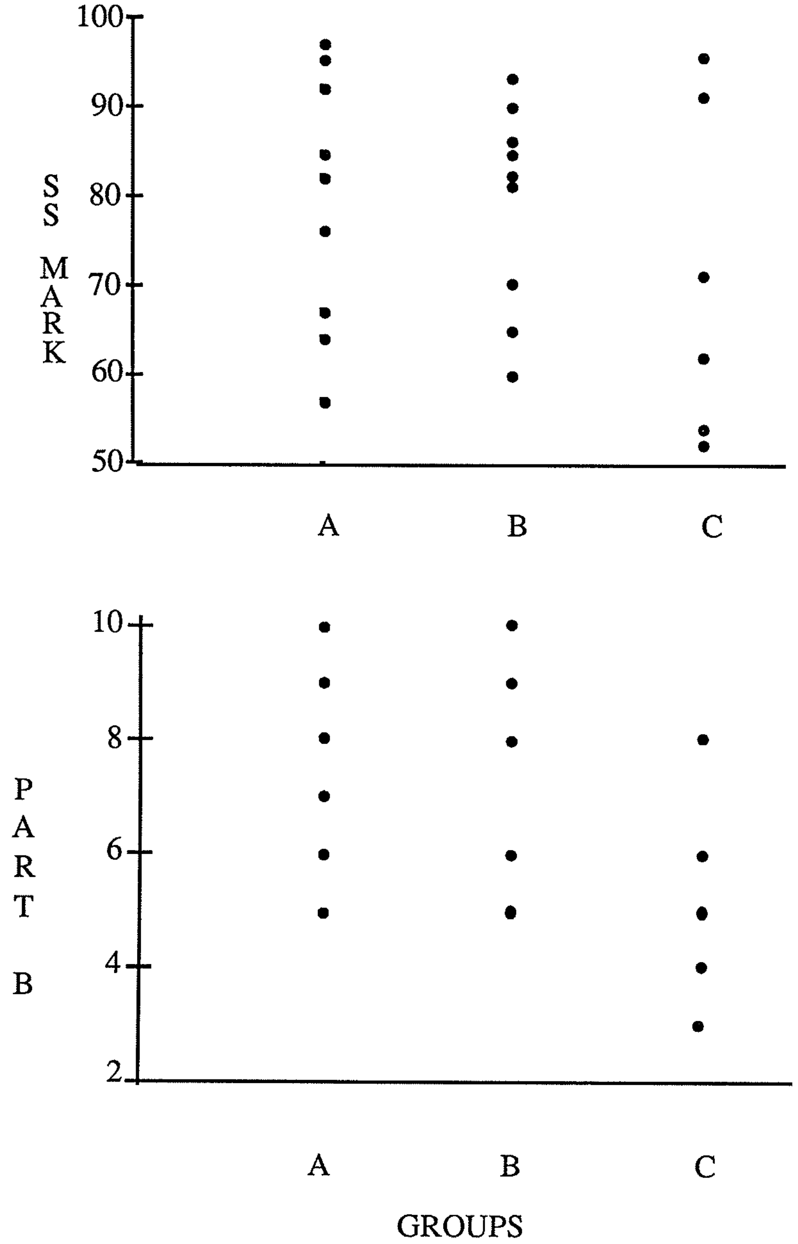


TABLE 5.4

PART B - RESULTS

Group Combinations	Df	χ^2 Value of .05	Calculated H Value	Result *
A, B, C	2	5.991	10.950	Reject
A, B	1	3.841	0.385	Accept
A, C	1	3.841	7.609	Reject
B, C	1	3.841	8.620	Reject

* The null hypothesis is that there is no significant difference between the groups.

Hypothesis Three

Part C of the post-test evaluated the students' ability to solve spatial problems after being introduced to the geography instruction associated with this research. The four combinations were tested for the three groups using the Kruskal-Wallis procedure. Groups A, B, and C did not differ significantly from each other as a whole. As well, the testing of the combinations of Groups A and B and Groups A and C did not produce significant values at the 0.05 level. The only combination which showed significant results was that of Group A and Group C. It was, therefore, necessary to accept the null hypothesis. The values for this segment of the post-test are displayed in Table 5.5 and the appropriate dot plots are shown in Figure 5.4. Again, although the results did not indicate significance at the 0.05 level the improvement in performance by students in Group B, in particular the lower ability students, is evident when the dot plots are examined.

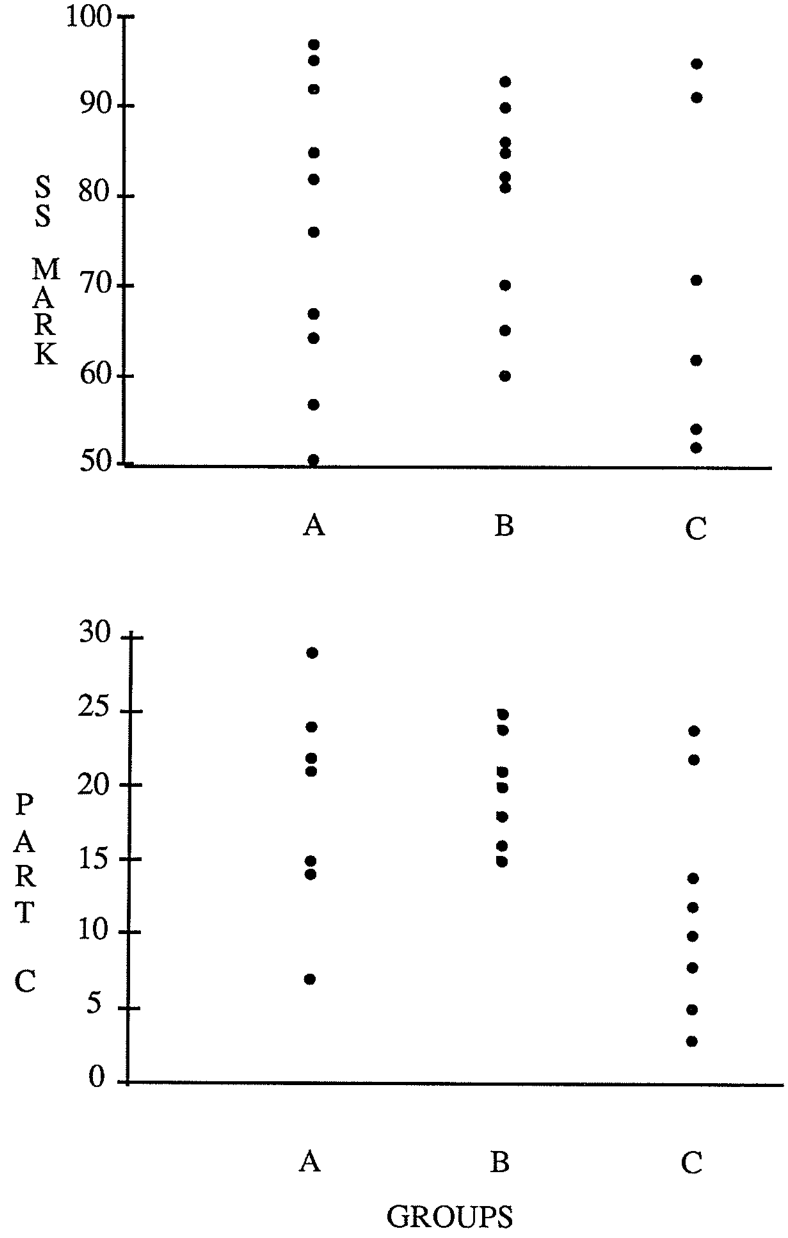
TABLE 5.5

PART C - RESULTS

Group Combinations	Df	χ^2 Value of .05	Calculated H Value	Result *
A, B, C	2	5.991	5.764	Accept
A, B	1	3.841	0.579	Accept
A, C	1	3.841	2.302	Accept
B, C	1	3.841	5.777	Reject

* The null hypothesis is that there is no significant difference between the groups.

FIGURE 5.4
DOT PLOTS: SOCIAL STUDIES (PRETEST) AND PART C (POST-TEST)



Hypothesis Four

Hypothesis four was the most important of the five null hypotheses in terms of evaluating the usefulness of the geographic information system as a teaching tool in a junior high school environment. The total post-test mark is shown in percentage form in Table 5.0 in the column labelled "TEST PERCENT". These scores evaluated the students' comprehension of the geography lesson as a whole, combining the results of Parts A, B, and C of the post-test. Testing was done using the Kruskal-Wallis statistical procedure to evaluate the differences among the three groups. In order to provide more statistical detail the Kruskal-Wallis technique was also used to analyse the difference in the students' scores from the pretest to the post-test. The results of the former are displayed in Table 5.6 and in the form of a dot plot in Figure 5.5. The testing of the difference between scores appears in Table 5.7. The detailed paired analysis indicates that Group A occupies an intermediate position in the study, the students have obviously benefited from the instruction but not to the extent achieved by Group B. The results showed that there was a statistically significant difference among the three groups, between Groups A and C, and between Groups B and C. However, this significant difference did not occur when comparing Groups A and B. It was, therefore, necessary to accept the null hypothesis.

