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The impact of teaching cartographic lexicon and of geographic experience on map use

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THE IMPACT OF TEACHING CARTOGRAPHIC LEXICON AND OF GEOGRAPHIC EXPERIENCE ON MAP USE

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ABSTRACT

Although maps are often thought to be easily understood, for many people they are not. Research into how best to make the map more useful to the user has taken different forms including applied psychology. While some researchers focus on the map maker, others are concentrating on the map user.

In this study, attention is focused on the map user. Specifically, the study tries to look at how "years of geographic instruction" and teaching of "geographic lexicons" can enhance the performance of map use activities. Since maps are more associated with geographers, it is believed that they are in a position to use them better. Frequent association with maps offers them the opportunity to be more familiar with map language (syntax and lexicon). The way map use skills might be taught is explored with reference to learning English as a Second Language.

The thesis includes an experiment using as participants second year honours geography students and honours psychology students. The test consisted of five questions reflecting the three levels of map use tasks proposed by Olson (1979). The two groups (psychology and geography) were split into control and intervention groups. The intervention group received instruction on cartographic lexicon items using techniques of Teaching English as a Second Language.

In the lower level tasks, neither teaching nor geographical experience affected performance, however this may have been due largely to ceiling effects in the performance of all groups. In higher level, more complex map reading tasks, both geographical experience and teaching showed a statistically significant difference in performance. The concept of teaching Cartography as a Second Language, then, appears operationally valid.

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CHAPTER 1

THE PROPOSED STUDY

Introduction

The concept of cartography as a science of communication has been with academic cartographers for about three decades. Board (1981, p 44) claims that "one of the first to explore the idea of cartography as a science of communication was Arthur H. Robinson in his second edition of Elements of Cartography published in 1960". The communications model implies not only a reader, but a receiver, who desires the information thus transmitted (Guelke, 1977). Yet these early theoretical models, drawing on the analogy of electronic communication models, paid little attention to the human receiver- in the case of cartography, the map user. Solutions to user needs can be found when we incorporate into our research map users themselves.

A few early researchers, for example Dornbach (1967, p 3), argued for the need to treat the map and the user: "as integral parts of an information system". Dornbach argued that we should consider not only the source of information (the map) but also how map users decode information from the map. The strategies they utilize and how these are acquired should be examined. If these are identified, then there is the possibility of raising the "level of graphicacy", and of information transmission, through formal instruction.

Balchin and Coleman (1966) and Boardman (1983) are of the view that graphicacy should be given the same pedagogical status as the more traditional written, verbal and numeric forms of communication. These researchers claim that acquisition of map skills, an aspect of visual literacy, should be seen as an integral part of school curricula. Unfortunately they did not describe how these skills might be taught.

Statement of the problem

There is increase in graphic communication in the 20th century (Anderson, 1987 p. 1). Currently, the development of video and computer cartography and the new computer-based Geographic Information Systems are making it possible for even more information to be communicated graphically. At the same time it is being recognized that map users are having problems with maps. On May 5th 1989, the Secretary of State Kenneth Baker pointed out the extent of the problem in the United States when he outlined the terms of reference of National Curriculum Geography Working Group (Boardman, 1989). He stated that everyone needs to be trained to read and interpret maps. This has not been achieved. The problem is attributed most often to limited exposure to maps and poor tuition by educators. As Boardman (1989, p 321) pointed out, "whatever recommendations may be made for attainment targets and programmes of study in geography, they are expected to include those aspects of graphicacy relating to the study and use of maps".

The question then is, are there any possibilities for increasing the efficiency of map users? If so, does general instruction in geography improve map use? If not, are there ways by which we can improve map use? Perhaps, we will have to give further consideration to the proposition made earlier by Balchin and Coleman (1966) that graphic literacy should be taught.

In accepting this proposition, we might turn to the proposal advanced by Head (1984) that maps may be considered part of the language system. According to Head there are basic underlying structures to our cartographic communication which are utilized by experienced map readers. If taught formally these structures should lead to improvement in map use. These structures include lexemes and syntax. The way words are combined in language to form phrases or sentences is referred to as the syntax (Elgood, 1986). That is, "syntax denotes certain grammatical rules which govern the positioning of words and the function that they will perform in a given context" (Wolf 1981, p 2321). "Lexicons when applied to natural language involve the vocabulary of a language of an individual speaker, of a subject, or of an occupational or other group" (Wolf 1981, p 1301).

A pilot study by Head and Elgood (1988), while limited in its number of subjects, suggested that even brief instruction sessions in such structures can have significant positive impact in map user skills. The study by Head and Elgood focused on the syntax aspects of the language and did not consider lexemes. Their subjects were grade ten students age about 15 years from Eastern Ontario.

If the teaching of cartographic language skills such as syntax can indeed improve aspects of map use, then we need to ask ourselves perhaps, the following questions:

1. To what extent does general geographical experience improve map language use?

2. Specifically, are university-level geography students better map users than those in other disciplines like psychology?

3. Can instruction in basic map language lexemes make better map users?

4. If so, which group, geographers or psychologists, will show the greater improvement with instruction?

5. Is the method of instructing English as a second language useful in "teaching cartography"?

Objectives of the study

The objectives of the study are basically to provide answers to the questions posed above. These include:

1. To examine the extent to which general geographic instruction relates to map use ability;

2. To further explore the paradigm of map language, specifically assessing the effects of the techniques of teaching English as a Second Language on cartographic test performance.

Hypotheses

The following hypotheses are formulated to guide the study.

1. General geographic education will have positive impact on map use performance.

2. Instruction in map lexemes (vocabulary) will improve map use performance.

3. This improvement will be greater with psychology students

than with geography students.

The first hypothesis is tested in order to find out if the basic instruction geography students received in map reading improved map use performance. Most people have associated maps with geographers and they believe that being a student of geography should make one a good map user. Sauer (1956) and Hartshorne (1939), both prominent geographers, have this to say;

> "Show me a geographer who does not need them [maps] constantly and want them about him, and I shall have my doubts as to whether he has made the right choice in life .... The map speaks across the barriers of language; it is sometimes claimed as the language of geography" (Sauer 1956, p 289).
>
> "So important, indeed, is the use of maps in geographical work, that .... it seems fair to suggest to the geographer a ready thumb to test the geographical quality of any study he is making: if his problem cannot be studied fundamentally by maps- usually by comparison of several maps- then it is questionable whether or not it is within the field of geography" (Hartshorne 1939, p 249).

Such statements suggest that geographers are better map users because:

1. They have more contact with maps and this provides them with greater opportunity and need to practice map use. Consequently, we would expect their experience to have a positive effect on their ability to extract information from the map (Olson, 1975).

2. Frequent interaction with maps enables them to be more familiar with certain surface level features of the map language. That is, they know more about the scale, orientation, reference systems, projections, legend and conventional signs (morphemes)

associated with maps.

3. Studying geography itself provides them with the lexemes of map language. Lexicons as defined by Wolf (1981, p 1301) involve "the vocabulary of a language of an individual speaker, of a subject, or of an occupational or other group". It is simply the morphemes and morpheme complexes of a language. In cartography the lexemes are composed of combinations of the various basic map symbols, the complexes representing geographic features like "ox-bow lake", "meanders", "elbow of capture" and "areas liable to flood".

The second hypothesis relates to the extent to which psychology students as examples of "the general public" who may have little geographical background are potential map users. It is expected that instruction in geography provides students with the lexicon of map use. Psychology students, it is assumed, have little or no instruction in geography and therefore may lack the lexicons of maps. It is therefore expected that instruction in the lexicon during the experiment would improve their level of performance.

<u>Rationale/Justification</u>

Even though reasons have been suggested for why geographers are better map users, there is still controversy as to whether years of professional geographic experience affects map use ability. On the one hand are those who disagree with the fact that geographic knowledge or related knowledge in maps aids performance in map use. Blaut and Stea (1974) suggested that even young children are natural map makers and can understand maps before they enter into the school system. This conclusion was based on a study conducted with 80 three, four and five year old children who were tested individually at a day care. The children worked with "a 3 feet by 2 feet piece of white paper, laid on the floor, and a multi-colored set of small toys including 20 wooden houses, a larger wooden building, a wooden church with steeple, 20 metal automobiles, and four thin paste board strips, painted to look like streets" (Blaut and Stea, 1974).

Data was collected using vertical three second time lapse photography, tape recording and notes. The test began with undirected toy-play. At this stage, children were asked to play freely with the toys. Play was freely terminated by each child. A jury consisting of three geographers and three psychologists reviewed the photographic record to determine whether the toy pattern represented a realistic landscape. "The examiners judged visually whether the child had connected up the street-segments into a complex alignment including two or more street-corners or, alternatively, at least one street-corner with an acute angle of intersection" (Blaut and Stea 1974, p 6).

The second part of the experiment requested that children should pretend they were located in their homes. They were then asked to drive along a chosen route. "A child was considered to have passed this test if an appropriate road pattern had been created, and if the child correctly drove from one house to the other without leaving the road" (Blaut and Stea 1974, p 6).

The third test was "a verbal exercise designed to elicit oral responses to words and phrases which would reveal whether the child had been thinking about the environment" (p 6). The examiner looked at the child's production and asked about what was located in a particular portion of the map by pointing specifically to a toy. The child was considered to have passed if the response showed that the child "clearly had a landscape in mind" (p 7).

Results indicated that similar scores were obtained by all age groups for the first two tests but not for the third test (Table 1.1). Blaut and Stea concluded that "children in the population studied are able to represent a cognitive map in the form of a physical map at the age of three" (p 7). The ability has already reached some sort of plateau by this age, and remains at this level (or perhaps improves slightly) through the ages of four and five (Blaut and Stea, 1974).

Table 1.1: Children Mapping: Values for each test are Percentages of Subjects who passed the test (after Blaut and Stea, 1971).

Age	No. of Subjects	Test 1	Test 2	Test 3
3:0 to 3:11	22	7.8	59.1	13.6
4:0 to 4:11	29	9.3	58.6	48.3
5:0 to 5:11	29	11.4	65.5	55.2
All ages	80	9.7	61.2	41.3

Source: Blaut and Stea, 1974.

Blaut and Stea further noted that, while the result was not in itself surprising, "the discrepancy between scores on verbal and non-verbal measures was methodologically significant" (p 8). They thus cautioned about using highly language-dependent procedures in such studies. "Such procedures do not fully reveal the extent of a young child's abilities and they may lead to confuse vocabulary growth with cognitive development" (Blaut and Stea 1974, p 6).

Supporting this view, Muehrcke (1973, p 324) maintained that "there is little theoretical basis for using years of geographic experience as an index of pattern recognition" and level of training in map use. Most geographic training programmes, he suggests, fail to teach the actual task of map use. This statement is true because most educators today fail to teach lexemes and syntax of geographic items which are vital if people are to understand the processes of map use (Boardman, 1989). What these researchers suggest is that there is no relationship between geographic instruction and ability to use maps (Dent, 1965; Olson, 1968).

Muehrcke (1973) was one of those who investigated the effects of "experience" on map use. Three groups of subjects were used for his experiment. These included "50 new Army recruits from Ft. Ord, California who were selected to represent subjects having minimum exposure to graphics and no formal map training. A group of 70 University of Washington undergraduate students were selected to represent subjects having considerable exposure to graphics but not formal map training. A group of 40 graduate students in the Department of Geography at the University of

Washington was selected to represent subjects having considerable exposure to graphics and formal map training" (Muehrcke 1973, p 192). There was no justification provided as to the assumed differences between the groups. The paper did not indicate for example, whether the undergraduate students were in geography or not.

The stimulus was a series of maps "created by extracting eleven 10 x 10 matrices from each of the five lowest-order trend surfaces (linear, quadratic, cubic, quartic and quintic). Each set of test maps consisted of a single independent variable exhibiting cross-correlations with ten dependent variables ranging from 0% to 90%, in increments of 10% as measured by the coefficient of determination" (p 192). Subjects were asked to study the base (referent) map and then to visually rank the other 10 maps in terms of their degree of likeness or association with the referent display.

Muehrcke (1973, p 323) found that both graduate and undergraduate university students performed visual map comparison tasks with "significantly fewer errors than Army map readers." But on the otherhand, he could not establish significant relationship between "years of geographic experience and map reading performance" (probably based upon the difference between the undergraduates and the geography students p 323).

There are those, however, who think that experience of some kind helps in map use, although perhaps not necessarily "geographic" experience. Cole (1981, p 56) maintains that it is generally assumed that if individuals are unaware of how to consult a map, they will merely conduct "incidental viewing". They will therefore notice only "general forms and the most prominent features" on the map (Cole 1981, p 56). This statement suggests that efficient map users need to have basic knowledge in map use, or perhaps should be familiar with what is being presented on the map.

Castner (1979, p 151) for example suggested that, for any two map readers, solving the same problem within the same time limit, the more experienced map reader will probably excel. Castner sees such experience as the "acquired skills and past intellectual activities, which are collectively manifested in differential abilities in such things as the performance of individual map reading skills, generating meaningful structures and sets from the geographic elements in maps, and dealing with information stress or information overload" (p 151).

Castner (1979) stated that research in cartography has shown that such experience might explain superior performance of some subjects on tests which examine the speed and accuracy of map information processing and extraction, such as magnitude estimations, locating and verifying, "all of which involve cognitive processing of specific elements within the map image" (p 145).

According to Castner, experienced subjects perform better because their frequent association with maps enables them to acquire the ability to encode larger subsets of related information under some common identifying label. He noted for example that, in vision, certain field organizations and some associated notions of functional relationships can be reinforced through repeated exposure or practice so that conceptual relations are noted among items and conceptually related items are increasingly likely to be clustered together in recall. This concept seems similar to the "chunking" of morphemes into syntagmes and simpler syntagmes into complex syntagmes in language.

Studies by Thorndyke and Stasz (1980) and Head and Elgood (1988) also seem to support this view. Thorndyke and Stasz (1980) showed that training can enhance map use activities. In their first experiment, they investigated the procedures that subjects used to acquire knowledge from maps.

Their first experiment included eight subjects, three "experienced" and five "novice" map users. The "experienced" subjects included "a retired Army officer who had field experience in map use and had taught map reading to recruits, a retired Air Force pilot with extensive military experience with maps, and a scientist who regularly used graphics display systems for geographic data bases" (Thorndyke and Stasz 1980, p 140). These individuals frequently used maps in their jobs. The "novices" were five undergraduate students who participated to satisfy a course requirement.

Subjects were asked to provide verbal protocols while performing tasks related to map learning. Results indicated that the more successful subjects were not necessarily "experienced" map users. However those who performed the task successfully invoked four categories of processes during learning. Thorndyke and Stasz called these processes "attention", "encoding", "evaluation" and "control". The less successful learners adopted "verbal", "schema", and "association" procedures. Thorndyke and Stasz provided the following definitions to the terms.

"Attention" is the act of directing one's thought to something. That is you do not let your thoughts wander about when engaged in a task. Good learners focused their thoughts to task relevant cues. The attention procedure involves "partitioning" and "memory-directed sampling".

"Partitioning" is a technique for restricting attention to a subset of the map information. "Since map information contained more information than subjects could learn on a single trial, they frequently decided on an early learning trial to attend selectively to well-defined portions of the map" (Thorndyke and Stasz 1980, p 147).

"Memory-directed sampling" occurs when "a subject decided to study particular elements that had not yet been learned" (p 147).

"Encoding" involves the "ability to recognize the pattern and relationships between map elements" (p 147).

"Evaluation" involves the ability to monitor the "learning process by considering what had already been learned and what they still needed to know" (p 147).

"Control" implies the ability of subjects to utilize mechanisms for the selection from a set of available processes those to be activated and when to terminate a particular process and switch to a new one.

"Verbal" learning procedures "operate primarily on semantic and linguistic information, such as the names of buildings or roads" (p 149).

"Schema" learning applies to the procedures where subjects "encoded information by associating it with preexisting information" (151). An example is when one "learns the spatial configuration of streets on a map by initially supposing a prototypical rectilinear grid and then learning particular deviations from that grid" 'p 151).

"Association" procedure involves relating map attributes to some prior knowledge. Thorndyke and Stasz (1980), for example, found that many of the subjects were able to identify the similarity between Market Street of both Town Map and San Francisco map. Both streets had oblique angles and were intersected by streets (Thorndyke and Stasz, 1980).

In their second experiment, Thorndyke and Stasz divided their subjects into three groups. Subjects for this second experiment were thirteen Santa Monica Community College students and thirteen students from UCLA. One group was instructed in six of the effective learning procedures defined in experiment 1, a second group (neutral) was instructed in six procedures unrelated to learning success, "mnemonies", "spatial labeling", "rehearsal", and three "association" procedures; subjects in a third group (no procedures) were asked to use their own techniques.

For the effective and neutral procedures groups, the experimenter described each of the respective procedures for that group in detail. Instructions about the usefulness of evaluation were emphasized to the effective procedures group. The training session lasted between twenty and thirty minutes.

Subjects were then given copies of a "County Map" and were instructed to practice the techniques that they had been taught. After that, they were presented with a "Countries Map" and instructed to use the techniques they had been taught whenever possible. Subjects were then asked to study and reproduce the map on five study-recall trials. At the end of their last trial, subjects were asked to complete two questionnaires by rating from "0" (did not use procedure) to "6" (procedure used during all trails) indicating how frequently they used the procedures (Thorndyke and Stasz, 1980).

The results indicated that those who were instructed in the "effective" procedures performed better than the other groups. The two basic conclusions from Thorndyke and Stasz's (1980) work are:

1) mere experience in map use does not necessarily improve performance. Users they had rated as "experienced" did not necessarily perform better, and some "novices" performed equally well.

2) 'good' map users employ particular strategies which aid

in performance.

The present study attempts to follow up on these two basic conclusions. Essentially, the study seeks to find out if mere experience in geographic knowledge enhances map use performance. That is, are geographers better able to use maps than people in other disciplines? We will not be able to determine the real reasons why geographers perform better than psychologists, if indeed they do, but we suspect that it might be related to their greater knowledge of the geographic lexicons. The second part of the experiment will focus on these lexicons within the context of cartography as a natural language.

Dacey (1970) pointed out that the languages of maps are fruitful areas for future work. According to Dacey (1970, p 71), "although there is an extensive literature on the design, construction and interpretation of maps, the cartographic literature has failed to develop concepts relevant to the design and operation of an information system capable of compilation, storage, selection, and retrieval of locative and other geographic data". He concluded that there are special languages for manipulation and communication of geographic information and we may apply the concepts, tools and methods developed by linguists to cartographic communication.

Subsequent researchers have made statements which related maps to language. Shimron (1975, p 1), for example, believes that "a map can be construed to be like a language, with both a surface structure and a deep level meaning". Head (1984) supported this in his work on maps as a natural language. In this study he related the process of reading printed text and the structures employed in the process to cartography but did not provide experimental evidence. Head indicated that, like reading printed text, an experienced map reader is likely to begin by processing portions of the map so that he can locate himself relative to his particular task. What Head means is that map reading like reading a printed text involves a systematic process.

Others like Robinson and Petchenik (1976) had earlier objected to relating maps to language. They claim that maps are "presentational" communications which are more like photographs and drawings. According to them, map marks are unique. In language a sound such as "chair" means the same thing in any discourse. In cartography a black dot might mean a city, height or have any one of a variety meanings attached to it. What they mean is that universal meaning is not often attached to map symbols. Head (1984) objected to this and stated that even in natural language the alphabet (symbol) 'a' has different meaning in English and French.

In this study, further consideration is given to the extent to which maps can be considered a natural language. In addition it goes beyond that to establish a relationship between learning the vocabulary of map language and learning English as a Second Language. Learning English as a Second Language (LESL) methods are applied to teaching lexemes to two groups- one geography students, and the other psychology students. If the results of the experiment show that performance of both geography and psychology students is significantly enhanced, then perhaps these methods should be seriously considered for teaching map use.

It is hoped that the study will serve as the basis for future researchers in the field of map use. This study could also help to improve the nature of our investigations into user requirements since this study examines teaching of geographic lexicon items. Perhaps most importantly, this study will help us to re-appraise the education and training of the entire population on map use.

Methodology

Sample

Data for the experiment were obtained from an experiment conducted on second year students of Wilfrid Laurier University. One group included honours geography students and the other honours psychology students.

This sample is basically purposive. A purposive sample is one in which personal judgement is used to decide which individuals of a population are to be included in this sample (Sheskin, 1985; Barber, 1988). This is because some experiments require that participants have some background knowledge in what is being examined. In this study, the background knowledge is lexemes of geographic items. It is assumed in this study that geography students have been exposed to the lexicon of geographic items and psychology students have not.

Materials

Boardman (1989, p 323) noted that "experienced map readers are able to build up images of the landscape which they retain whilst reading and interpreting other features shown on a topographic map and less experienced map readers, however, may not be familiar with the method of depicting relief and its limitations, and accordingly may perceive the relief on the map in a way which is quite different from that shown by the contours."

Topographic maps therefore appear to be suitable for this study. This is because topographic maps provide enough information to test subjects' abilities to use maps in the comprehension of geographic features like ox-bow lake, hill, steep slopes and valleys. Three topographic maps were used in the experiment. Two maps were used in teaching an "intervention" group and the other was used to test subjects in the main experiment.

Questions were asked relating to the map use tasks proposed by Head (1984), which are navigation and visualization. These tasks can help examine subjects' knowledge of map lexemes. The two tasks differ essentially in terms of content (Head, 1984). As Head pointed out, visualization as related to natural language is the process of creating a mental image and subsequent production of chunks. These are normally stored in the long term memory of experienced map users in the form of lexicons which allow them to identify such features as roads, settlements, rills, streams, rivers and lakes rather than having each time to build each of these complex images from low-level map marks (Head, 1984). According to Head (1984, p 13), map reading for navigation incorporates Landscape Visualization processes but goes beyond them to require constant comparison of map-derived landscape visualization with similarly-simplified visualizations derived from the environment through which the navigator is passing. The questions, even though related to navigation and visualization, reflect the three levels of map use tasks proposed by Olson (1979) and later expanded by Board (1984).

Subjects

Sixty-four students participated in the experiment. Forty-three students were geography students and twenty-one psychology students (Table 1.2). Twenty-seven geography and fourteen psychology students received instruction, while sixteen geography and seven psychology students were not instructed. Assigning psychology students into control or intervention groups depended on which students were in class at the time of the experiment. Those students who came to class at 10.30 a.m. were assigned to the control group and those who came to class at 11.30 a.m. were assigned to the intervention group. Attendance was poor because the students were informed about the experiment taking place that day. Moreover, the experiment was conducted near the end of term, when students have lots of other things to do.

Geography students were also tested in a classroom setting. They were divided into two groups through their seating arrangement in class that day. The control group was asked to move to a separate classroom where they were tested with the help of assistants. The intervention group remained in the original classroom.

In order to ensure that students in each group (control and intervention) have equal spatial abilities, a spatial ability test was conducted. The most suitable for this study was visualization problem solving which serves to test the ability to sense and maintain geometric forms (Pellegrino, 1985). The types of problems posed in such tests include the construction of geometric figures, surface development and figure identification. The first two tests (construction of geometric figures and surface development) were used in this experiment.

Table 1.2: Distribution of participants into groups.

	Instruction (Intervention group)	No instruction (Control group)	Total
Geography	27	16	43
Psychology	14	7	21
Total	41	23	64

The first test involves presentation of geometric figures which are divided into different parts and five answer frames containing an assembled form. The task of the examinee is to select the one answer frame showing how the disassembled figure would look if the parts were fitted together (Anastasi, 1982).

Surface development tasks require the examinee to determine which of the completed three-dimensional patterns is consistent with the unfolded pattern (Pellegrino, 1985).

Procedure

Two separate experimental sessions were conducted. One session involved geography students and the other psychology students. The experimental work required three components: a pre-test of spatial abilities of all subjects to ensure comparability; an intervention of teaching cartography as a second language; and a post-test of each group to determine map use abilities. The intervention group was taken through fifteen minutes of instruction and five minutes of questions and answers. A limited set of lexemes of map language and their use in a map reading context were instructed.

Subjects were provided with sample maps, and a model was used as a teaching aid. This is related to the situational method of teaching ESL in which the underlying procedure is that everything should be taught in a situation or context that links the words with the things being taught (Hill, 1974).

Summary

This study is an attempt to explore the possibility of integrating the field of linguistics into cartography. Most previous studies in the field of cartography have depended more on applied psychology (Shimron, 1975; Thorndyke and Stasz, 1980), but have not aimed at improving map use performance. Much research has aimed at teaching English as a Second Language and about increasing levels of performance in other natural languages. By applying such techniques to cartography, perhaps we can make real progress in improving map use performance.

CHAPTER TWO

COMMUNICATION RESEARCH IN CARTOGRAPHY: A REVIEW

Introduction

In his book The Look of Maps, first published in 1952, Arthur H. Robinson proposed the modern theory of map as functional graphic displays. Their function, he held, is to communicate geographical information. From this position, rapidly accepted as the dominant one within academic cartography, developed the field of study of cartographic communication, the study of the process of map reading and attempts to improve it. A wide variety of approaches to this study has been implemented, beginning with psychophysical experimentation with individual map symbols, through research in eye movement studies to the most recent concerns with the analogy of cartography as a natural language. Examples of these types of studies are given below.

The first generation: Psychophysics

"Psychophysics concerns the manner in which living organisms respond to the energetic configurations of the environment" (Gilmartin 1981, p 10). In cartography, researchers have used the techniques of psychophysics to determine map users' perceptions of cartographic symbols (for example; Mackay, 1954; Flannery, 1956; Clarke, 1959; Crawford, 1973). Those who have adopted this approach believe that the problem of map users in understanding maps lies with the type of symbols employed in the construction of maps. To assess this, these researchers have employed both quantitative and qualitative thematic symbols to investigate the psychophysical functions associated with the perception of certain map symbols by users. The utility of this approach has been strongly expressed by Cuff (1974) who stated that:

> "The ideal guidance for cartographers should come from the reactions of readers .... because only this evidence is truly relevant to the design of maps" (p 55).

Mackay (1954) was one of the first to publish results of experiments with dots, circles, spheres, cubes and isolines in which students were asked questions pertaining to numbers, size and personal preference. His study was designed to investigate individual reactions on tests which were given to three hundred college students. Each test was given to two groups of students, one with and the other without laboratory instruction in basic cartographic symbols like dots, circles, spheres, cubes and isolines. A detailed description of the laboratory instruction was not provided. Several tests were conducted on equivalent projections by asking students to estimate areas of Australia and Greenland as they appeared on six different map projections. He found that map reading ability was greatly improved by laboratory practice in estimating and comparing numbers, areas, volumes and shapes.

This study was followed by Flannery's (1956) Ph.D. research at Wisconsin conducted under Robinson. He singled out circles and studied their efficacy as cartographic performance. He was concerned with how the size of circles affected perception. A sample of 1040 students from five colleges and universities was used in the test. "Subjects were asked to make 46 individual judgments of the size differences of black circles on a white background in both a map and non-map context with areal size differences ranging from 2 to 1 to 32 to 1, and diameter sizes ranging from 3 to 24 millimeters" (Flannery 1971, p 97-98). Comparisons were made with both larger and smaller circles serving as the standard stimulus and estimates recorded as size differences.

Flannery (1956) found that when circles of graduated sizes were used as cartographic symbols, map readers consistently tended to underestimate their quantities. This was illustrated by results of his research which indicated that 70.5% underestimated the sizes, correct estimates were 16% and overestimates 13.5%. Within a non-map context, Flannery found that the subjects underestimated the sizes of the circles.

The second group of tests were primarily in a map context. A sample of 200 college students each made a total of 44 different comparisons. "Circle size differences ranged areally from 2 to 1 to 44 to 1 and diameter sizes ranging from 3 to 24 millimeters and subjects were requested to compare how much more crop was grown in one country than in another by estimating the size difference of the circles" (Flannery 1971, p 100). Results showed that 73.5% were underestimates, 19.5% overestimates and 7.0% were correct estimates.

Despite these shortcomings, Flannery (1956) thought that circles are good cartographic symbols when compared to other quantitative symbols. He based his conclusion on the advantages of graduated symbols over other symbols. He claimed that:

1. "It is relatively easy to convert basic quantitative data to circular form;
2. Aesthetically, users prefer circles (62%) over bars (38%) and 60% ranked circles first over triangles, squares or rectangles;
3. Circles can be placed on maps more rapidly than other types of symbols;
4. Circles use space efficiently at least when compared to bars;
5. Circles represent patterns of distribution reasonably well;
6. When used as pie charts, circles more effectively communicate parts of the whole than do segmented bars" (p 97).

From Flannery's work has come one of the most fundamental guidelines in the design of proportional circle maps; the circle radii are scaled as data raised to the power of 0.57, the emperically derived value that corrects for the general underestimation his work has confirmed.