TABLE 5.6

POST-TEST - RESULTS

Group Combinations	Df	χ^2 Value of .05	Calculated H Value	Result *
A, B, C	2	5.991	7.870	Reject
A, B	1	3.841	0.579	Accept
A, C	1	3.841	3.671	Accept
B, C	1	3.841	8.100	Reject

* The null hypothesis is that there is no significant difference between the groups.

FIGURE 5.5

DOT PLOTS: SOCIAL STUDIES (PRETEST) AND PERCENT (POST_TEST)

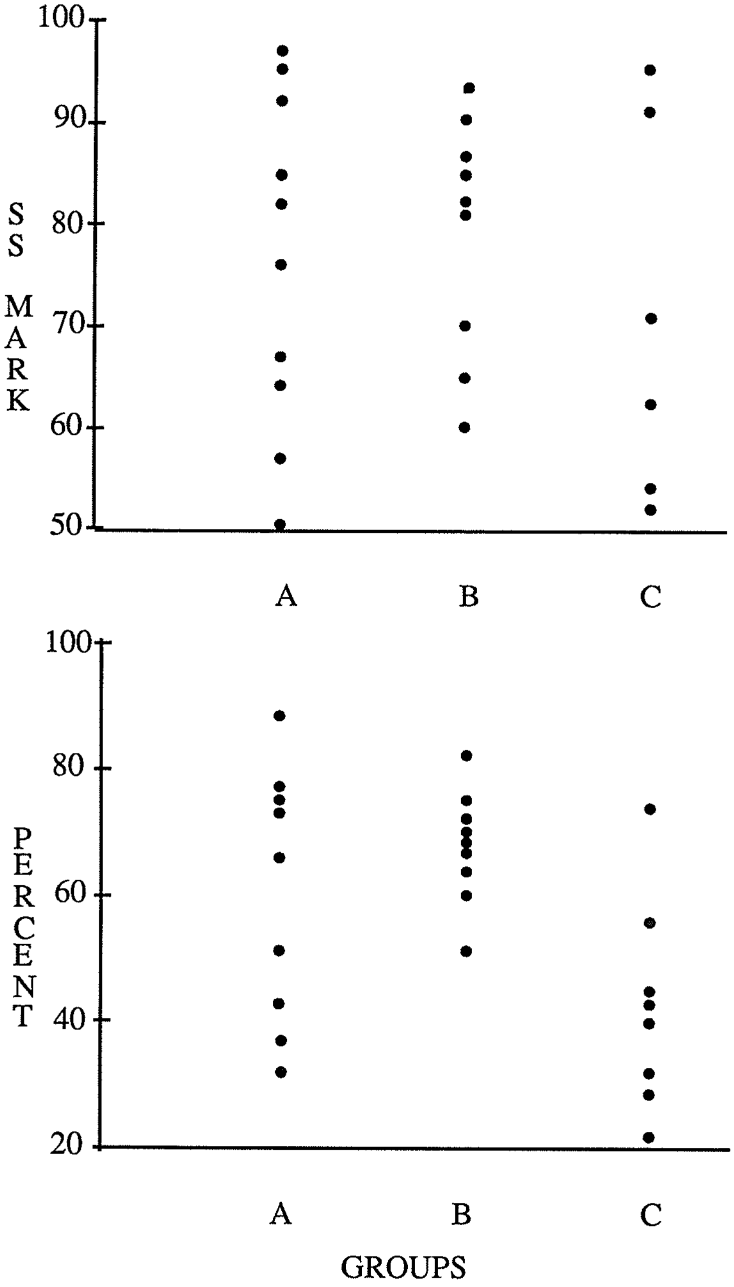


TABLE 5.7

PRETEST - POST-TEST DIFFERENCE

Group Combinations	Df	χ^2 Value of .05	Calculated H Value	Result *
A, B, C	2	5.991	9.150	Reject
A, B	1	3.841	0.305	Accept
A, C	1	3.841	5.992	Reject
B, C	1	3.841	7.609	Reject

* The null hypothesis is that there is no significant difference between the groups.

Hypothesis Five

The final null hypothesis of this research is that a computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the comprehension of a geography lesson by lower-ability students. Pupils from Groups A and B who received a pretest mark of 70 percent or less were compared. The results are displayed in Table 5.8. The Kruskal-Wallis procedure identified significant differences between these groups with respect to lower-ability students. The various dot plots shown in this chapter convey this fact graphically. It is, therefore, necessary to reject the null hypothesis. This result is possibly the most important finding of this thesis in that it opens questions as to the allocation of computer resources in our educational system. Further discussion on this point appears in Chapter 6.

TABLE 5.8

LOWER-ABILITY STUDENT RESULTS

Group Combinations	Df	χ^2 Value of .05	Calculated H Value	Result *
A, B	1	3.841	3.8559	Reject

* The null hypothesis is that there is no significant difference between the groups.

CHAPTER 6

SUMMARY, DISCUSSION AND CONCLUSIONS

The first section of this chapter is a summary of the experimental design procedures and methods of data analysis used in the research. It is followed by a discussion of the limitations of the study, results, conclusions and recommendations for further investigation.

Summary

This thesis began with a view of major world environmental problems and the supposition that an improvement in geographic education could assist in the solution of these problems. The specific objective of the study was to determine if a computerized geographic information system has a role to play in geographic education at the junior high school level, particularly in the areas of spatial concepts and regional geography. Based upon literature on spatial awareness in children, a specific age group (12-13 years) was identified as being the youngest group capable of benefiting from such instruction. As well, an extensive literature on computer-assisted instruction (CAI) provided evidence that this research was a valid exercise. No literature was found which examined the use of the computerized geographic information system as a tool for teaching geography. The subjects participating in this study were the grade seven students at Saint John Brebeuf school in Winnipeg, Manitoba, in the year 1990. The pupils were divided into three equal groups according to their class marks in social studies. This set of marks served the function of a pretest for the experimental design of the project. Groups A and B were given instructional material dealing with spatial concepts and the regional geography of Australia, the only difference being that a computerized geographic information system was used as a teaching tool to introduce the information to Group B. The third group (Group C) was used as the control group. A post-test consisting of three segments was completed by the students of all three groups at the conclusion of the study. These segments were designed to evaluate the students' retention of geographic facts, the understanding of spatial concepts (i.e. direction, distance, scale, and coordinate system), and the ability to analyse and solve problems in geography. The results of the post-test were evaluated statistically using the Kruskal and Wallis analysis of variance by ranks procedure.

The statistical analysis used supported the acceptance of four of the null hypotheses and the rejection of one. There was no statistically significant difference in performance between the group receiving conventional instruction in geography and that receiving instruction using a computerized geographic information system. This was true for all three parts of the post-test, recall of factual information, the understanding of spatial concepts, and problem solving. However, the results have demonstrated that a degree of improvement has taken place with the group receiving instruction with the GIS, albeit not a statistically significant improvement according to the 0.05 level. The final null hypothesis was rejected as a statistically significant difference was found between Groups A and B with respect to lower-ability students.

A general overview of the concept of the geographic information system was undertaken in Chapter 3 and a description of PAMAP, the GIS used for this study, was outlined in Chapter 4.

Limitations

The results obtained in this study must be evaluated with reference to a number of limitations. The most crucial of these are outlined in the following paragraphs.

The first critical limitation was the small sample size. Only 28 students were involved in the experiment. Although such a sample is small it is not uncommon in educational or psychological research to perform experiments with such numbers. It is not possible, however, to make broad generalizations about a population from a sample of this nature.

A second point regarding the sample was the fact that it was not characteristic of the full socio-economic range of Canadian society. Most of the students tested could be described as middle-class. Also an uneven ratio of male to female students existed in this sample. This did not allow for an analysis of results by gender.

The short period of instruction -- 1.5 hours -- could also be viewed as a limitation of this study. An ideal situation would allow students to be instructed for a full academic year using the techniques described in this research. Due to such a short instructional period there is also a danger of the results of the GIS instructed group being influenced by the novelty of such computer work. Improved results over a short period of time could be attributed to this novelty.

The physical limitation of having to transport the GIS-instructed subjects to an off site location in order to gain access to the appropriate hardware and software should also be cited. Any alteration in the environment in which an experiment takes place is not advisable. However, in this case it was not possible to arrange for the use of the geographic information system at Saint John Brebeuf School.

Related to the previous point, the design of the experiment, although reviewed by a number of junior high school teachers, did not receive input from professional educators involved in this style of testing. The teaching techniques and testing undertaken would no doubt have been more sophisticated had the research been performed by such people. Also, a testing of the validity of the instructional material and the post-test on students of this age group, outside of the experiment and before the study began, should have been undertaken. This would have removed ambiguities and made the written material more effective in terms of communication.