Clarke's (1959) study was more related to Mackay's. He expanded the concept of examining the effectiveness of circles as cartographic symbols into other forms of point symbols. Other cartographic symbols considered were bars, squares, spheres and cubes. To test the accuracy, error and variability in estimating the size of these symbols, nine separate cards each containing three symbols were shown individually and at random to 33 second-year geography undergraduates. Each student was asked to compare the sizes of the smallest and largest symbols with that of the standard symbol. The results of the study showed that the more dimensions and the greater the difference between the symbol and the comparison, the greater was the error and the less accurate the visual evaluation.

Graduated squares were given considerable attention in a study published by Crawford (1973). His research was designed to find out how map readers distinguished the relative size of graduated squares and readers' abilities to make accurate estimates of the relative magnitude of squares. The range of square sizes used on the test approximated those commonly used on small scale thematic maps.

"The test consisted of three parts, each having a numbered standard square and five lettered squares of variable sizes for comparison" (Crawford 1973, p 85). In parts 1 and 2 of the experiment, the standard squares were smaller than the comparison squares, and in part 3, the standard square was larger than the comparison square. The squares ranged in size from a minimum of 42.25 mm.sq. to a maximum of 529 mm.sq. A total of 196 undergraduate students without prior cartographic training participated in the study.

Results of his study showed that subjects correctly estimated the relative area of graduated squares within the range of sizes used in the experiment. This finding is not consistent with the finding of Flannery (1956). While Flannery (1956) concluded that readers underestimated sizes of circles, Crawford (1973) found that map readers correctly estimated sizes of graduated squares. Crawford argued that, participants may have correctly estimated the squares because of the limited size of the test squares. He noted that, had larger squares been included in the study, the results would have showed significant underestimation of the relative size (Crawford, 1973).

More complex studies of psychophysics during this era were represented in studies by Head (1972) and DeLucia (1972). These studies were a shift away from earlier research.

Head (1972) was more concerned with the suitability of symbols to represent qualitative rather than quantitative map content. Twelve sample maps representing different ways of differentiating land from water were chosen. The symbols represented a mixture of conventional and those designed on various graphic perception principles relating to figure-ground discriminations and visual depth perception.

"Twelve sample representations were printed on 3" by 3" cards and were randomized both in order and in orientation within test packets" (Head 1972, p 30). The test was conducted on 34 students enrolled in an Introductory Landform Geography course at the University of Wisconsin, Madison. A second test was conducted on 124 students enrolled in a second year cartography course at McMaster University. The task demanded that subjects simply mark on the card the letter "L" for land on the area they thought was land, and "S" on the area they thought was sea.

Results indicated that the symbolisms produced different interpretations- from misinterpretation to complete ambiguity to correct and unambiguous interpretation. Head concluded that the most effective way to distinguish land from water on a map is to keep all the labelling of land locations on the land and to use a "subtle" areal symbolization to reinforce the land or water identification established by lettering.

DeLucia (1972) examined the effects of shaded relief compared with contour lines on the accessibility of other map information. This information included the number of specific symbols in a designated map area, locating various geographic items on the map and reporting their area(s) of occurrence, making a visual comparison of some type of symbol from one map area to another, and verifying visually a statement regarding some particular type of symbol in a specific area of the map. He made it clear that he was not concerned with map users' abilities to read the relief symbols. Two sets of maps were produced, one set utilizing contour lines to illustrate relief and the other set utilizing shaded relief.

For each condition, a total of 64 individual test trials were administered. Analysis of the accuracy and reaction time data revealed few statistically significant differences between the two groups (that is, he did find differences) on either measure.

Underlying this experimental work was the basic communication model which saw the map as a medium for communication. The conclusion from this model is that if we know how the average reader reacts to an individual map symbol or symbol component (size, shape, colour, etc.), we can better design the map to communicate specific data. And if we can discover more formulae for so doing, we can build an efficient map, reducing redundancies thus increasing the amount of data correctly communicated.

By the late 1970's and early 1980's, there were criticisms of this mechanistic approach (Petchenik, 1979; Shortridge and Welch, 1980; Gilmartin, 1981). Petchenik (1979) noted that many experiments had concentrated on testing only a single symbol in isolation and that this ignored the map contexts in which these symbols may be used. In most cases, the same symbol may mean different things on different backgrounds and in different contexts. Results from one experiment may not be used to generalize to others. Moreover, if research is directed to the suitability of specific map symbols then we may not be in the position to test map use abilities of subjects. Higher level map users are often interested in the pattern and distribution of geographic items. Testing the suitability of map symbols will tend to ignore this important aspect of map use.

Shortridge and Welch (1980) demonstrated how the experimental instructions and the subject's expectations can influence the results of psychophysical tests and suggested that this may limit the conclusions which can be drawn from such studies. In their study, subjects were asked to discriminate between dots associated with place names. "Stimulus dots were 2.8 in. apart, with intervening lettering. Size of dots ranged from .0248 to .0758 in. in diameter, with the standard at .0505 in. In contrast to the two stimulus dots which changed for each trial, all other information on the map remained constant throughout the series of maps" (Shortridge and Welch 1980, p 20).

Under condition 1, subjects were induced to believe that one or the other of the dots was larger. The task specifically demanded that subjects choose the larger of the two dots associated with two settlements "Pancras" and "Runcorn". Specifically, the question read, "You will be asked in all cases to determine which of the two dot symbols associated with 'Pancras' and 'Runcorn' is the larger symbol of the two. Clearly circle that dot which you think is larger" (Shortridge and Welch 1980, p 21). Under condition two, they were made to believe that some symbols were of the same size. Specifically, the question read "Circle both dots if they appear to be the same size" (p 21). Finally, under condition 3 the emphasis was more on the "sameness" of the two symbols. In this condition, the statement "On some maps dots are the same size" was added to the general procedural instructions (p 21).

Subjects were shown a series of 78 black-and-white maps which were collected together into booklets. Each size comparison occurred six times, randomly distributed throughout the booklet. The subject's task was to report the perceived difference between two dots associated with two designated place names on the map.

Subjects in condition 1 who were asked to indicate which symbols appeared to be larger were able to discriminate dot size differences. About 88 percent of all responses in this condition were answered correctly. Even extremely small differences were discriminated. The smallest absolute difference was .0022 inches diameter. This was the smallest dot difference that was discriminated.

"Under condition 2, in which subjects were asked to indicate the dot they thought to be larger but also to circle both dots if they appeared to be the same size, the suggestion of a correct "same" response altered the results" (Shortridge and Welch 1980, p 21). That is, not only was accuracy less than 75 percent, but also one particular comparison was judged correctly on only 39 percent of the trials.

Subjects in condition three were asked to show which symbols were of the same size. This affected responses of subjects. Four dot comparisons were not perceived easily. That is, subjects found it difficult to compare four dot sizes. The smallest difference was reported correctly on only 15 percent of the trials as compared to 45 percent in the second trial and 90 percent in the first trial. "These results correspond more closely to what one might expect in everyday map reading when choosing between dot sizes, since one usually expects to encounter a number of equal-sized symbols" (Shortridge and Welch 1980, p 21).

Gilmartin (1981) also pointed out that even if we knew answers to every psychological question and could theoretically design the "ultimate" map from a psychophysical view point, we still would know little about how people read maps in the sense of learning, remembering and making use of them. This is true because map use tasks involve not merely psychophysical processes, but also cognitive processes.

The second generation: the process of map reading

Most cartographers twenty years ago had come from the engineering sciences or from geography, neither being fields that prepared them for in-depth studies in the area of human information processing. A few, however, have attempted to cross their research with experimental psychology in order to better understand the human mental processes.

Eye movement studies

On the surface, at least, eye movement studies appear to be a concrete way of tracing the spatial shifts of attention within the visual field of a map user, and thus provide a window on the processes or strategies he or she may be employing to access map data. The early eye movement research occurred outside of cartography and for the most part was not concerned with the reading of maps specifically. Of interest to cartographers are those studies that deal with the larger movements of the eyes (saccades) that occur as a person shifts his gaze from one area of the graphic display to another. These studies try to describe which areas of the stimulus are attended, and what proportion of time is spent in examining the various parts of a map. "The graphic stimuli that have been studied and are most relevant to cartography include paintings, newspaper advertising and photographs" (Steinke 1987, p 42).

Making a case for eye movement studies, DeLucia (1976) stated that eye movement studies are extremely relevant to analyzing the visual performance of the map reader. DeLucia

(1976, p 137) pointed out that "when a researcher is interested in the problem of how complex visual information displays such as maps are perceived, records of eye movements (consisting of fixation and duration at a point) provide the best way for investigation".

Dobson (1977) also realized the utility of eye movement studies in noting that eye movement recording and analysis provided a more comprehensive understanding of map reading and information communication than traditional cartographic research techniques. He claimed that eye movement recording will prove to be a useful tool in unravelling the problems related to map use and should be further explored.

The views of DeLucia (1976) and Dobson (1977) were supported by Castner and Eastman (1985). According to them, "eye movements are an outward manifestation of visual/cognitive processing and by examining 'how' the eye moves, we can gain important information about the workings of this crucial process by which the reader confronts and understands the map" (Castner and Eastman 1985, p 29).

The first to apply the study of eye movements to cartographic research was Jenks (1973). He investigated how his graduate class regionalized patterns of dots on a map showing the distribution of hogs. "Jenks asked his students to show regional boundaries around clusters of dots of low, medium and high density on a dot map showing the distribution of hogs in North Carolina in 1967" (Steinke 1987, p 51). He found that the distribution was recognized differently by the subjects and reasons for this were considered. Among them was the eye movements of the students.

Jenks then decided to explore this further by photographing the eye movements of the same students in his graduate class as they looked at the hog map. He analyzed the results by connecting succeeding fixations with a line, to produce a scan path for each subject. "The results indicated that the sequence in which the map was read was erratic, unorganized, redundant and highly individualistic and all of his attempts to categorize them ended in a failure" (Steinke 1987, p 51).

DeLucia (1976) examined the eye movements of his subjects through free-scan or non-directed search. A total of nine men participated in the experiment. The first part of the experiment was the free scan method. This is a non-directed search. The purpose of this was to provide information as to what people might look at on a map when they are basically casual viewers. The second condition was task oriented (directed search). This condition was included to provide information as to how map readers would go about retrieving information to answer specific questions. The first part of the task required that subjects locate items on the map and then report their areas of occurrence. Secondly, they were asked to "compare visually a specified type of symbol from one part of the map with a similar symbol in another part of the map and make a ranking-type decision between the two" (DeLucia 1976, p 139). Test materials were a 1:250,000 topographic sheet of Soda Spring, Idaho.

Results of the experiment showed that some areas of the map attracted subjects' attention more than others. The two fundamental factors which determined the eye movement response pattern to the map were:

a. the graphic character of the image itself,

b. the nature of the map reading task to be performed.

He concluded that "in the absence of a specified task to control or channel the subject's search (free scan), the graphic characteristics (the set of built-in visual priorities) of the map symbols used exercised the greatest influence on the eye movement patterns" (p 140). In a task situation however, the nature of the map reading task to be performed (the specific problem or question facing the user at the moment) determined the structure of the attention pattern exhibited.

Steinke (1979) also reported an investigation of eye movements. His study was designed:

> 1. "to find out more about the reading activity as it might be revealed by eye movement recordings,
> 2. to determine if the presence or absence of certain map elements affects the way the map is read,
> 3. to find out if the presence or absence of individual map elements, other than the entire map body, affects readers' understanding of the primary thematic message provided in the map body" (p 56).

He constructed three types of graduated circles of South Carolina showing cash crops receipts. One version contained only the map body. The second had the same map plus a title, legend and source statement, that is those map elements that were judged to be essential. The third version had the same map body, title, legend and source statement as the second plus a north arrow, scale, author and neatline, that is elements that are commonly included on thematic maps.

The eye movements of three groups of twenty subjects each were recorded as each group looked at one of the three versions of the map. Subjects were told to look at their map. "They were given no particular task to perform and were told that they could look at the map for as long as they wanted" (Steinke 1987, p 56). When eye movement recording was completed the subjects were asked to complete a quastionnaire. Part of this questionnaire was a reconstruction of the pattern of circles making up the body of the map as a measure of how well the subjects had understood the map's message.

Results of the test showed that map activity was complex and very individualistic. When the map reading activities of the three groups of subjects were compared, a number of differences were found. "As the number of map elements increased, the amount of time needed to visually process the map increased, but less absolute time was devoted to the map body and other informative elements of the map" (Steinke 1987, p 56).

Despite great variation from subject to subject in many of the tasks there were some aspects of the activity that were typical for many subjects (Steinke, 1979). Attention was focussed upon "basic information" (p 56). Map elements that provided this included the legend, title and map body. Scanning most often began in the "upper or central part of the display field" (p 56).

Cognition

Petchenik (1977), Olson (1979) and Gilmartin (1981) argued that the psychophysical approach with its emphasis on the immediate perception of the map has ignored the higher mental processes which are required to understand a map. Accordingly, they encouraged a more cognitive approach to research in cartography. To them, map interpretation is a cognitive task. Such a task has been defined by Carrol (1983) as one:

> "that requires persons to act upon instructions [verbal or otherwise] given by an experimenter or tester or that they themselves adopt, at least implicitly, when confronted with a challenge to achieve a certain outcome .... [The task] critically required the processing of information-information from the outside world that can be perceived by the individual and placed in some kind of memory, compared with other information retrieved from memory, transformed or manipulated by complex procedures or algorithms. There are many possible types of cognitive tasks, varying in the type of information processing involved, the types of content operated on, and the types of response expected" (p 3).

"Cognition itself has been defined as the processes by which a living creature obtains knowledge of some object or becomes aware of its environment. Cognitive processes are: perception, discovery, recognition, imagining, judging, memorizing, learning and often speech" (Eysenck and Arnold 1972, p 177).

This is not different from the definition provided by Corsini (1984). He maintained that "cognition comprises all mental activity or states involved in knowing and the mind's functioning and includes perception, attention, memory, imagery, language functions, developmental processes, problem solving and that of intelligence" (p 228).

These definitions suggest that cognition involves more than mere perception. Cognition is concerned with higher mental processes which people use to acquire, store and use information. In order to understand map users better, we need to go beyond psychophysical experimentation in cartography and explore the cognitive processes that are involved in reading maps (Petchenik, 1977). It should be noted however that psychophysical research does not ignore these other cognitive activities. All of them are still there and active. The only thing is that they are just not experimentally manipulated. As Gilmartin (1981, p 10) noted, "the methodology used in cognitive research depends upon laboratory experiments and modelling and simulation techniques".

One of the few cognitive studies related to map use is that of Marino (1979). The study was conducted to examine the issue of the selection of characteristic points along a line by two groups of individuals: (1) trained and/or experienced map-makers; and (2) cartographically naive individuals. The underlying assumptions were (1) "that certain points (characteristic points) on a line must be maintained in order to communicate the character of the line, and (2) that lines symbolizing certain geographical features can and do have a different character from one another" (Marino 1979, p 71).

She hypothesized that skilled map makers (cartographers and geographers) would select the same set of points along any given line, and that this set would be similar to that selected by a group of cartographically naive individuals. Lines representing geomorphological features of three types of rivers and three types of coastlines were used in this study. Respondents were instructed to mark those points on the lines which should be retained at three successively increasing levels or degrees of generalization.

Subjects were instructed to stick a set of straight dressmaker pins directly into those points on the line they considered to be essential in preserving the character of the line for an implied degree of generalization. "The degree of generalization was implicitly communicated by geometrically decreasing the number of pins given to the respondents" (Marino 1979, p 71).

They were given a copy of one of the sample lines mounted on a piece of fiber board and a box containing a specific number of pins. "After a respondent marked points on the line, he or she was given a second copy of the same sample line and a box containing half the number of pins given in the first stage of the experiment" (p 71). The third trial contained one-fourth the number of pins given in the initial stage of the experiment.

Results showed that there was no difference between the responses of cartographers and non-cartographers. Both cartographers and non-cartographers were in close agreement as to which points along a line must be retained in order to preserve the character of these lines as generalization occurred.

Thorndyke and Stasz (1980) tried to identify learning strategies good map users employ. This was done through an experiment conducted on what they considered to be "experienced" and "non-experienced" map readers by exposing them to a previously unfamiliar map. "Experienced" map users were defined as those who frequently used maps in their jobs and "novice" map users were considered as those who have had little knowledge about maps. Each group studied the map for two minutes, then the map was removed and the subjects attempted to draw it from memory. Each subject received six study and test trials on the same map. On the basis of the recall data, subjects were divided into good and poor learners.

Thorndyke and Stasz used protocol analysis in their experiment. This is a method of obtaining information from subjects by asking them to verbalize their thoughts as they proceed through the task. They found that majority of good map learners frequently used partitioning procedure, encoding and evaluation. Poor learners frequently reported that they could think of no procedure for learning the spatial information, and, in general, their repertoire of spatial learning techniques was different from that of good learners. They concluded that successful map learning depended on the strategies which the subjects used, rather than their past experience with maps. The best subject scored 100% and the worse subject scored 19%. Yet both had been considered as experienced map users.

In a second experiment, Thorndyke and Stasz directly compared the effectiveness of various learning procedures. Subjects were divided into three groups.

1. The effective procedures group were instructed in six procedures which were related to successful learning in experiment 1, that is "partitioning", "imagery", "pattern encoding" and "evaluation".

2. The neutral procedures group received instruction on six procedures that were not related to performance, "mnemonics", "spatial labeling", "rehearsal", and three "association" procedures.

3. The third group received no training.

The definitions provided by Thorndyke and Stasz for these terms are:

"Partitioning" involves trying to define a subset of the map information. "A subject adopting this strategy would define a subset of the map information and focus on elements in that subset until all the elements in the set had been considered" (Thorndyke and Stasz 1980, p 13).

"Imagery" refers to a situation where the subject tries to memorize the visual image of the map during learning.

"Pattern" encoding is the situation whereby subjects attempted to identify the shape of the map elements. Some subjects noticed for example that a particular street curved to the east.

"Evaluation" is the ability to find out what information is yet to be learnt from the map. Good learners primarily evaluated unlearned elements.

"Mnemonics" involves the use of cues for the identification of map features. For example, 'F' can be used as a mnemonic for retrieval of Farm and Fishing.

In "spatial labeling", subjects use verbal cues to recall complex spatial information.

"Rehearsal" procedure is adopted when subjects actively engage in recalling the names of map elements through memory.

The "association" procedure involves relating map elements to some prior knowledge. The ability of a subject to recognize that the shape of a street on one map resembles that on another map, implies that the subject has employed this procedure.

Subjects were first taken through a pre-test which was basically three study-recall trials which was similar to experiment 1. After that they were taken through a training session which lasted between 20 and 30 minutes. This training exposed subjects to the procedures mentioned above. They were then asked to use the procedures they had learned in recalling a map. This was done for five trials with the same map. After the last trial, subjects were asked to report how often they used some of those procedures. The results showed that the more frequently subjects used the effective procedures, the greater their improvement in performance. The effective procedures group performed better than the neutral procedures group who also performed better than the no procedures group.

It can be deduced from the literature examined so far that cartographic research was following the general history of research in experimental psychology. As Castellan and Restle

(1979) pointed out:

> "It seems fitting that the history of experimental psychology begins with Fechner's study of psychophysics, because measurement of subjective values is deemed prerequisite to a quantitative science of psychology ... Theories of psychophysics expanded to become theories of cognition and judgement. Thus experiments on problems in stimulus comparison and combination, for example, had implications not only for sensory psychologists who hoped to discover properties of neural transducers but also for a larger audience of experimental psychologists concerned with the understanding of information processing and judgement" (p 1).

The Third Generation: The carto-linguistics paradigm

Ackerman's (1957) conceptualization of maps was an early attempt to identify them as a form of language. According to him:

> "There are four basic ways in which men communicate with one another.... Music is one, words another, numbers still another and finally what we might call portrayal. Thus there is a language of words; there is a language of numbers or mathematics; and in a sense there is a language of graphic portrayal which includes sketching, photography, the architectural or engineering plan and maps.... The map is the most important instrument of graphic portrayal" (p 8).

Shimron (1977) also realized the relationship between a map and language. He vividly echoed that a map can be taken to be like a language because it has both a surface and a deep level meaning.

Beyond simple assertion, the linguistics paradigm remained little developed. Indeed, two of the major players in cartographic thought declared that the linguistic concept was not directly applicable to cartography (Robinson and Petchenik, 1976). These researchers rejected the language analogy on two grounds.

The first criticism of Robinson and Petchenik (1976) is based on the fact that we do not attach definite meaning to map units. For example a map symbol like a circle can represent 10,000 tonnes of coffee or 20,000 tonnes of the same product on two different maps. They also maintained that maps belong more to a class of symbolism called presentational- a class that includes photographs and drawings. Viewing of such symbols they say is continuous and it is difficult to isolate the smallest independent symbol. Robinson and Petchenik stressed that one of the fundamental characteristics of maps that makes them 'unique' is that one views them 'all at once'.

Head (1984, p 7) rejected this argument noting the fact "that a black dot has different meanings from map to map does not invalidate the whole concept of maps as natural language, particularly when meaning is given in the map title or legend" because there are similar instances in natural language, for example the "symbol 'a' means different things in English and French". He also argued that there is enough evidence that foveal vision allows us to 'see' but a small part of a visual display at any one time, and that the eye constructs another every 250 milliseconds. "From this perspective, then, we do read a map in units (whatever they may be) and piece them together sequentially, as is done with verbal and written languages" (Head 1984, p 7).

The second argument put forward by Robinson and Petchenik

(1976) is that there is no syntax that is binding one map symbol to the other on a map. This may be true because a look at the map surface shows that there is nothing specifically connecting the various symbols. But as Head (1984) noted this problem exists even with natural languages such as English, and the concept of the example they gave of 'car hits man' can be restated in another arrangement such as 'man is hit by car' (p 10). "At the surface level, the arrangement of the sentence is different, but at a deeper level- a concept level, or meaning level- the three basic elements of vehicle, impact and person are the same" (p 10).

Despite these arguments, a number of researchers more recently (Guelke, 1979; Head, 1984; Eastman, 1985; Head and Elgood, 1988) have argued that the language analogy can provide a very useful means for investigating the graphic medium. Guelke (1979), for example, stated that map symbols are the equivalent of words in a sentence. He also suggested that further arrangement of these symbols may be likened to the composition of a paragraph.

This parallels Head's (1984) suggestion that the process of map reading, like the process of reading texts, requires the existence of structures (syntax and lexicon) in the reader's mind that are at least equally as important as the marks on the paper. The way in which words are combined in language to form phrases, clauses, or sentences, is referred to as syntax. "Syntax denotes grammatical rules which govern the positioning of words, and the function that they will perform in a given context" (Guelke 1979, p 62).

Similarly syntax in cartographic language involves the combination of the symbols on the map. And following a semiotic approach, Schlichtmann (1985) argued that whereever signs combine to form signs of a higher order, the "combinatorics" are of the nature of a syntax. Elgood (1986) stated that cartographic syntax is the structuring and ordering of the symbols which constitute the map's message.

"A lexicon of a natural language is the vocabulary of a language of an individual speaker, or subject, or occupational or other group" (Wolf 1981, p 1301). The lexicon is simply the morphemes and morpheme complexes of a language. In cartographic language, lexicons are made up of the various map symbols and the symbol complexes representing simple geographic features like spot height and complex geographic features like "highlands", "lowlands", "marshy areas", "steep slopes" and "gentle slopes".

Eastman (1987), complementing the ideas proposed by Head (1984) and Schlichtmann (1985), provided an analogy between graphic language and natural language (Table 2.1). According to Eastman (1987, p 20), graphic variables can be considered "the most primitive elements of map symbolism." They parallel the phonemes or graphemes in natural language. These graphic variables he claimed are the material from which graphic signs are created. Head (1984) felt that the phoneme equivalent is missing from the cartographic language, that there is no equivalent to phonemes or graphemes (letters of the alphabet) that are building blocks for morphemes (Head, 1984).

Eastman (1987, p 90) explains further that "by linking a content to a graphic variable either by convention, or by means of legend, a graphic sign can be created." A cross graphic for example can be used to represent a church. He sees what he calls graphic signs as the "minimal units" of form that still carry meaning and "therefore correspond most closely to morphemes in natural language" (p 90). When graphic signs are created, the

Table 2.1: The strata of graphic language and their natural language equivalents (after Eastman, 1987)

Graphic Language	Natural language
Graphic structure	Text
Graphic syntax	Sentence syntax
Graphic symbols	Words
Graphic signs	Morphemes
Graphic variables	Phonemes

Source: Eastman, J. R. (1987)

form may be assigned to content on either arbitrarily, image-related or concept-related grounds (Modley, 1966).

These "graphic signs" are further built into graphic symbols which Eastman considers to be parallel to the words of natural language. The graphic symbols have the characteristic of location. He claims that these symbols represent distinct geographic phenomena-features which are localized in space, and which possess certain attributes. "Graphic symbols are thus localized, compound signs, ... 'words' on a graphic page" (Eastman 1987, p 91).

He further noted that these words in isolation do not communicate anything meaningful. What needs be done is to bring them together to provide higher order understanding. This means that we need to construct sentences as in natural language. In such a situation therefore, we need to have an order of presenting the symbols. According to Eastman, the most evident ordered aspect of map symbols is the location of the symbols. "This syntax is not superimposed, like word order in natural language. Rather, it is embedded within the very symbols themselves" (Eastman 1987, p 92). This means that unlike natural language where word order follows specific sequence, map symbols do not exhibit such characteristics. On the map, it is the symbols themselves that determines where they should be located.

Eastman (1987) also argued that "graphic syntax is concerned with the surface structure of map representations, which are basically visual relationships among the various elements on the map" (p 92). Head (1984) argued that graphic syntax involves both surface (arrangement of symbols) and deeper levels (conceptual levels). He claimed that, "a vast number of map forms may unfold their meaning with the use of much smaller number of deep structures, concept-level syntaxes" (p 10). Eastman (1987) argued further that, the arrangements of the symbols give rise to map structure. He noted that without structure there can be no adequate understanding of the material mapped. He concluded that "it is the structure presented by the map that is the main concern of the map user and map designer" (Eastman 1987, p 92).

Carto-linguistic researchers have provided an elaborate analogy between natural language and map language. They have however failed to support their findings with empirical evidence. Because of that their conclusions have not addressed issues like what needs to be taught and how. If such issues are to be addressed then we may have to go beyond merely drawing a relationship between natural language and map language. It is time we direct research towards ways of teaching and learning map use.

Elgood (1986) pointed out that ability to read a map involves a knowledge of how to approach a map and if this ability is to be acquired, it must be taught. One would expect that such instruction would enable a proficient reader to approach map use with a clearly defined question, or set of questions providing a framework for inquiry or map use search (Elgood, 1986). One option available to us may be to adopt the methods used by those who teach English as a Second Language.

<u>Summary</u>

Research in map use has taken different forms. Most researchers have relied on the fields of psychology and more recently linguistics. While psychophysical and cognitive researchers have provided empirical evidence to support their arguments, research in carto-linguistics has been more descriptive. Even though psychophysics and cognitive researchers have supported their research with empirical evidence, they have not indicated what needs to be taught in order to improve map use performance. Studies related to carto-linguistics have identified the potentials of teaching map use. Head and Elgood (1988) for example, noted that the teaching of map syntax improves map use performance.

CHAPTER THREE

THE CONCEPT OF MAP USE

Introduction

The origin of the map is lost to history. No one knows when, where or for what purpose someone got the first idea to draw a sketch to communicate a sense of place, some sense of here in relation to there. "It must have been many millennia ago, probably before written language" (Wilford 1981, p 10). The oldest map so far discovered is believed to show a neolithic village around 5,000 B.C. "Engraved upon a large rock overlooking the village in a valley in central Italy, the map depicts stilt houses, enclosed fields, animal pens and pathways" (Abler, Adams and Gould 1971, p 51). This chapter examines map use processes and the types of map tasks defined in the literature.

Definition of map use

To many people, map use is assumed to involve a single and quite simple use, that is the naive realist assumption that it is about acquisition of locational information. Muehrcke (1978, p 15) claims that "map use refers to the process of transcribing the physical map into a mental picture of reality." Blades and Spencer (1986, p 48), in providing a working definition of map use, stated that "map use includes the ability to follow a given route, and the ability to use a map to find an appropriate route between two places." This is a narrow way of looking at the concept because map use involves more than a locational task. Indeed, even a locational task presupposes a host of preexisting experience, notions and goals.

"Broadly defined map use involves reading, analysis, and interpretation of geographical data" (Dent 1985, p 13). This definition shows that maps perform multiple functions. It does not imply however that in every given situation, maps are used for all of these purposes. The purpose for which a map can be used depends on the goal of the map user and the type of map.

<u>Types of maps</u>

Head (1981, p 6) claimed that "most attempts to classify maps do so on the basis of a map's general appearance, its producer or distributor, or its content". Head cited two examples to support his argument. He noted that Monkhouse and Wilkinson (1964) presented chapters on relief maps, climatic maps, economic maps, population maps and maps of settlements. Lawrence (1971) made a distinction between topographic and thematic maps and then official maps, commercial maps, sea and air charts, aerial photographs and computer maps.