In the book, Learning Through Geography, Slater (1982) notes that the act of teaching is " ... a highly personal and somewhat idiosyncratic activity", and that the personality of the teacher has a strong influence on the style of planning and presentation. A drawback to this study was the fact that the instruction was not done by a professional teacher. Although the instruction was undertaken by the same individual for both the conventional and the computer segments of the experiment, the study would have been better served by a professional in conveying information to children.

Regardless of the limitations outlined in the previous paragraphs, the geographic information system is an important tool which is being used by geographers at the present time and which would seem to have valuable applications in geographic instruction.

Discussion and Conclusions

The following paragraphs discuss the results of the research that have been described in Chapter 5. An examination of each hypothesis will be followed by a synopsis of the conclusions.

Part A of the post-test examined the students' retention of geographic facts. Both the conventionally instructed group (Group A) and the group instructed by using the computerized geographic information system (Group B) received the same information from the teacher. It is not surprising, therefore, that there was not a statistically significant difference between the post-test scores of the two groups, and that it was necessary to accept the null hypothesis. Figure 5.2 displays graphically that Group B showed improvement on the post-test in comparison to their pretest scores. Groups A and C did not show this trend. The question arises from these results whether a 0.05 level of statistical significance is valid for educational research. The application of physical science laws to behavioural science does not appear to be appropriate in this situation. This point will be discussed later on in this chapter. As noted in the section dealing with the limitations of the study an improvement among the students in the retention of geographic facts, could be attributed in part to the novelty of using a computer for such instruction.

Part B of the post-test evaluated the students' comprehension of spatial concepts. As previously described these included direction, distance, scale, and coordinate system. Various studies have stated that the twelve to thirteen year old age group should be able to comprehend these ideas (Piaget and Inhelder, 1956) (Dodwell, 1963) (Pufall and Shaw, 1973). It was surprising, therefore, to discover that the majority of students from all three groups did not understand ratio scales. It was anticipated that the students receiving instruction via the geographic information system might have trouble comprehending scales because of the ability of the software to window (enlarge sections of the map) areas and thus make any stated ratio on the original input map wrong. For example, an original map may be created at 1:20,000 and the scale stated as such, but the map may be viewed on the screen at 1:5000. However, a 1:20,000 label would still be visible. This is why ratio scales are not appropriate for computer maps. Having stated this, the research was not conclusive that this was the case, as the other two groups performed poorly as well on the questions concerning ratio scales. Direction was also a concern for the Group B students. Not having a printed map to physically rotate and orient to the north, it was suspected that these students would have trouble with the direction questions. Again, however, there was no proof to confirm this. The null hypothesis was accepted that there was no significant improvement between the Part B post-test results of Groups A and B. The other group combinations were tested to ascertain if there were significant differences between them. Table 5.4 indicates that this is the case. It can be concluded, therefore, that there were improvements in the results of the GIS instructed group but not enough to be considered significant.

The last part of the post-test evaluated the students' ability to solve spatial problems. The supposition in this case was that the computer instructed group would perform better than the other groups. This would reflect the capability of the geographic information system to overlay different thematic maps and, in general, provide a clearer understanding of geographical relationships. A noted advantage of such systems is the problem solving capability. The Kruskal-Wallis statistical test indicated, however, that there was no significant difference between Groups A and B and that it was necessary to accept the null hypothesis. A true evaluation of problem solving in geography between the two groups would involve Group B actually making use of the geographical information system in the post-test. This was not possible in this study.

The three segments of the post-test were totalled and a percentage was obtained to give an overall rating for the students' comprehension of the geography lesson. This value is listed in the "TEST PERCENT" column of Table 5.0 and provides the means to evaluate the fourth null hypothesis, this being that a computerized geographic information system used as a tool in classroom instruction in geography at the grade seven level will not significantly improve the students' comprehension of a geography lesson. The Kruskal-Wallis test was used to evaluate if there was a significant difference between the various group combinations. In order to provide further detail it was also used on the mark spread between the pretest and the post-test. Although significant differences were noted between the control group and the other groups, the null hypothesis was accepted because the difference between Groups A and B was not significant at the 0.05 level. Again it was not surprising considering that both groups were given the same instructional material. A 0.1 or even greater level of significance would perhaps be a better measure in this situation. It would seem that a teaching procedure which has any chance of generating improved performance should be investigated further.

The fifth null hypothesis deals with lower-ability students. The various dot plots shown in the previous chapter seemed to indicate that the lower-ability students who received instruction through the computerized geographic information system performed better than their counterparts in Groups A and C. The Kruskal-Wallis statistical procedure was used to compare the lower-ability students of Groups A and B. The results indicated that there was a significant difference between the groups and, accordingly, the null hypothesis was rejected. This result is perhaps the most important finding of the entire research. The literature in computer-assisted instruction has not examined this phenomenon to any great extent. Edwards et. al. (1975), however, does refer to two studies which indicate that CAI techniques may be more effective for lower-ability students.

The growing problem of geographic illiteracy is a major concern in our society. In response to this, educators have begun to revamp teaching methods and curricula. The shortage of class time to teach geography is, however, a problem that will be difficult to solve. The motivation behind this research was to investigate a technique for teaching geography which would be more efficient and effective. The prime goal being that students would learn more in the same amount of class time. The results of the study were, as outlined, not conclusive. Although statistically significant differences were, in general, not identified between the GIS instructed group and the conventionally instructed group at the standard 0.05 level, the technique should not be disregarded. The geographic information system used as an instructional tool proved to be as effective as the conventional instruction, and in terms of the lower-ability students it was more effective. The expectations of the research in terms of performance with regard to the students' retention of geographic facts, the understanding of spatial concepts, and problem solving in geography did not materialize. As well, however, the anticipated drawbacks of the GIS instruction technique such as the problem with ratio scales mentioned earlier in this chapter did not occur. The small sample size and the nature of the experimental design can be cited as factors which did not permit this information to emerge. The use of statistical levels of significance relevant to pure science may be inappropriate in a study which deals with behavioural science. It would seem that the extraneous influences involved in human behaviour should justify a more liberal parameter. Such an adjustment in the level of significance would alter the results of this work substantially.

A result of the research not related to the initial goal was the discovery that the majority of students in the study groups did not understand the concept of scale when it was shown as a ratio. The literature reviewed in Chapter 2 suggests that students of this age group should be able to comprehend such a concept.

In general, the students reacted positively to the instruction via the geographic information system. The experiment leads to the conclusion that it is both possible and and desirable to use the computer and GIS software in the junior high school classroom.

Recommendations

The advent of the computer has generated enormous debate on how it should be used in an educational environment. As well, the development of geographic information system software has initiated a similar debate in the discipline of geography. As would be expected the use of a GIS in education is very experimental and very controversial, a fact that seems to occur when disciplines overlap with each other. As stated previously, this thesis was in no way a condemnation of educators in geography. The specialized knowledge of GIS that has emerged from geography has led to research in neighbouring fields of study, in this instance education is such a field. Educators, as yet, do not possess the specialized knowledge needed to undertake studies such as this.

The research outlined in this thesis is not intended to advocate the geographic information system as the total answer to improved geographic education. A GIS is merely a tool which may be used by the teacher to assist him or her in the achievement of set goals in geographic education. The development of GIS is still in a growing stage at the time of this study. Systems at present are not particularly user friendly nor do they provide all the capabilities that could be made available. However, their potential as an instructional tool is much greater than the single factor CAI programs which exist at present. Hopefully, this study will provide a starting point for others examining the use of the geographic information system as a teaching tool in elementary and junior high education.

The limited emphasis given to the use of computers in teaching geography is reflected by the Education Technology Program of the Manitoba Department of Education and Training. The 1989 Fall Professional Development Program consisted of forty seven separate workshops, none of which focused directly on geography. This is rather distressing in light of the previously cited literature outlining the growing level of illiteracy in geography. The use of computers in education appears to be taking place in subjects such as mathematics and science and, to a certain extent, languages.

The results of this study with regard to lower-ability students is extremely interesting and should be investigated further. Educators may wish to target such pupils and give emphasis to the use of the computer in their instruction. The allocation of computer resources in schools should be examined with respect to this information.

Richard Diem (1986) notes that the elementary school students in our society are extremely receptive to computer instruction and, in general, knowledgeable of microcomputer technology. However, educators as a whole have not developed the appropriate technological skills and, accordingly, the instructional power of the technology has not been achieved. Geography teachers must be made aware of the capabilities of the computerized geographic information system and as such systems become easier to operate encouraged to incorporate this tool into their teaching methods.