Robinson, Sale, Morrison and Muehrcke in their book <u>Elements of Cartography</u> published in 1984 classified maps into three groups namely: general, thematic, and charts.

<u>General or reference maps</u>

These are maps that have been constructed purposely to show the "spatial association of a selection of diverse geographical phenomena" (Robinson et al 1984, p 7). An attempt is made by producers of such maps not to emphasize one feature at the expense of others. As much as possible each item is given roughly the same visual stress (Robinson et al, 1984). This objective has not been achieved because different features are represented by different colouring. Some colours are brighter than others.

Both natural and man made features can be shown on the map. These include such features as routes, rivers, heights and settlemnts. An attempt is made to represent these features on such maps as they exist in reality. Reference maps therefore show the location of geographical phenomena. These maps can further be classified regionally and according to their scale, which can vary from the very small scale of a general world map to the much larger scale of national map series (Hodgkiss, 1981).

Thematic maps

These are normally referred to as special-purpose maps. They concentrate on the spatial variations of a single attribute or the relationship among several attributes. With thematic maps, the objective is to portray the form or structure of the distribution, that is the character of the whole as consisting of the interrelation of the parts (Robinson et al, 1984). That is, thematic maps can be used to denote for example average annual precipitation and population distribution. They can be grouped into two types- "qualitative maps which show merely the nature and location of phenomena and quantitative maps which convey a visual impression of quality, value or amount" (Robinson et al 1984, p 8).

Each of these main groups can be used to show phenomena at a series of points, those map features occurring within specified areas, and those which delineate linear features such as roads or rivers (Hodgkiss 1981). Thematic maps were used extensively for taxation purposes (cadastral maps) by the Babylonians and Egyptians in the ancient world and the Romans made route maps to assist administration (Hodgkiss, 1981).

Charts

These are maps made purposely to serve the needs of navigators. What differentiates charts from maps is that "charts are to be worked on, but maps are to be looked at" (Robinson et al 1984, p 9). "Charts have courses plotted, positions determined and bearings marked" (p 10).

A distinction can be made between nautical and aeronautical charts. Nautical charts apply to those used in sea navigation and aeronautical to air navigation. "Nautical charts include sailing charts for navigation in open waters, general charts for visual and radar navigation, offshore charts used to locate landmarks, coastal charts for near-shore navigation, and harbour charts for use in harbours and for anchorage" (Robinson et al 1984, p. 9). These charts provide important information on hazards such as shoals, wrecks and dangerous reefs.

There are two types of aeronautical charts. These are charts used for visual flying and those used for instrument navigation. These charts are usually small scale due to the speed at which a plane travels, and are strongly colored with emphasis on altitude of hills and mountains, location of land marks, airfields, radio beams and beacons. These charts provide information on names of interesting places and regions (Robinson et al, 1984).

This summary indicates that maps play different roles. The user in any given situation will be more interested in looking for particular information. The goal of map users therefore determines a great deal the use to which a map is put.

Goals of map users

The actual use of a map is jointly determined by the information provided on the map and user's ability and goals. An individual may be interested in determining distance, locate phenomena such as settlements, or just examine the general information provided on the map. Different but related opinions have been expressed as to why and for what purpose people use maps (Hodgkiss, 1981; Keates, 1982; Salichtchev, 1983; Sandford, 1985).

Salichtchev's (1983) classification of map use seems to be the most comprehensive. He noted that it would be futile to try and enumerate all directions taken by the exponential growth of map uses today- they are innumerable. However, he generalized and singled out three main uses of maps.

a) Communicative uses: This involves the use of maps for storage and dissemination of spatial information.

b) Operative use: This is where maps are used to solve practical problems. In this case, maps can be used in navigation and management of urban or rural economy.

c) Cognitive use: This is for spatial and even spatial-temporal investigations of natural and social phenomena and the acquisition of new knowledge about them.

One thing which appears common in these classifications is the use of maps essentially as a medium of communication whether to be from map maker to reader or from the map itself to the reader, which is related to our concerns with map language.

<u>Navigation</u>

The most widespread uses of maps is that of route finding. Most people use maps in travelling especially when they are unfamiliar with the place. For navigational use, automobile maps are the most extensively used. These are issued by commercial establishments, motoring organizations and petrol companies. These maps are functional because the information provided usually indicates services available to motorists and features which may have to be avoided.

<u>Media or journalistic purpose</u>

Apart from navigational purposes, maps have been used to illustrate issues on printed paper and on the television screen for the purpose of advertisement or news. Arnold (1969, p 191) noted that these maps are used "to attract and hold the reader's attention, to help explain and interpret the meaning of an event, and to increase message retention".

Gilmartin (1985, p 1) was of the view that journalistic maps are used most extensively to show the "location of places featured in the news" and to "help explain spatial aspects of news". She was of the view that, journalistic maps serve more people especially in explaining the weather on either newspapers or television. In addition to that, reporting of current events are supported by maps which show the location of the event. Maps were used, for example, to show the war between Iran and Iraq.

There are some shortcomings of these maps. The first is that these maps are prepared by laymen. Because they lack the necessary skills, such maps may be poorly constructed. Leimer (1982) pointed out errors of up to 400 miles in locating South Georgia Island on small-scale maps which accompanied news accounts of the Falkland invasion.

Leisure

This is another field in which maps have been used. Leisure activities such as mountain climbing and walking involve using maps for route finding and to determine the nature of the terrain. Not only do maps provide information about the terrain, but they also help to locate hazards such as marshes.

Holiday makers and tourists also use maps. Maps provide information to tourists concerning location of hotels, shops, streets and resort centers such as beaches. Such information guides tourists in planning their vacations.

Other people find themselves using maps not for any of the above reasons but just for the fun of it. Such people use maps as we read story books. They use maps during their leisure hours to locate towns and features depicted in the map. They do not use the maps beyond the pleasure of identifying these features.

Sports

Orienteering is a sporting event in which maps play an important role. This type of sport requires efficient map reading abilities. The sport involves cross-country navigation on foot using a map and compass to identify specified check points. Topographic maps were extensively used during the early days of this sport, but they have been found not to be adequate because they lacked detailed information (McNaughton, 1986).

"The key to orienteering map reading is the development of a lexicon of landscape features, and the ability to recognize and visualize them rapidly from map symbols" (McNaughton 1986, p 25). "Landscape visualization is the first step in the use of orienteering maps and it is a process of skimming the map to gain an "essential map image" of the major features of the terrain" (p 25). The second step is navigation. To an orienteer, this is a learned activity. "Orienteers are taught to look for a hierarchy of map features, and to remember them in order to reduce time spent on map reading" (p 25).

Education

Maps are used extensively as scholarly tools. They are used by teachers and students as teaching and learning aids. In the classroom, teachers use wall maps and globes to illustrate their teaching. Also, projected maps can be used to explain concepts to students (Hodgkiss, 1981). It is a common practice by students to use maps to aid them during learning. Studies in regional geography are normally supported by constant reference to maps of towns, cities, countries or continents.

Maps are useful to other disciplines. Botanists for example use maps showing the distribution of plants and historians use maps showing the political situations at different periods. A medical officer will be interested in maps depicting the distribution of diseases.

Military purposes

This is another specialized use of maps. Even though maps are made specifically for military purposes, most military personnel use standard topographic maps. Schaubel (1971, p 7) observed that "the Canadian Armed Forces are the largest single users of topographic maps in Canada, using about as many maps as all other users combined". A military officer might use maps for example in the location of enemies. A gun man might like to determine the distance and direction of enemy territory before shooting. A tank commander might need information concerning obstacles like swamps and forests.

"Maps are said to be essential to the military and it is expected that every soldier knows how to read maps" (Schaubel, 1971, p 7). In World War II for example, troops received basic training in map reading. Every soldier went through this programme because military use of maps involves group work. For example, while a gunner might be scaling distances, or selecting target reference points, another may be searching for possible hard standing and concealment for his guns (Schaubel, 1971).

Literature

It is important also to make mention of maps which are used for literature purposes. Many maps of fictional countries have been used by many authors to illustrate or give meaning to the title and story of their books. These maps which appear on the front pages of books are intended for advertisement and amusement. They are colourful and eye-catching.

In 1881, Robert Louis Stevenson constructed a map of an island and wrote a novel called Treasure Islands which was based on the map (Hodgkiss, 1981). Also in 1877, Frederick Rose drew a map of Europe with Russia depicted as a large octopus, "curling its tentacles in all directions to grasp at territories in different parts of Europe" (Hodgkiss 1981, p 18). Customers might be lured into buying such books because of the beauty of these maps.

Air and sea travel

As mentioned earlier, charts are used for air and sea travel. Pilots use charts to identify relief, roads and railways, urban settlements, wooded areas, hydrology, airports and designation of more heavily travelled highways. In sea navigation, charts are used to locate ports of call, and to identify physical features and directions.

Using a map for any of the above purposes does not occur automatically. But then it is possible for someone to become efficient at retrieving information from a map through constant practice. With constant practice, it is possible to develop better map reading processes.

Processes of map use

To most people, using a map appears to be a straight forward and natural task. "Finding a place, selecting a route, discovering a prominent hill, are all familiar and indeed quite elementary processes" (Keates 1982, p 1). Contrary to this assertion, some researchers have pointed out that the process of reading a map involves a complex tasks (Keates, 1982). Yet beyond the studies reported in chapter two, there has been little experimental work to discover the sequence of actual map use process.

Board and Taylor (1977) gave some suggestion as to how map processing takes place, but in their paper did not provide experimental evidence. They stated that, in map reading, the reader first detects and discriminates different kinds of map symbols. They related this activity to the identification of words in text. The next stage is visualization of symbol groupings, a stage which they think conforms to comprehension of sentences in a text. This is followed by interpretation and analysis. "Analysis depends on the isolation of certain elements in total while interpretation is commonly a comparative activity" (Board and Taylor 1977, p 23).

Similarly, Head (1984) suggested that, in analyzing spatial patterns, we look for concentrations, discontinuities (edges), homogenieties and interconnections. In relating these activities to the reading of text, he says the map patterns are like groups of words in a spoken language or clusters of marks on paper in written language. We try to connect these clusters of marks to things we know (or think) exist in reality. For example, identifying a drainage basin from a map involves the following processes. First we look for rills and connect them to streams. Streams are then joined together to form a river. The various rivers will then be connected to form an entire drainage basin.

Casual interviews with colleagues in the M.A. programme tend to confirm these suggestions. Many of those intervived suggested that reading maps begins by simply scanning through the entire map. In doing so, the reader at this stage does not search for specific things. This stage allows the reader to become familiar with the contents of the map. At this stage it is possible to locate areas of concentration.

After scanning through the entire map, most often, areas of concentration are identified. This involves among other things the location of major economic activities, areas with many settlements, and agglomerations of physical features. Naturally, the distribution of physical features is not uniform on earth: Some areas are more endowed with some features than others.

At this stage some readers may focus their attention on attractive areas of the map. These may or may not be areas of concentration. At times maps are designed in such a way that some features appear distinct on the map. This is usually done through colouring. For example prominent features like mountains, rivers, seas and heavy industrial areas may be aesthetically presented. This makes them appear attractive to map users.

The next stage is to delineate the map into regions depending on the nature of the map and the type of information being searched. In identifying a settlement on a map, for example, a map user at this stage will delimit the map into macro and micro settlements. Bigger and more prominent settlements might be identified, followed by less prominent settlements. Stevens and Coupe (1978) suggested that a location is encoded in terms of its spatial relation to its immediate super-ordinate and its immediate sub-ordinates, that is, the immediate largest city and the immediate smallest city.

The last stage involves relating the various pieces of map information and attaching meanings to them. At this stage, the map reader will try to provide answers to such questions as why, how and what. This stage is beyond dealing merely with the map symbols. At this stage the map user is able to retrieve the needed information and decisions are taken by relating the information to the real-world situation.

In order to retrieve the maximum information from the map, some users may refer to the legend at this stage. Legends are provided in order to attach meaning to symbols. This is because there is no standardized way of representing symbols.

The processes outlined above can be utilized simultaneously. There is no definite sequence that one has to follow. However, some processes are more appropriate at certain times. This may be determined by the type of map use task. Again, it should be stressed that these map use procedures are but "self-reports" and have not been confirmed experimentally.

Map use tasks

Olson (1976) proposed three basic levels of map reading which she claims can be organized into a hierarchical structure in which the very basic tasks are less demanding than the next higher level ones. Olson (1976, p 152) noted that "at level one, the user simply looks at a map and compares the characteristics of individual symbols (shapes, relative sizes and importance)". For example, comparing the shapes of two rectangles would be a level one task.

"Level two involves the recognition of properties of symbol groups on the map as a whole" (p 152). Here the user is interested in identifying spatial patterns and likeness to other map patterns. For example, at this level, the map user may observe whether a distribution of symbols is simple or complex. "At this level we are dealing with relatively complex concepts, but, as in level one, we are still considering abstract symbols" (p 152).

In searching for identifiable groups of symbols, the map user may begin to recognize patterns and this may lead to preliminary analysis of the spatial distribution (Dent, 1985). The identification of any observed patterns leads to a comprehensive analysis which Olson terms level three map reading. This level requires the use of "a map for decision making or content-knowledge-building device through integration of the symbols with other information about the real world" (Olson 1976, p 152). "At this level of map use, the user has to understand the relationships among the various symbols, but the symbols themselves are only important insofar as they represent phenomena and their spatial characteristics" (p 152). An example is the recognition of a glaciated region on a map.

Board (1978) also set out three basic tasks but his classification was not based on different levels. He named his tasks navigation, measurement and visualization.

Board (1978) describes navigation as using a map to aid movement from one place to another. This involves matching the map with reality. First, the map user must locate his starting position and that of his destination. According to Board (1978, p 6) "the user tries to search for an optimum route by looking for the shortest distance, the quickest, quietest, prettiest, safest or the lowest gradient path".

Measurement involves using the map to obtain quantitative information. These tasks are more appopriate if the information so desired by the map user concerns places of smaller magnitute (Board, 1978). For example, when reading a geological map, it is often necessary to determine formations of rock outcrops at a particular point.

Visualization involves an overall analysis of the map to obtain the geographical distribution of phenomena. "Relatively large parts, commonly the entire map face, are scanned for clues in a search for order, regularity or pattern of some significance" (Board 1978, p 7).

Board subdivided the three basic task-types as indicated in

Table 3.1.

Morrison (1978) offered an alternative arrangement for considering map reading tasks, including pre-map reading tasks and attitudes on map style, that is, those words used to describe the aesthetic qualities of a map and of the map reader's reactions to a map. His classification involved the following task types: detection, discrimination, and recognition tasks, and estimation tasks. These tasks were again subdivided into smaller individual tasks as seen in Table 3.2.