The present concern with the geographic ignorance of students, reported by the mass media and of immense interest to those within the discipline, offers an opportunity, according to Downs et al. (1988), to reform the teaching of geography at all grade levels. Related to this, McNally (1987) states that techniques need to be developed for teaching geography in a relevant and effective manner. Educators are certainly aware of the problem. The Manitoba Social Studies Assessment Program (Manitoba Education, 1984) emphasizes the development of inquiry and discovery skills, including map skills, in the new curriculum. The geographic information system provides one means to accomplish these goals. This study examined the use of GIS as a teaching tool in grade seven geography instruction. However, if the work of Thake (1976), concerning the building blocks of spatial concepts, is valid, the computer and GIS software possibly have a role to play in earlier grades as well.

With the proper instruction by the teacher a geographic information system can be a tremendous tool. Castner (1990) in his revolutionary book on geographical education states that the emphasis in teaching geography should shift to the ways in which geographic information and its relationships can be isolated and communicated graphically. Castner does not deal with geographic information systems in his book but it is obvious that a GIS is an ideal tool to accomplish such goals.

In conclusion, this research was not extensive enough to prove unequivocally that computerized geographic information systems can improve the quality of instruction in geography at the grade seven level. However, the results are sufficient enough to warrant further investigation. Hopefully, as professional educators become familiar with such systems, more sophisticated studies will be undertaken to ascertain the effectiveness of this technique.

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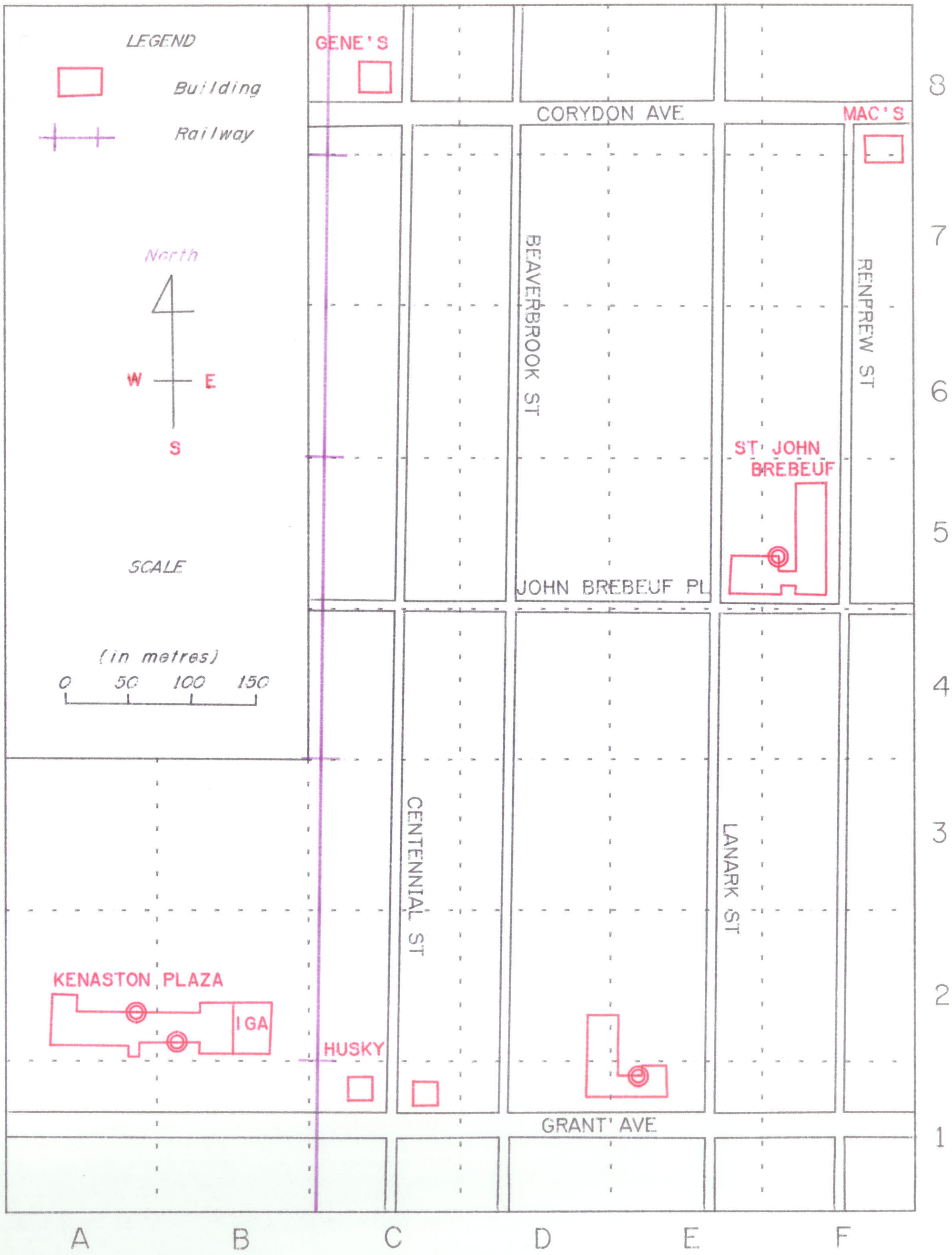
APPENDIX A

INSTRUCTIONAL MATERIALS

ST JOHN BREBEUF NEIGHBOURHOOD



INSRUCTIONAL MATERIAL

A REGIONAL GEOGRAPHY
OF
AUSTRALIA

Australia is the smallest, flattest, and apart from Antarctica, the driest of the continents. It is also the only continent which is occupied by a single nation, the Commonwealth of Australia, a federation of six states (Victoria, New South Wales, Queensland, South Australia, Western Australia and Tasmania) and two territories (Northern Territory and the Australian Capital Territory). Western Australia is the largest state and Tasmania is the smallest. Tasmania is also the only island state, being separated from the mainland by the Bass Strait. The Australian Capital Territory consists only of a small region surrounding the national capital city of Canberra (population 245,000).

The oldest and largest city in Australia is Sydney, with a population of 3.3 million. It is also the capital of New South Wales. Melbourne, Australia's second city, is the capital of the state of Victoria and has a population of 2.9 million.

The total population of the country is 16.2 million. This is a surprisingly low figure considering that Australia has a land area almost as large as the United States (the population of the United States is approximately 246 million). The majority of the population is concentrated in the major cities on the south and east coasts of the continent (Melbourne, Sydney, etc.). This trend results from a variety of factors, including history, climate, and the physical characteristics of the country.

The exact land area of Australia is 7,682,300 square kilometres. This makes it the sixth largest country in the world. It stretches between latitudes 10 degrees 41 minutes south and 43 degrees 39 minutes south, and longitudes 113 degrees 9 minutes east and 153 degrees 39 minutes east. This means that the distance from the Indian Ocean on Australia's west coast to the Pacific Ocean on its east coast is 4000 kilometres.

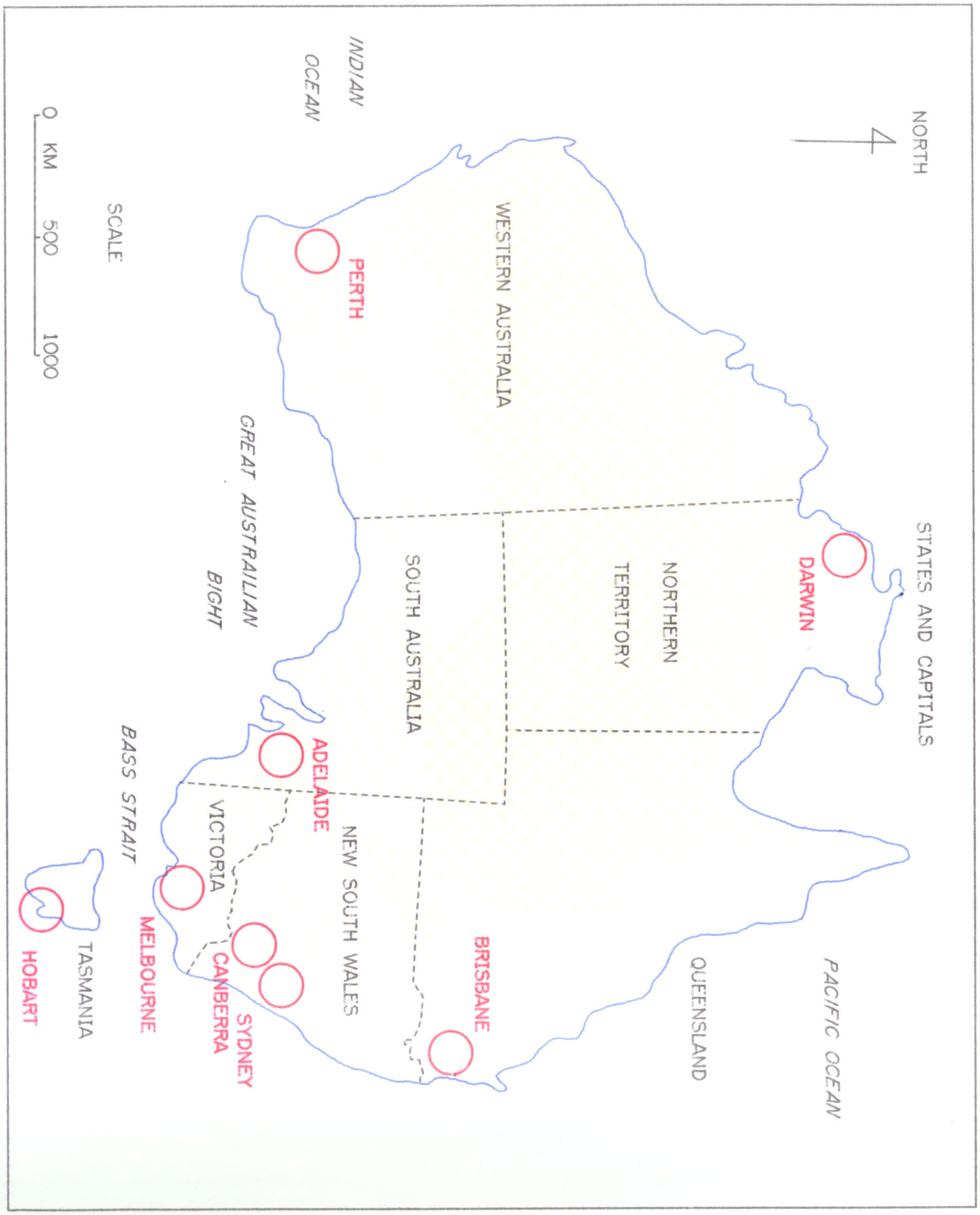
The major reference latitude running through Australia is the Tropic of Capricorn. The northern portion of the continent is located in the tropics.