Table 3.1: A check list of map reading tasks (after Board, 1978).

Navigation	Measurement	Visualization
Search	Search	Search
Identify and create own position on map	Identify	Identify
	Count	Describe
Orient map	Compare	Compare
Search for optimum route on map	Contrast	Contrast
	Estimate	Discriminate
Search for landmarks en route	Interpolate	Delimit
	Measure	Verify
Search for destination		Generalize
Identify destination		Prefer
Verify		Like

Source: Board, "Map Reading Tasks Appropriate in Experimental Studies in Cartographic Communication", <u>The Canadian Cartographer</u>, 1978, p.6.

Keates (1982) identified four-tier tasks. These are detection, identification, recognition and interpretation. Keates noted that we depend on two processes at the initial stage of map use. These are detection and discrimination. The map user must be able to respond to what is there; that is, the symbols on the map must be detectable. Also, the map user should be able to differentiate between two symbols before discriminating between them (Keates, 1982).

Keates (1982) further indicated that whereas map users can detect and discriminate between symbols without knowing what these symbols represent, identification is a learned activity. If the map being used is familiar to the user, then there might not be any need to consult the legend. Identification may not fulfil the needs of map users, although this depends on the goals of the user. A step further from identification is what Keates refers to as recognition.

Table 3.2: Basic Map Reading Tasks (after Morrison, 1978)

Detection, discrimination and recognition tasks	Estimation Tasks
Search	Count
Locate	Compare or contrast
Identify	Measurement
Delimit	a) direct estimation
Verify	b) indirect estimation

Source: Morrison, "Towards a Functional Definition of the the Science of Cartography with Emphasis on Map Reading", The American Cartographer, 1978, p.99.

Forgus and Melamed (1976) made a clear distinction between identification and recognition. According to them, "recognition means being able to say that something looks familiar, whereas identification means that we say what it is or name it" (Forgus and Melamed 1976, p 18). This means that during recognition, we tend to attach meaning to what we see. In most cases, the legend serves as a guide in recognition.

The preconditions for map use include detection, discrimination and identification (Keates, 1982). Beyond this point, there must be a further stage of interpretation by which information is processed in order to perform a particular map-using task. Individual skill and knowledge determines the differences in which map users interprete maps even though in most cases there might be similarities (Keates, 1982).

Even though basic differentiation can be made between these tasks, it is not possible to differentiate between them when it comes to actual performance of the task. These tasks are performed sequentially but often quickly. For example, in planning a journey from one settlement to the other, a map user will have to be able to detect, discriminate and identify the settlements, recognize them as those that he wants and go on to detect, discriminate and identify the potential routes.

Head (1984) modified the tasks of Board and related them to natural language. Head's tasks were "landscape visualization", "navigation" and "interpretation for place and space" (p 12). "The basic language skill essential to the process of landscape visualization is the ability to chunk and to assign meaning to these chunks" (p 12). The marks on the map can either aid or hinder the communication process. Head noted that "the user with a developed lexicon of geographic items will be better equipped to move quickly and effortlessly through the successive stages of the visualization process" (p 12). Usually these lexicon items are stored in the long term memory of experienced map users which allows them to identify such features as rills, streams, rivers and lakes (Head, 1984).

Reading maps for navigational purposes involves landscape visualization (Head, 1984). Head noted that navigation involves more than visualization because navigation requires the map user to frequently compare the information from the map with that of the environment he is navigating. In most cases, experienced map users are able to create chunks which enables them to identify elements important to the task (Head, 1984). This may include the location of the vehicle, the road to be used, possible features along the route and destination (Head, 1984).

Map use for interpretation of place and space involves identification of location and spatial forms. Head noted that, in location for example, a map can be used to identify settlements like Waterloo, Ontario and with the aid of a legend, interprete the population of the the city. Identification of spatial forms or patterns requires that the map user searches for groups of map symbols that indicate for example industrial activities and through that we are able to create mentally an industrial region (Head, 1984).

Summary

Many people are not aware of the varied processes which map use may involve. For some, it seems that there is a single and quite simple use for maps´ the acquisition of locational information. Broadly defined, map use includes reading, analysis and interpretation of geographical data. If that is the case, then the map user needs to be considered as an active participant in the communication process. The potential role of the map as a medium of communication is determined by the purpose for which an individual uses a map.

This means that in order to improve the efficiency in cartographic communication, we need to address map user needs completely. Olson (1976) pointed out that sets of symbols which may be difficult or even misleading to the naive user could perhaps be taught so that a more sophisticated (or trained) user could extract information more easily and more accurately. One way to achieve this objective may be through the application of methods of teaching English as a Second language.

CHAPTER FOUR

ENGLISH AS A SECOND LANGUAGE: IMPLICATIONS FOR MAP USE

Introduction

It is common to hear people speaking different languages. To promote easy interaction, a conscious attempt is made by some people to learn those languages with which they are unfamiliar. English and other international languages are learned as second languages by many people for this purpose. The question then is how can a second language be learned? Are the methods used in teaching English as a Second Language suitable in teaching and learning map use? This chapter attempts to examine how second languages are acquired, taking English as a case study and relating it to the teaching of map use processes.

Definition of English as a Second Language

It is important that a brief distinction be made between "second" and "foreign" language in terms of a non-native speaker. A second language is one which has some specific functions within a society, and which is learned after the mother tongue (Faerch and Kasper, 1983).

In Britain, Canada and the United States, English is regarded as a second language to immigrants and ethnic minority groups for whom English is not a mother tongue. Similarly, in many former colonized countries, the colonial language has been retained after independence for educational and administrative purposes. In Ghana for example, English is a second language in the multi-lingual society.

A foreign language is one which has no internal function in the learner's country and which is learned in order to communicate with native speakers or other users of the foreign language who might not be natives (Faerch and Kasper, 1983). This means that those who acquire the foreign language do so basically to interact with those from outside their native community. For example, the Russian language can be learned by a Ghanaian student in the University. This student is not likely to use such a language within the Ghanaian community. But it can be used to interact with a Soviet or someone who understands a Russian language.

It should be noted that a language whether acquired as a second language or foreign language can function as a Lingua Franca, a language used between people with no common language and for neither of whom it is the first language (Faerch and Kapser, 1983).

Maps are useful within a society and can equally be utilized by people from other cultural backgrounds so long as they understand what the map means. Moreover, map use is a day to day activity. This means therefore that map use is more related to second language than foreign language.

Learning second languages does not occur naturally and most often it is learned by adults. In learning such languages, learners have to follow basic rules. Most often the syntax and lexemes of the language are learned. As much as possible, those who speak second languages try to acquire these skills through learning so that they can be used fluently as native speakers. This can be done through formal instruction or informally by interacting with native speakers. It may however be easier and faster to learn a second language through instruction.

The same is applicable to map use. Like second languages, map use skills are said to be learned rather than acquired. This is because, if a map is given to an illiterate person who is not familiar with map language, he will think that it is a paper made of symbols. The person may not be able to attach meaning to the symbols. The implication is that, as with second languages, conscious efforts are made to learn how to use maps. People make such efforts because of the following reasons.

<u>English for specific purposes</u>

Students at times learn a language with one objective in mind. For example, an air traffic controller needs English to guide aircraft through the skies. This might be the only time when English is used during the day. A businessman may need English for international trade. One thing peculiar about this group of learners is that the type of English acquired is limited basically to the purpose for which it is learned.

<u>Educational</u>

Many students today study English because English is part of the school curriculum. In some cases, it is mandatory for people to pass an English examination before proceeding to a higher level of learning. This applies especially to countries which were colonized by the British. In most of these countries like Ghana, Nigeria and Kenya, English is learned in school formally because this is considered the official language. Daily communication is through the local dialects but official communication is through English.

<u>Culture</u>

Some students study a second language because they are attracted by the culture of one of the target language communities. In order to know more about the people who speak it, they have to learn their language. This allows them to have access to the literature related to them, and to enable them to interact more frequently and easily with the people.

<u>Advancement</u>

Some people want to study a second language because they think it offers them the chance for advancement in their daily lives. It is possible that a good knowledge of a second language will help one to get a better job than if one is limited to only their native language. In some cases, an offer of a job demands that one has a working knowledge of a language.

The reasons outlined above are not entirely different from why people use maps. Among them are for navigational purposes, leisure, sports, education and literature. Detailed discussion of these is provided in the preceding chapter. If these are reasons why people study a second language, then the question is what factors can promote or retard people's efforts to learn a second language?

Factors Affecting Second Language Acquisition

The environment

"Where English is taught in an English speaking community, students naturally have many opportunities for direct contact with the language outside the classroom" (Finocchiaro 1969, p 11). Students utilize the community to acquire further experience. The language learned in the classroom will acquire increasing meaning since it will have an immediate functional application outside the school. Students can be expected to learn the language incidentally by speaking with their peers, reading signs, listening to conversations on the buses and on the radio.

On the other hand, where English is not the predominant native language of the community, the teacher will have to create an intensive English speaking environment in the short time his class is in session. The teacher has to furnish the listening, speaking, and reading opportunities which can not be found outside the classroom. This means that students in such communities have fewer opportunities to allow them to acquire the language within the shortest possible time.

In cartography, it is possible for people to become competent in using maps depending on how frequently they are exposed to the process of map use. The environment can partially provide an opportunity for people to use maps more frequently. Those who live in bigger cities and do lots of travelling have the opportunity to use maps to navigate around frequently. In such a situation, learning to use maps may be acquired.

<u>The pupil</u>

The factors within the pupil in acquiring second language are many and varied. His native language is of fundamental importance. Whereas native speakers of languages such as English find similar alphabets and words to facilitate learning, speakers of some other languages will have to learn new alphabets and writing systems and may find fewer similarities in vocabulary items. In this case, what the student already has in mind may affect his ability to acquire the language.

Even though we can not compare geographers to first language users, there seems to be a relationship between the two. With geographical background, it is possible for a student to understand easily such features as eskers, hanging valley, and pyramidal peak. These concepts can be learned in a geology class. When it comes to applying them to map use, such a student stands the chance of identifying the concept in a map environment.

<u>The teacher</u>

The teacher is said to be the most important single person in any teaching situation. It has been frequently said that, there are no good or bad methods, there are only good or bad teachers (Finocchiaro, 1969).

The personality of the teacher coupled with his attitude towards his students and his work determines the extent to which any program, no matter how well formulated, can be carried out. Naturally, the general teaching skill of the instructor, his special training in the field of language teaching, and his linguistic ability also affect the teaching-learning situation.

In teaching and learning map use, the teacher plays an important role. His training in cartography will determine the extent to which his instruction can be easily understood by his students. The teacher has to develop methods that can be efficiently used in the learning process by his students.

It is also possible to relate techniques employed by learners of a second language to those that map users can adopt. Faerch and Kasper (1983) claim that the following are the techniques adopted by learners of second languages:

a) learning words in context,

b) practicing vocabulary,

c) practicing words in context,

d) practicing communication.

In map use situations one has to go through similar or related learning processes. These are:

a) preparation and memorization of vocabulary associated with maps. The vocabulary includes conventional symbols representing both man-made and natural features,

b) learning the symbols of the maps in the context they are used,

c) practice the basic vocabulary of map use,

d) actual processes of map use.

Also second language learning requires the learner to have two basic types of knowledge:

a) Declarative (knowing that): This consists of internalized second language rules and memorized chunks of language.

b) Procedural (knowing how): This consists of the strategies and processes employed by the learner to process second language data.

In map use, acquisition of such knowledge is related to internalization of basic map symbols and how to go about retrieving information from the map. The question is how can map users be made competent in these skills? Since there is a relationship between map use and second language, then perhaps it is rational to adopt methods that teachers of second languages employ in teaching their students.

<u>Methods used in teaching second languages</u>

Head (1984) noted that it should be possible to apply lessons in teaching a second language to learning map use skills. He claims that the map reader's skill builds as his lexicon is expanded, for example through the introduction of complex forms such as the basic forms of karst topography, or of dry land morphology, or of tropical forest topologies. Head's (1984) proposal can be evaluated within the context of evidence from past studies which indicates that instruction of some sort enhances performance of map users.

Atkins (1981) performed an experiment to determine the extent to which preschool children can learn map and globe skills when taught. The subjects were 22 preschool children, aged 4.4 to 5.4. There were two groups with eleven in each group. The experimental group received four weeks of instruction related to map use and the control group was not instructed.

During the experiment, the subjects learned certain basic concepts. They were taught how to determine directions in the classroom by using a magnetic compass and the lay out of the classroom. This was followed by a discussion on a model of the room. The discussion involved a comparison between the model and the actual room. Children were then asked to view photographs of the room in which they were located. After that, the children were shown the relationship between the map, the actual room and the model. The same procedure was followed in comparing the building, its surrounding and the community. The instruction finally related the community to the state, the state to the United States and both to the whole world. The globe was used as a model during the instruction.

The pre- and post-test questions assessed children's understanding of such concepts as location, symbols, distance and scale, directions, orientation of the map, the shape of the earth, the globe as a model of the earth and earth-sun relationships. The tests were administered to both groups. "A comparison of post-test performance indicated that the experimental and control groups differed significantly with regard to map and globe skills" (Atkins 1981, p 231). However, "the experimental group scores were consistently above 70 percent and the control group scores ranged from 0 to 59 percent" (p 231).

A related study was reported by Lloyd (1989). His experiment was in two stages. The first part included 30 University students who had lived in Columbia, South Carolina for "at least three years and could pass a preliminary test that required them to verbally describe where all the land marks and reference points were generally located in the city" (Lloyd 1989, p 107).

The second part involved a task requesting subjects to "learn the locations of 15 land marks and three reference points located in Columbia from a topographic map and then estimate the locations of the land marks relative to reference points" (p 107). The 32 subjects of this part of the test were university students who had neither lived in Columbia for any specific length of time nor had any previous knowledge of the land marks used in the study.

Both groups were instructed to study the map so that they could associate each location with its name. The task required that subjects identified the location of the city from a map represented with dots without names. The results indicated that subjects who were long-time residents of the city and who had learned the locations of the land marks through navigation were unable to perform the task as efficiently or as consistently as subjects who had learned the "same" distribution of land marks from studying a cartographic map for a short time. Even though he did not instruct the subjects, there was an indication that the few minutes of learning the map by the intervention group enabled them to perform better. These results suggest the significant contribution that map use can make to spatial understanding.

The question is can subjects be taught how to search for such information? May be adopting methods employed by educators in the field of second language as suggested by Head (1984) can be helpful. These are structural, direct, vocabulary selection, oral, drill and situational.