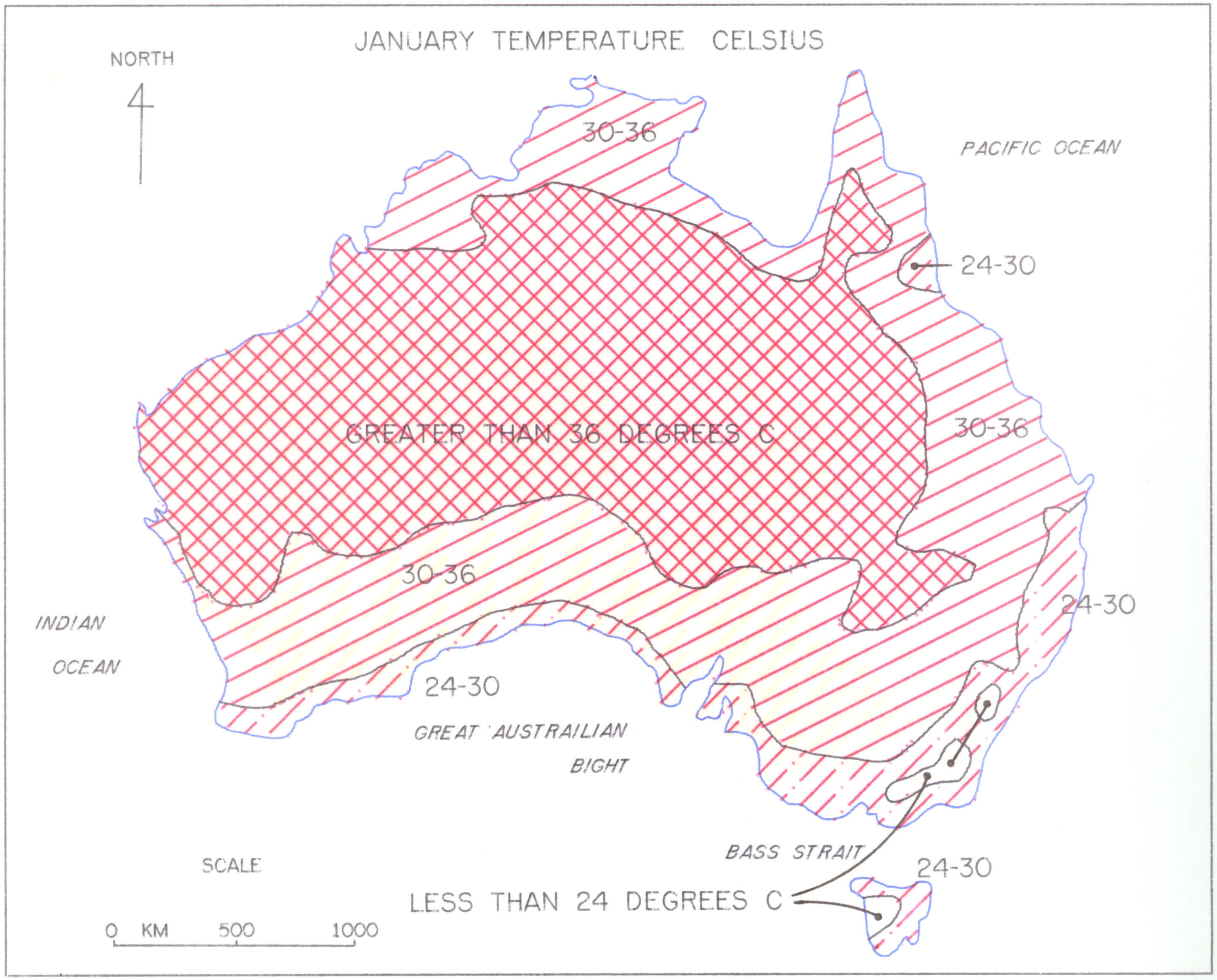
The most important elements in the topography of the continent are the huge central plateau and the Great Dividing Range. The Great Dividing Range is the highland area which parallels the east coast of the country. The highest point in the country is found here at Mount Kosciusko in the state of New South Wales. It reaches a height of 2,229 metres.

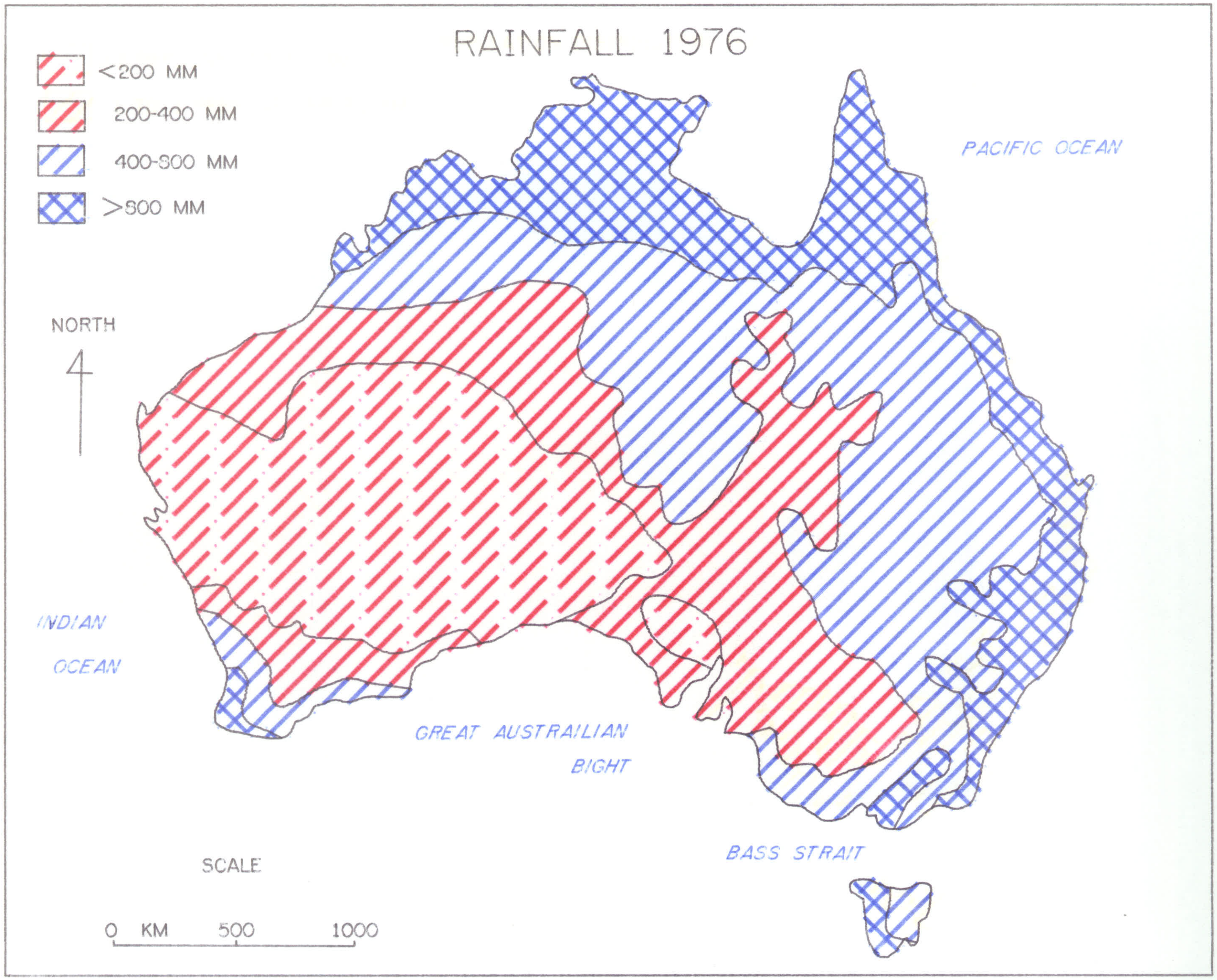
Australia consists of a vast arid and semi-arid interior, extensive open plains, and moister zones on the edges of the continent. The heart of Australia is dominated by the Great Sandy Desert and the Great Victoria Desert.

It is not surprising that a country as large as Australia has an extensive and diverse natural resource base. The rich mineral resources include iron ore, gold, copper, silver, lead, bauxite, uranium and some oil and natural gas. Australia is highly industrialized, and products range from aircraft, ships and automobiles to textiles, chemicals, electrical equipment and metal goods.

Agriculture is also important in the economy of Australia. Twenty five percent of the world's wool comes from Australia and the country is also a major producer of wheat and meat.


STATES AND CAPITALS
NORTH
INDIAN OCEAN
PACIFIC OCEAN
WESTERN AUSTRALIA
PERTH
NORTHERN TERRITORY
DARWIN
SOUTH AUSTRALIA
ADELAIDE
QUEENSLAND
BRISBANE
NEW SOUTH WALES
SYDNEY
CANBERRA
VICTORIA
MELBOURNE
TASMANIA
HOBART
GREAT AUSTRAILIAN BIGHT
BASS STRAIT
SCALE
0 KM 500 1000


JANUARY TEMPERATURE CELSIUS
NORTH
PACIFIC OCEAN
30-36
24-30
GREATER THAN 36 DEGREES C
30-36
30-36
24-30
INDIAN
OCEAN
24-30
GREAT AUSTRAILIAN
BIGHT
BASS STRAIT
24-30
LESS THAN 24 DEGREES C
SCALE
0 KM 500 1000