<u>The structural method</u>

This approach consists of teaching the structures of a language rather than the words to learners of a second language. That is, this method attempts to teach the arrangement of words in a sentence. The assumption is that, if those who are learning a second language can master the frames or patterns of language structure, they can fit words into them easily. "The structural approach involves not only sentence patterns (syntactical structures) but also such things as the sound patterns of a language (phonological structures), the patterns of words (how they are built up from smaller pieces or morphological structures), different meanings of words and patterns, and idioms" (Hill 1974, p 86).

In cartographic communication, this approach involves teaching of syntactic relationships between both geographic concepts and cartographic symbols. It is important that students are instructed on what types of cartographic features might appear together. For example we should expect a harbour to be located close to the sea or water body. If this is explained to them, they will be able to associate one feature to the other and consequently their ability to build complex forms from simple forms may improve significantly. This is because instruction in geographic concepts and cartographic symbols will help build conceptual items (content or meaning) and perceivable items (expressions) during the actual map use process.

In his explanation, Schlichtmann (1985) stated that a map sign conveys two basic sets of contents. "Locational information is location in globe space, that is, on the two-dimensional, horizontal globe surface" (Sclichtmann 1985, p 4). Substantive information refers to other characteristics of the items signified, such as magnitude or function. What Schlichtmann calls "localized signs" include "location" as part of these content. Localized signs may then be combined into "texts", just as sentences are used in language (Schlichtmann, 1985). He gave an example of "valley bottom with winding river, ox-bow lakes and backswamps" (p 4). These features are grouped together because they "occupy slots in a network of relations, just as the units make up a sentence. Contents as well as expressions of these features are linked by syntactic relationships" (p 4). The syntagmatic (or combinational) order determines how units are combined. In the content "harbour", for example, "water body" and "ships" are in a syntagmatic relation. "Combined items are present at the same time: combination is based on relations of co-presence" (p 5). Schlichtmann noted that "instruction in syntactic relationships may therefore help students to use the concept of spatial assemblages of the individual features to identify structured wholes, where each individual feature is represented by a localized sign" (p 6).

The direct method

Other methods were proposed when it was realized that students had problems learning a second language by following rules, grammar and specific expectations (Hill, 1974). This led to the direct method which follows the same procedure as children learn first languages (Hill, 1974). This method stresses practice instead of theory. Students learned to speak by speaking, to understand by listening, to read by reading. They are normally introduced into a second language, at first in simple form, and then in a progressively more difficult form.

Applying this to map use implies that students should be given the opportunity to make use of maps as much as possible. Frequent exercises relating to map use should be handed out to students. These exercises should first be directed to simple features and gradually to the complex forms. This will offer them the chance to use maps and then appreciate the problems involved in map use. It is only through constant interaction with maps that students will become good map users.

Vocabulary selection

In addition to the above methods is the vocabulary selection method. This method involves careful selection and grading of words. Research was undertaken to discover the frequency of words, and text books were written for teaching second languages "in which the vocabulary was graded according to

2 OF/DE 2

its frequency, utility and its teachability" (Hill 1974, p 85).

This method was found not to be as adequate as hoped (Hill, 1974). Although the words were selected and graded, students still had great difficulties. This was because even though they knew all the words in a sentence, they could not understand what the sentence meant. The reasons were that:

> a) "most words have more than one meaning,
> b) there are a large number of idioms in every language; for instance, if one knows the meaning of yellow and the meaning of jacket, it does not follow that one will know the meaning of "yellow jacket" (a stinging insect),
> c) what causes most difficulty in language use are not the actual words, but the ways in which they are combined into sentences. The structural method had addressed this" (Hill 1974, p 85).

Despite these criticisms, vocabulary selection is relevant to map use. This is because teaching and learning map use involves knowledge of cartographic vocabulary, such as conventional signs representing features like mountains, rivers, lakes and towns. Without basic knowledge in these, it may be difficult for us to use maps efficiently.

<u>The drill method</u>

Proponents of this method believe that a second language can be acquired through repeated hearing, speaking, reading and writing. This is because it is difficult for one to gain perfection in a language by interacting with it only once. The best thing therefore is to have repeated exposure to the language so that we can instantaneously recall it when we need it. This applies especially to words which are much related, for example, "is this", "who is", "where is", "they are". These words are learned so that they come automatically when required.

In cartography, this method calls for constant practice by map users. In a way therefore this method is related to the direct method. The difference between them however is that the drill method emphasizes practice whereas the direct method emphasizes learning language from simple to complex forms. The practice is not limited to once but several times.

The situational method

The method requires that teaching of second language should be done within the context of linking words with what is being taught (Hill, 1974). For example, if a teacher wants to teach what a pencil is, then he has to take a pencil to class and demonstrate to the students when he is referring to it. With this method it is believed that "the meanings of words and structures are obtained only by the situations in which they can be used" (Hill 1974, p 88).

In geographical teaching and learning, it is not possible to bring everything to the classroom for demonstration. However, the use of diagrams, airphotos, models and slides are quite useful for this purpose. The situational method has been adopted in the experiment of this thesis.

The oral method

This method even though not directly applicable to map use needs mentioning. This method emphasizes the fact that the easiest way to acquire a second language is to begin orally. When the teacher is presenting the materials, students are required only to listen and they are expected to use the materials first through speech before reading or writing (Hill, 1974).

This is because it is believed that it is more natural to learn to understand what one hears and to speak first, since that is how we learned our own language. People could speak for countless thousands of years before writing was invented, and the majority of people in the world still can not read or write although most of them can speak a language (Hill, 1974).

In geographical studies, the oral method can be related to "landscape appreciation". Most people are aware of the natural and man-made landscape. Through daily experience, people are able to move around their environment. Naturally, every individual knows the landscape around. This in a way helps in the process of map use.

Summary

Just as human language allows us to communicate ideas and concepts, the map provides a medium for communication. Unlike human language which is part of our daily existence, the development and use of map reading skills is a selective process which is acquired most often formally. This is related to the process of acquisition of a second language. As with second language, map use is said to be learned. If that is the case, then we can adopt methods of teaching second language in teaching map use. This possibility is explored in an experiment which seeks to incorporate the structural and situational methods of teaching English as a Second Language in map use situations.

CHAPTER FIVE

THE EXPERIMENT

Introduction

The preceding chapter suggests a relationship between map use and English as a Second Language. It is therefore hypothesized that a simple instruction in map use which incorporates methods of teaching English as a Second Language has the potential of enhancing user's performance. The focus of this chapter is to outline the experiment which was conducted.

Experimental Design

Hypotheses:

1. General geographic education will have a positive impact on map use.
2. Instruction in map lexemes (vocabulary) will improve map use performance.
3. This improvement will be greater with psychology students than with the geography students.

In order to test these hypotheses, it was first necessary to design a map and accompanying question set which could be used in an experimental situation. The first part of this chapter is devoted to a discussion of the map and to an explanation of the rationale of each individual question. The second part deals with the teaching intervention.

The stimulus

A topographic map was used for the main experiment (Figure 5.1). It was hand drawn in black and white. The map is fictitious

TEST MAP

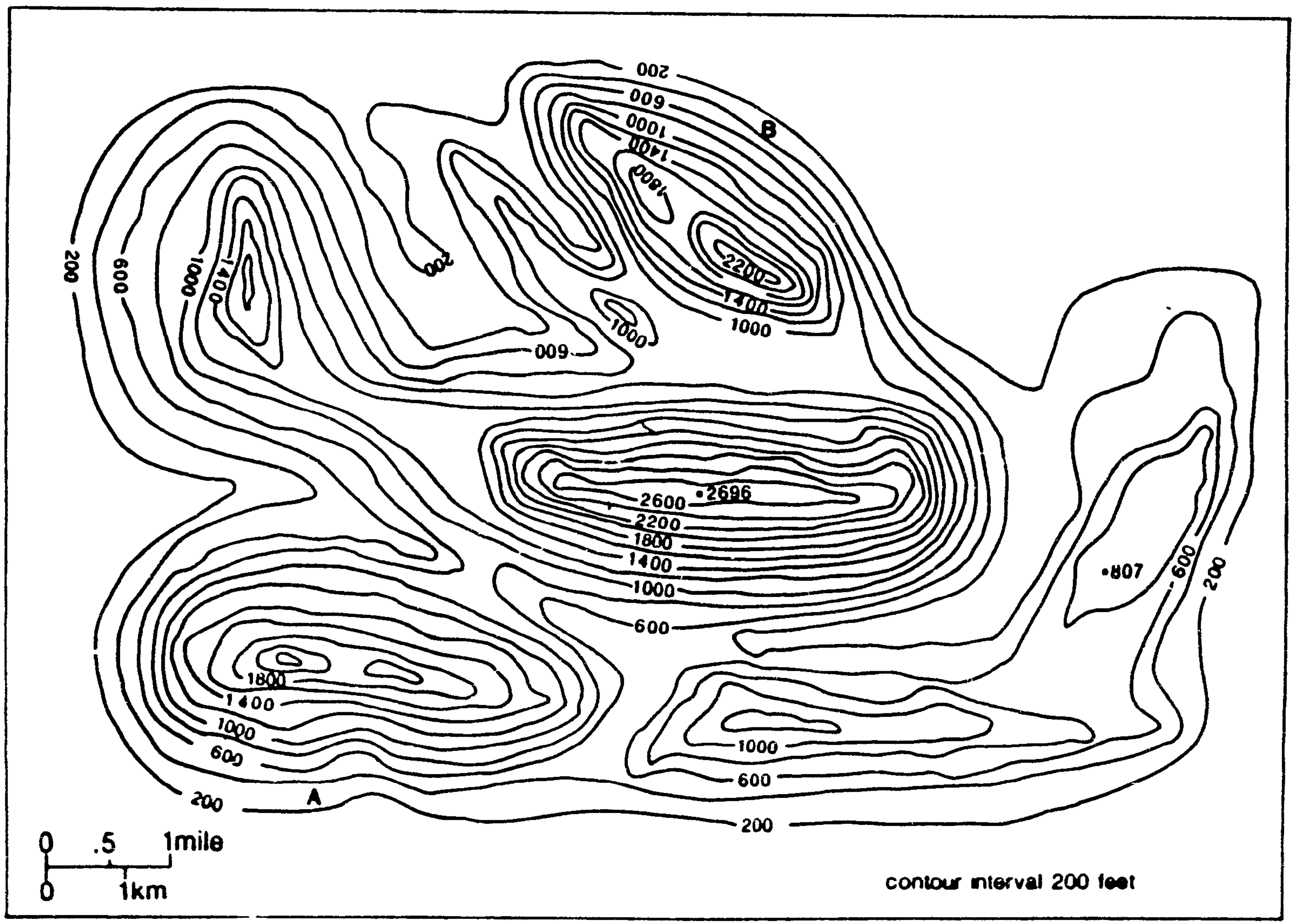


Figure 5.1

in the sense that the landscape shown on the map does not exist in reality. On the map, contour lines are used to represent points of the same elevation above sea level. These contours are labelled with contour interval equal to 200 feet. The lowest contour is 200 feet and the highest is 2600 feet. Apart from showing heights above sea level, contours can be used to represent relief features such as slopes, spurs, gaps, highlands and lowlands. These features are represented on the test map but are not labelled on the map.

Participants were presented with two copies of the map during the test. One of the maps was used to answer question one and the rest of the questions were answered on the second map. This was to prevent participants from going back to make changes in their response to question one. Subjects were informed verbally not to make any changes after they had attempted question 2 to 5. A brief instruction was provided to the students concerning the test. This was followed by the maps and the questions. The students were given fifteen minutes to complete the test.

The Tasks

The test questions reflected the three levels of map use tasks proposed by Olson (1979) and later expanded by Board (1984). According to Board (1984), map use tasks can be grouped into three levels. He claimed that in performing level one tasks, map users focus upon "individual symbols, differentiating them on the basis of their shapes, relative sizes, etc" (Board 1984, p

85). Examples of these level one tasks would appear to be the identification of a particular contour line, place name, town, spot height, street junction or farm hut.

Board notes that level two tasks incorporate the level one tasks. This level of task requires subjects to recognize properties of symbol groups on the map as a whole which leads to visualization of the spatial patterns presented. According to Board, this level of task does not demand that subjects make symbol-referent relationships. Examples might be recognition of slopes, valleys, highlands, lowlands, and drainage patterns.

Level three tasks, according to Board, are involved when a map is used for "content-knowledge-building" or decision making. This involves "the integration of map symbols with other information" (Board 1984, p 86). The symbols are identified as representing actual phenomena in a real landscape. Board gives the example of the ability of a map user to identify "regions of high flood risk" (p 86). Another example might be a user's ability to infer from the infoımation provided on the map that a particular area or areas are not suitable to navigate through. These are, as Board calls them, "higher-order" map use tasks. The higher level tasks incorporate those at the lower level.

Board pointed out that one of the aims of geographical education has been to enable individuals to undertake the higher level or higher-order map use tasks, in particular the visualization and interpretation of patterns. Head (1984) refers to such processes as 'chunking', that is the selection of meaningful bits and their assembly into structures.

<u>The subjects and test questions</u>

Subjects for the test were second year honours geography and psychology students. A total of sixty-four students participated in the experiment. Forty-three students were geography students and twenty-one psychology students. Twenty-seven geography and fourteen psychology students received instruction, while sixteen geography and seven psychology students were not instructed.

The test was made up of five questions. The first question presented a "higher order," level three task; the second and third questions were level two tasks and the fourth and fifth questions were level one tasks. The higher order task was examined first followed by lower order tasks. This sequence was used to avoid "leading" the subjects to use answers from lower order tasks in answering the higher order questions.

<u>Question 1</u>

Mark on the map the shortest route from A to B when flying an ultra-light aircraft whose maximum flying height is limited to 1800 feet above sea level and whose minimum flying height is set at 800 feet above sea level.

This question requires students to plan efficient routes. The question assesses not only the participants' abilities to recognize the shortest route, but also their abilities to know what features they can take advantage of and those that they have to avoid. As the question suggests, students will have to avoid areas above 1800 feet and fly above 800 feet. This means that they have to avoid highland regions and take advantage of lowlands; "highlands" and "lowlands" are not marked directly on the map, but rather are concepts created by the subject through "chunking". Visualization of form is created to improve efficiency of route planning.

In flying so close to the ground, students may use the notion of "slopes", a concept that requires chunks of a series of contour lines. Slopes are useful since the transition between low and highland regions may often be marked by steeper slopes. The height above sea level of valley floors (a level one task) is of significance as well as the height of mountains.

<u>Question 2</u>

Outline on the map an area whose lower elevation is gently sloping and higher elevation steeply sloping.