RAINFALL 1976
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NORTH
PACIFIC OCEAN
INDIAN OCEAN
GREAT AUSTRAILIAN BIGHT
BASS STRAIT
SCALE
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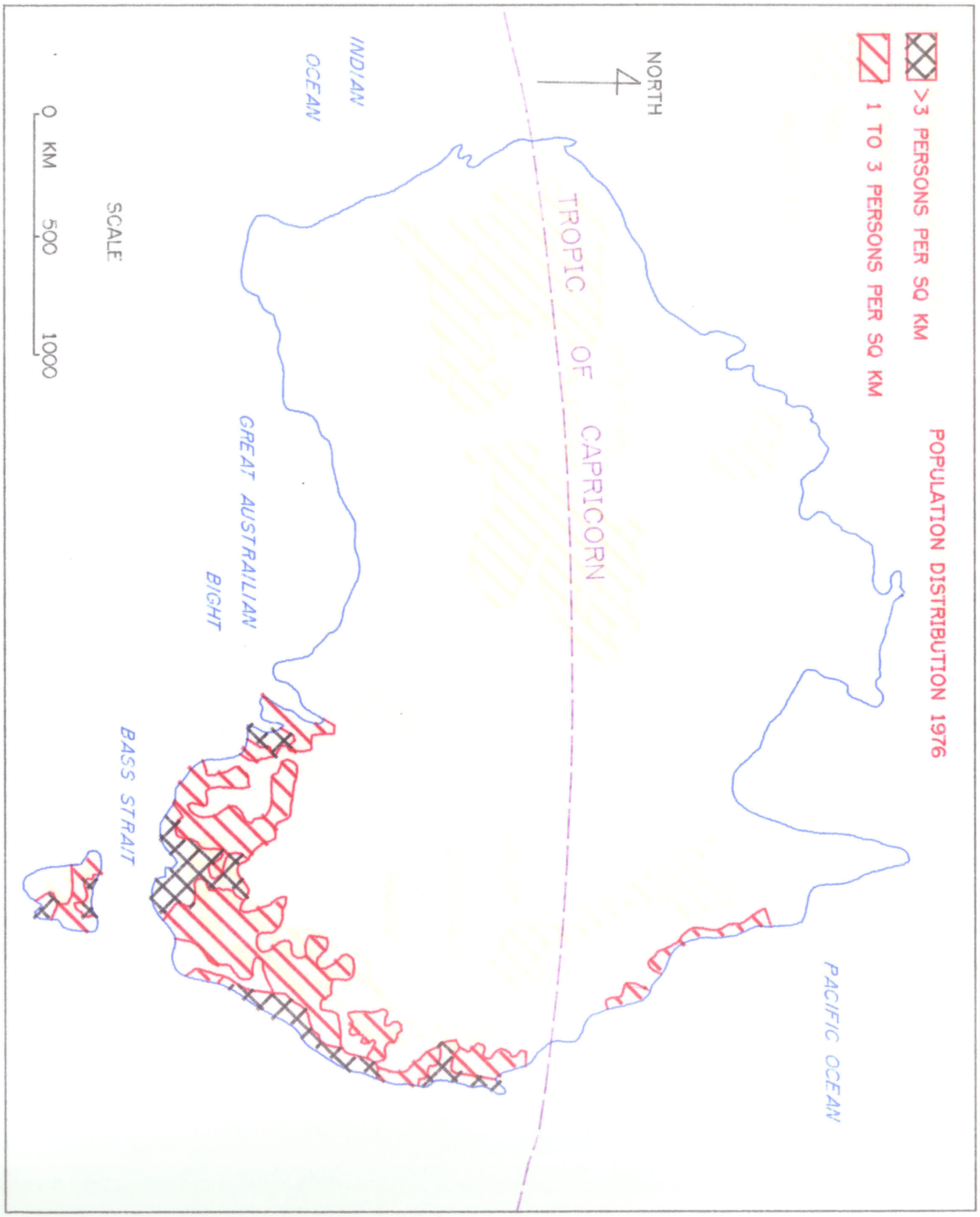
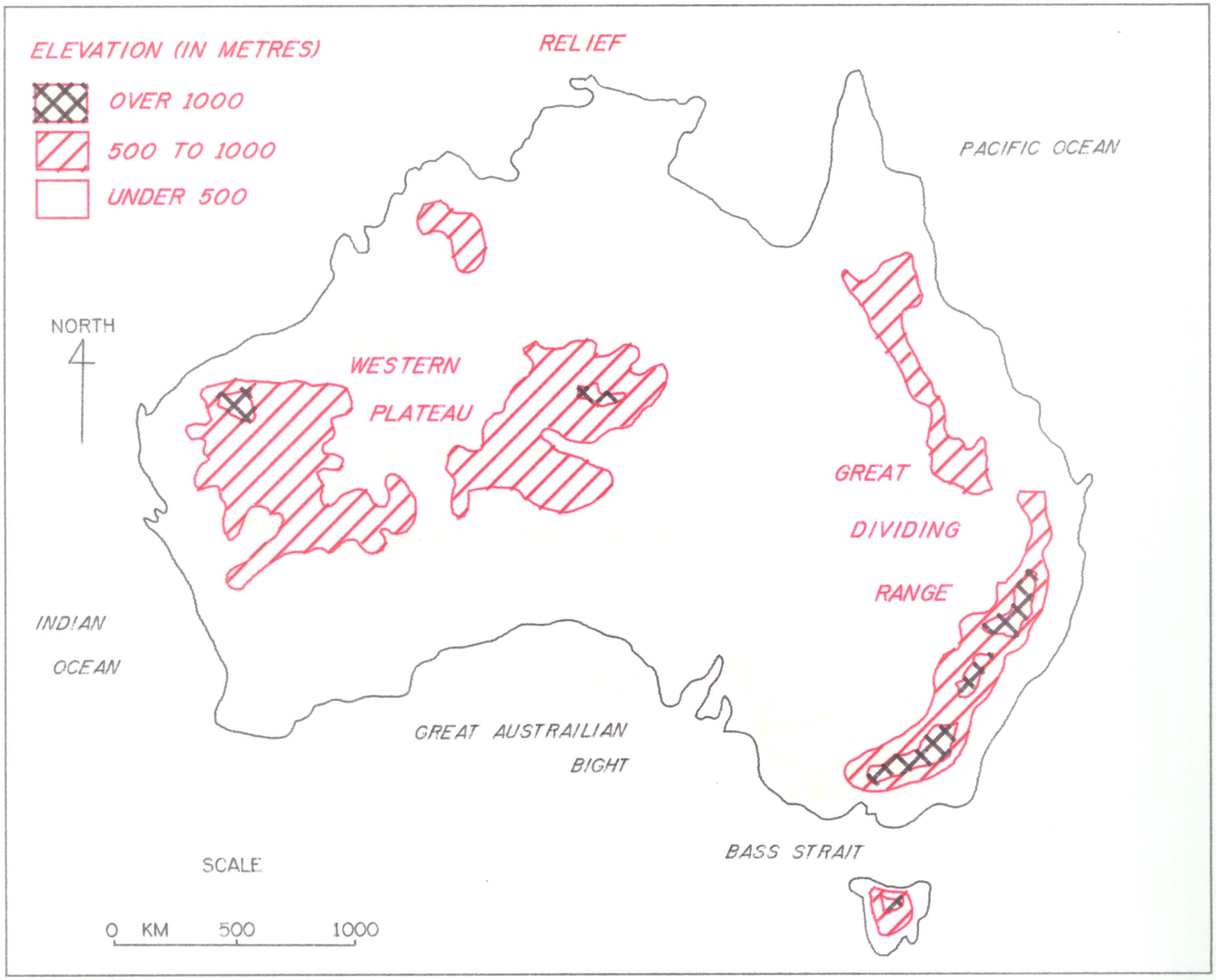
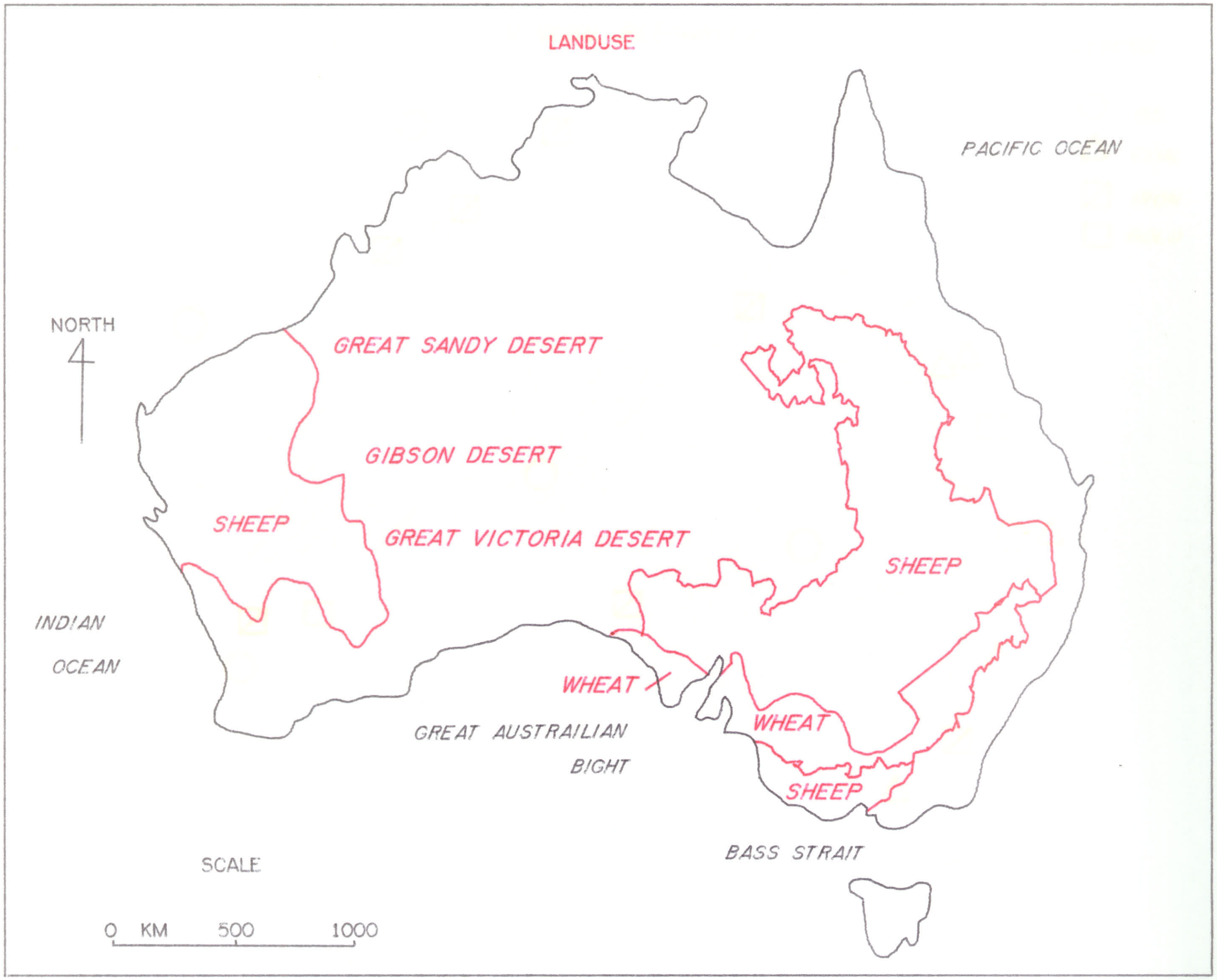
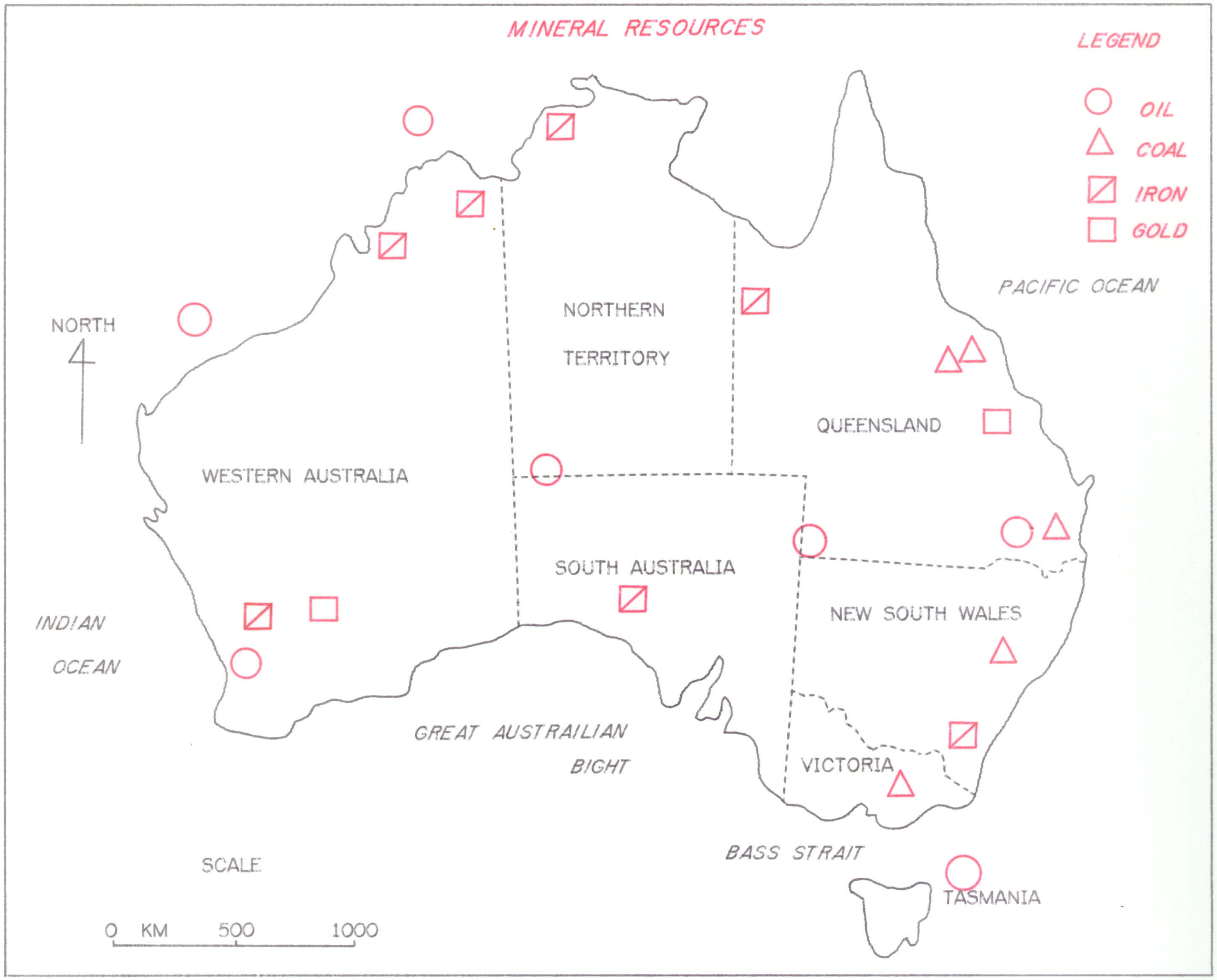

POPULATION DISTRIBUTION 1976


RELIEF
ELEVATION (IN METRES)
OVER 1000
500 TO 1000
UNDER 500
NORTH
WESTERN PLATEAU
GREAT DIVIDING RANGE
PACIFIC OCEAN
INDIAN OCEAN
GREAT AUSTRAILIAN BIGHT
BASS STRAIT
SCALE
0 KM 500 1000


LANDUSE
PACIFIC OCEAN
NORTH
GREAT SANDY DESERT
GIBSON DESERT
SHEEP
GREAT VICTORIA DESERT
SHEEP
INDIAN
OCEAN
WHEAT
WHEAT
GREAT AUSTRAILIAN
BIGHT
SHEEP
BASS STRAIT
SCALE
0 KM 500 1000


MINERAL RESOURCES
LEGEND
○ OIL
△ COAL
⧄ IRON
□ GOLD
PACIFIC OCEAN
NORTH
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
INDIAN OCEAN
GREAT AUSTRAILIAN BIGHT
VICTORIA
BASS STRAIT
TASMANIA
SCALE
0 KM 500 1000

APPENDIX B

POST-TEST INFORMATION

POST-TEST
PART A

Name: ____

Please answer the following questions.

1. All maps have some characteristics that are the same (for example, all maps should have a title). In the space provided below list some elements that are found in all well made maps.

____

____

____

2. What direction is Corydon Ave. from St. John Brebeuf School?

____

3. Circle the correct answers for the following sentences:

The countries closest to Australia are ____________________.
a) India b) Indonesia c) New Zealand d) China e) Japan

The largest state in Australia is _________________________.
a) Tasmania b) Queensland c) Victoria d) New South Wales e) Western Australia

The capital city of Australia is _________________________.
a) Sydney b) Canberra c) Adelaide d) Perth e) Darwin

The ocean off the west coast of Australia is the ______________.
a) Indian Ocean b) Pacific Ocean c) Arctic Ocean

The largest city in Australia is _________________________.
a) Darwin b) Perth c) Melbourne d) Sydney e) Canberra

The distance from the west coast to the east coast of Australia is ______________.

a) 2000 km b) 3000 km c) 4000 km d) 5000 km e) 6000 km

The gulf located at the southern coast of Australia is called ___________________.

a) Gulf of Carpentaria b) Great Australian Bight c) Bass Strait d) Timor Sea e) Cook Strait

A desert located in the centre of Australia is the ______________.

a) Sahara b) Great Victoria c) Gobi d) Kalahari e) Mojave

The highest elevation in Australia is located in the ____________.

a) MacDonnell Ranges b) Great Dividing Range c) Northern Territory d) Simpson Desert e) Western Plateau

The country of Australia is divided up into two territories and how many states? _______________

a) three b) four c) five d) six e) seven

4. Which of the following facts about Australia are correct. Please circle your answers.

Australia is __________________________

a) the driest continent (other than Antarctica).
b) the coldest continent.
c) the flattest continent.
d) the wettest continent.
e) the newest continent.
f) the most populated continent.
g) the smallest continent.
h) located in the Western Hemisphere.
i) located in the Eastern Hemisphere.
j) south of the Equator.

5. Please circle True or False for the following questions.

a) Australia has a small and limited natural resource base.
True or False

b)Australia has a vast arid interior, extensive open plain lands, and moister areas on the edge of the continent.
True or False

c) The Australian economy was built on sheep ranching.
True or False

d) The population of Australia is spread evenly throughout the country.
True or False

e) The production of wheat is important to the economy of Australia.
True or False

f) Victoria is the most populated state in Australia.
True or False

g) Coal is mined in the state of New South Wales.
True or False

h) Australia is the only country that occupies an entire continent.
True or False

i) The population of Australia is 16.2 million.
True or False

j) Tasmania is the smallest state in Australia.
True or False

POST-TEST
PART B

Name: ____

Please answer the following questions using the map provided.

1) Which direction is Corydon Ave. from Grant Ave? _________________

2) Which direction is Kenaston Plaza from St John Brebeuf School?

____

3) How far is it (in metres) from Grant Ave. to Corydon Ave?

____

4) Using a scale of 1:4000, what distance on the ground does one centimetre on the map represent? ___________________

5) What is the length of the railway track on the neighbourhood map? _______________

6) Using the letters and numbers (coordinate system) on the edge of the map, give the location of Gene's corner store. ____

7) What store is located at B2? ____

8) Use the data table at the end of these questions to decide which is the cheapest store to buy bread and milk. Write your answer below.

____

9) What is the coordinate location of the most expensive store? ____________________

10) Your teacher at St John Brebeuf School sends you to Gene's corner store to buy bread and milk. How far do you have to walk to get there and back? How much money do you need?

______________________________ ___________________________________

DATA TABLE
(PRICES IN DOLLARS)

STORE	MILK	BREAD
GENE'S	1.89	1.49
IGA	1.87	0.99
HUSKY	2.20	1.48
MAC'S	2.10	2.10

POST-TEST
PART C

Name: ____

1. Using the "States and Capitals" map provided answer the following questions.

a) What direction is Perth from Sydney? ____________________________

b) What direction is Darwin from Hobart? ___________________________

c) How many kilometres (approximately) is it from Perth to Sydney? ________

d) How many kilometres (approximately) is it from Hobart to Darwin? ______

e) What states share a border with New South Wales?

____

2. Using the various maps provided answer the following questions.

a) How many states does the Great Dividing Range run through? ___________

b) Which state has the highest elevations in Australia? ___________________

c) What is the smallest state in Australia? ______________________________

d) Which states have the hottest temperatures in January?

____

e) Compare the elevation map with the temperature map. Give reasons for the cooler temperatures in New South Wales and Victoria.

____

____

____

f) Which states have the lowest rainfall? ______________________________

g) Compare the population map with the rainfall and temperature maps. Explain how the climate has influenced where people live in Australia.

____

____

____

h) The landuse map shows the location of various deserts. Which state has the most desert?

____

i) Which state has the greatest area for growing wheat? ___________________

j) How much rain falls (approximately) in the wheat growing areas? __________

k) Does sheep production require abundant rainfall? ______________________

l) What are the most important agricultural states in Australia?

____

m) Which states have coal reserves (use the mineral resources map)?

____

n) What mineral resources are found close to Sydney?

____

o) Which state has the highest population?

____

APPENDIX C

PAMAP INFORMATION

PAMAP GIS operates on minicomputers, workstations and microcomputers. The hardware configuration of the micro-based system is decribed briefly. Please consult Appendix B of the PAMAP User's Guide for information on other hardware platforms.

Microcomputer

HARDWARE

- IBM AT or certified compatible
- 640 Kb RAM, with 1Mb extended memory
- Minimum 40 Mb hard drive
- 1.2 Mb floppy disk drive
- Math co-processor
- 2 RS232 serial ports
- 1 parallel port (printer)
- IBM Enhanced colour monitor (or equivalent)
- EGA graphics board (640x350 with 16 colours)
- Digitizing tablet and cursor (eg. Summasketch)

SOFTWARE

- MS-DOS 3.30, located in the MSDOS directory
- DBase III+, located in the DBASE directory
- Executable programs, in the PAMAP GISPROG directory
- Data and configuration files, in the PAMAP gISDATA directory

PAMAP GIS SUBSYSTEMS

Core Modules

MAPPER - data input, modification, and display, database interaction

UTILITIES - map creation, modification, database interaction, map-merging, rubber sheeting and edge-tying

PLOTTING - plotting utilities

Analysis

ANALYZER - distance and area calculations, thematic data manipulations, overlaying, corridor analysis and proximity studies

PLANNER - area statistics and planning reports

Digital Elevation Models

TOPOGRAPHER - 3D data input, digital elevation model creation, slope and aspect generation, perspective views and interviewability

Image Data

INTERPRETER - image data interface

Format Conversions

Translators: Intergraph - IGDS, Intergraph - SIF, ARC/INFO - DLG, Autocad - DXF

Displayer

Colour raster plot utility

ANNOUNCEMENT

PAMAP AWARDED GIS CONTRACT BY THE FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

February, 1990

Rome, Italy

PAMAP Graphics Ltd. of Victoria, British Columbia, has been awarded a contract by the Food and Agriculture Organization (FAO) of the United Nations to supply the PAMAP Geographic Information System to its headquarters in Rome.

The PAMAP GIS will be used by FAO officers to perform various land-use planning studies and projects. Effective integration of spatial data from various sources is particularly important to FAO's land-use planning operations. FAO needed a GIS software which could work on a wide range of platforms in order to expand its GIS operations to remote project sites using Personal Computers operating under DOS, and to apply GIS on centralized Mini-Computers.

For more information on PAMAP's Geographic Information Systems, please contact:

Bill S. Denney, Sales Manager
PAMAP Graphics Ltd.
301 - 3440 Douglas Street
Victoria, BC, Canada, V8Z 3L5

Phone (604 381-3838
FAX (604) 389-1134
Telex 049-7232