This question is posed in order to find out how accurately participants can process the spatial distribution that is presented on the map. The question demands that participants recognize that clustering of contours indicates a steep slope and widening of contours indicates a gentle slope. However, knowledge of steepness and gentleness is not enough. Participants must also be able to differentiate between high and low elevations. The training session enabled participants to identify areas with steep and gentle slopes.

Question 3

a) Shade an area of land that is completely at or above 1600 feet above sea level.

b) Shade an area of land that is completely at or below 600 feet above sea level.

This question also tries to probe participants' abilities to recognize spatial distribution. Good performers will be able to recognize that the 1600 feet contour will be in a highland area and 600 feet will be in a lowland area. They can therefore identify these contour lines and shade the areas accordingly.

Question 4

Trace with a pencil or a pen any 1600 feet contour and 800 feet contour.

This is a level one question. Participants are requested to recognize and locate specific contour lines. The intervention group is likely to perform better in this question because they can use their knowledge about contour interval to identify these particular contour lines.

Question 5

What is the highest point on the map?

This is also level one question. This question requires participants to use their knowledge about spot height to answer the question. Those instructed are expected to have an advantage over those without instruction. The instruction group should be aware that a dot with a figure indicates height. With their basic knowledge about highlands and lowlands (higher level tasks) during the instruction, they should be able to locate exactly and more quickly the spot height in a highland region.

THE INTERVENTION

Purpose

The lesson was intended to teach "geographic lexicon" items at a variety of levels and to initiate or encourage the use of the higher levels of map use that require "chunking". For example, narrow brown lines on a map are contour lines. A combination of three to five contour lines can then give rise to the concept of "slope" which may be gentle or steep. The various slopes can then be built into higher level items like mountains and hills. Mountains and hills can then be recognized as highland regions. This is what Head (1984) refers to as "chunking".

To achieve optimum instruction therefore, the lesson sought to reinforce the subjects' abilities to chunk. Their ability to chunk would enable them to build concepts from simple to higher level items. By so doing they could efficiently recognize the distribution and the geographic space in which the geographic items are found. Acquisition of these skills would enable subjects to initiate processes that could help them solve higher order map use tasks. Higher order tasks requiring chunking are employed during navigation and visualization. As Elgood (1986) pointed out, at the advanced level of map use, the more sophisticated user is interested in the visualization of spatial patterns formed by the distribution of phenomena. The aim of the test was to examine subjects' abilities to engage in such processes. The lesson therefore taught lexicon items starting with the simple items moving progressively to more complex.

Materials

Simple reference (topographic) maps were drawn for instruction and all participants were provided with copies during instruction. These maps were not the same as those used in the main test. A topographic map attempts to portray relief, drainage, settlements, communication and transportation lines as they exist on the earth's surface. For the purpose of this experiment, a few lexicon items were carefully chosen. These were land surface features which are shown on maps by means of contour lines. Those included here were slopes, valleys, hill, mountain, plateau, ridge, col, and spur. Others such as drainage and spot heights which are not represented with contour were also shown on the map.

In order to make participants appreciate the reality of what was being taught (to reinforce the semantic links), they would ideally be exposed to the actual features in the field. However, due to time constraints, models were used to illustrate these features. These teaching aids show the three-dimensional forms of the features. They are intended to help reinforce the impression of solid landscapes to assist visualization.

The teaching

Participants were introduced to these lexicon items through verbal instruction, illustration from an overhead, and exposure to the model.

Stage One

The first part of the instruction dealt with the exposure of students to a simple map showing contours, valleys, spurs and rivers (Figure 5.2). After giving them the map the following explanation was provided through verbal instruction. An overhead projector was used to explain the features to participants.

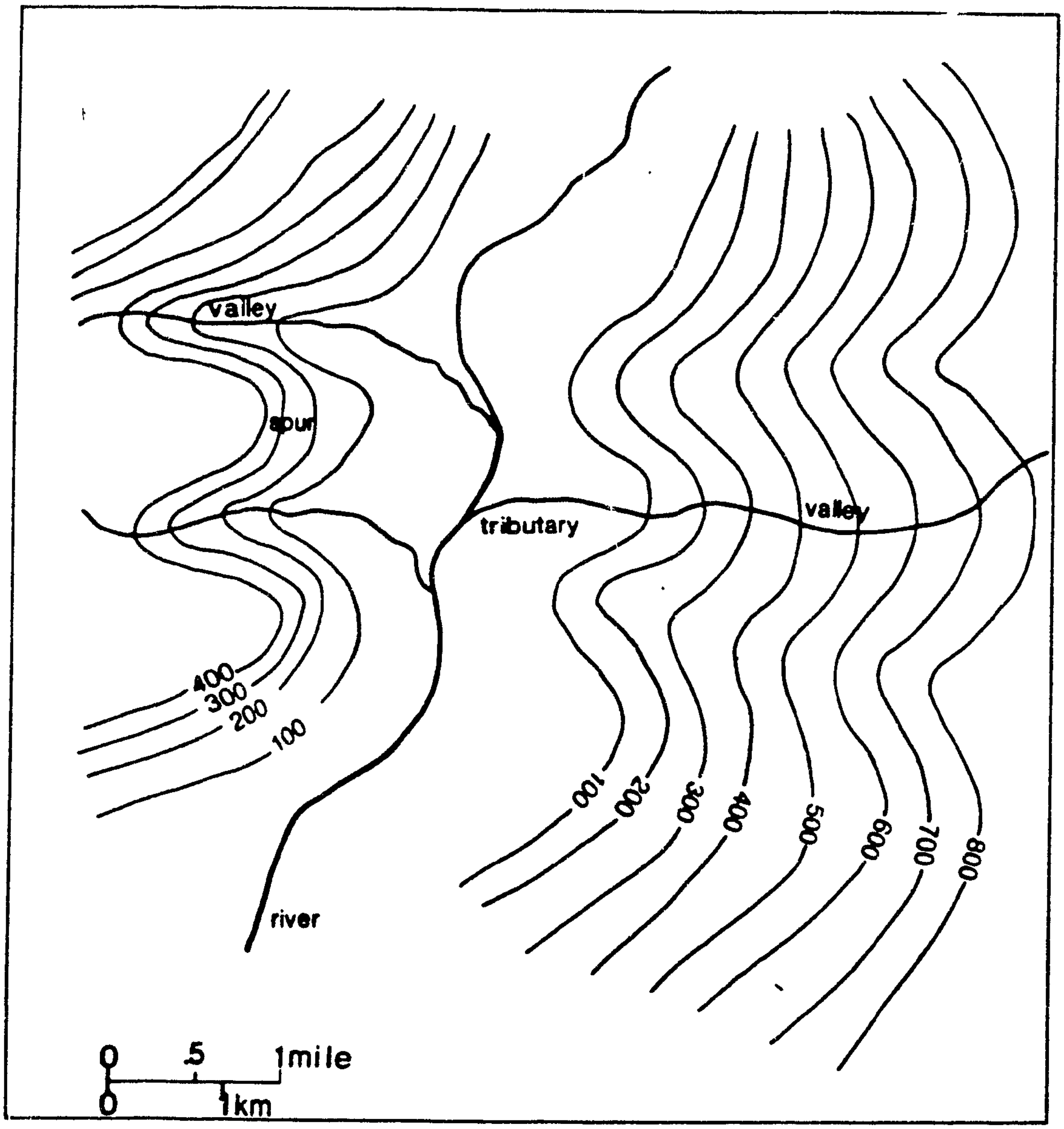
Description of the features

A contour is a line on a topographic map showing areas of the same elevation above sea level. The interval between successive contour lines is referred to as contour interval. It is always constant on any one map sheet.

Apart from contours, spot heights can be used to represent heights above sea level. They are specific points accurately surveyed.

A group of contour lines denotes the degree of slope on the landscape. If the contour lines are widely spaced, a gentle slope

Figure 5.2
SIMPLE LAND SURFACE FEATURES



is indicated and where they are closely spaced a steep slope is indicated.

A valley is a long depression between stretches of high ground usually occupied by a stream. The upland bend of valleys is towards highlands.

A spur is a projection of land from high to low ground. Unlike a valley, the outward bend of a spur is towards lowland.

During this instruction, care was taken to show clearly the building of complex items from lower lexicon items. For example, contours lead to slopes and combinations of slopes lead to features.

Stage Two

The other map showed the distribution of highlands and lowlands (Figure 5.3). Features such as hills, mountains, plateau, wind gap, steep slopes and gentle slopes were shown on the map (Figure 5.3). There was a brief description of these features while participants looked at the map. Further illustration was provided with the models through verbal instruction.

Description of the features

A hill is a feature higher than its surroundings. A mountain is generally higher than a hill, and may often be more rugged in that it has more local difference in elevation. On this map, a hill has an elevation less than 2000 feet above sea level and higher than 200 feet. A mountain has an elevation above 2000 feet.

COMPLEX LAND SURFACE FEATURES

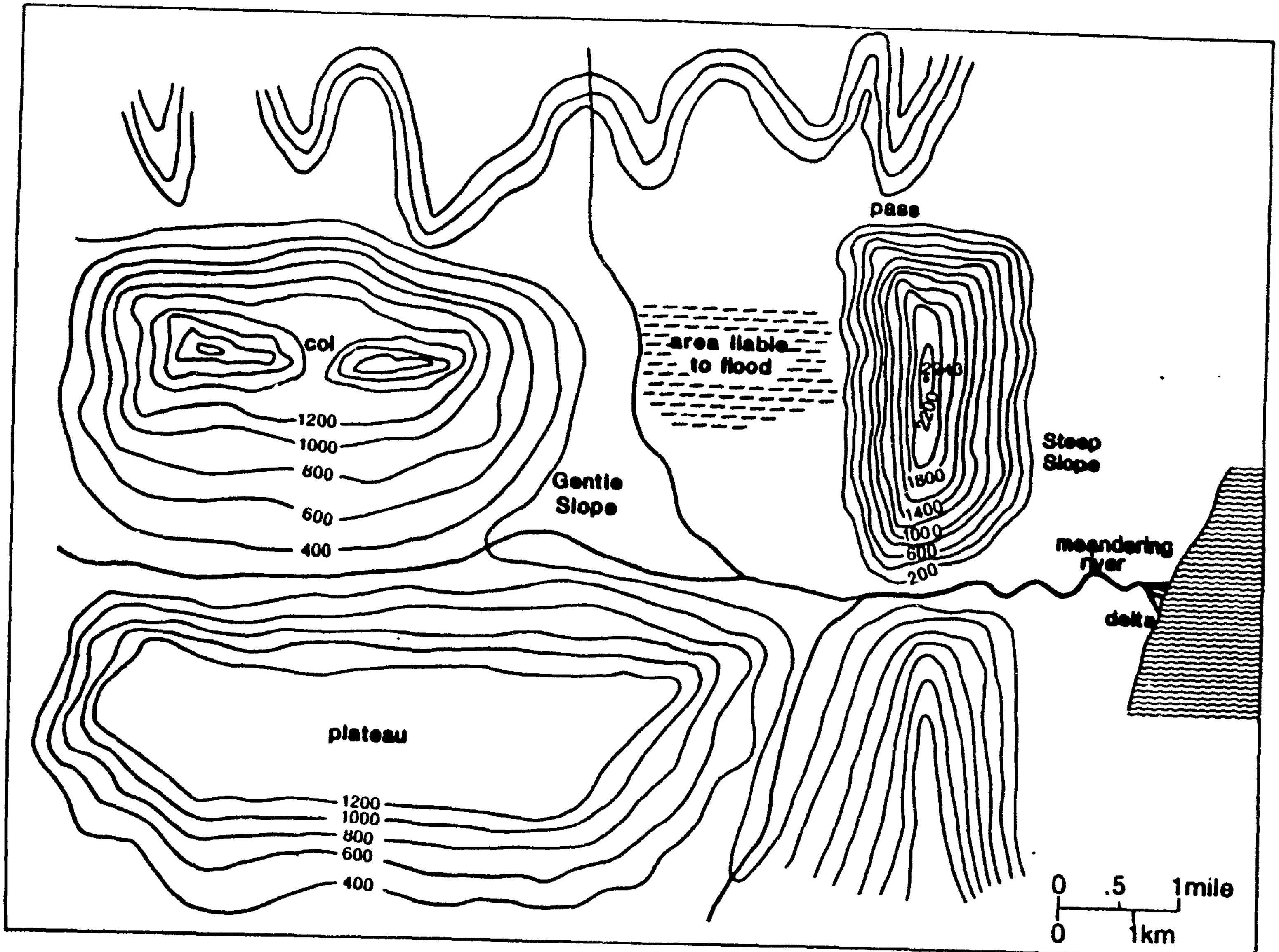


Figure 5.3

A plateau is a highland with comparatively flat surface.

A col is a depression between two highlands.

A pass is a col that provides a route through a line of hills. This may be at a high or low level.

Stage Three

Questions were answered from participants and the maps were taken away from them. The test was then administered to the participants with the help of six assistants. Each assistant timed two participants on question one to the nearest minute using stop watches and wrist watches. Due to lack of appropriate equipment, it was not possible to time all participants on all the questions. Those timed were randomly chosen. Both copies of the test maps were first distributed to the participants. This was followed by the test questions which were presented on one page. The test materials were pre-coded to identify the participants group type (see page 20) and carried a number that allowed correlation of the two maps and the spatial abilities test. Subjects were informed orally to answer the questions independently and every participant was asked to answer question one first. The assistants watched the subjects as they worked on the maps. The subjects were deemed to have finished the question when they had shifted to the next question. After answering question one, the answer sheets were taken away. Subjects were given fifteen minutes to finish the test. Most participants however finished before the fifteen minutes.

Scoring of Responses

All questions were scored out of twenty points. In question one, the twenty points were awarded according to participant's abilities to utilize or avoid such features like cols and height indicated by contours in planning the air route. Five points were awarded to participants who avoided the height above 1800 feet immediately the plane took off (Figure 5.4). Another five points was awarded to those who avoided the second highland area and thus plan the route below 1800 feet. Those who realized that the height represented by 1200 feet was not an obstacle and therefore flew above it were awarded five points. Finally, five points were awarded to those who utilized the col immediately before the plane landed (Figure 5.4). For participants to earn the full twenty points their routes had to conform to what is indicated on Figure 5.4.

Participants were awarded twenty points for answering question two correctly. To earn the maximum points, participants were expected to indicate gentle and steep slopes in the same area (Figure 5.4). They were expected to indicate the features by marking across, labelling or both. Those who identified steep slopes in the highland areas but did not identify gentle slopes in the same area were awarded ten points. The same applied to situations in which participants identified gentle slopes in lowland areas without a corresponding steep slope.

Question three was made up of two sub-questions with each sub-question allotted a maximum of ten points. Participants who

SCORING PROCEDURE

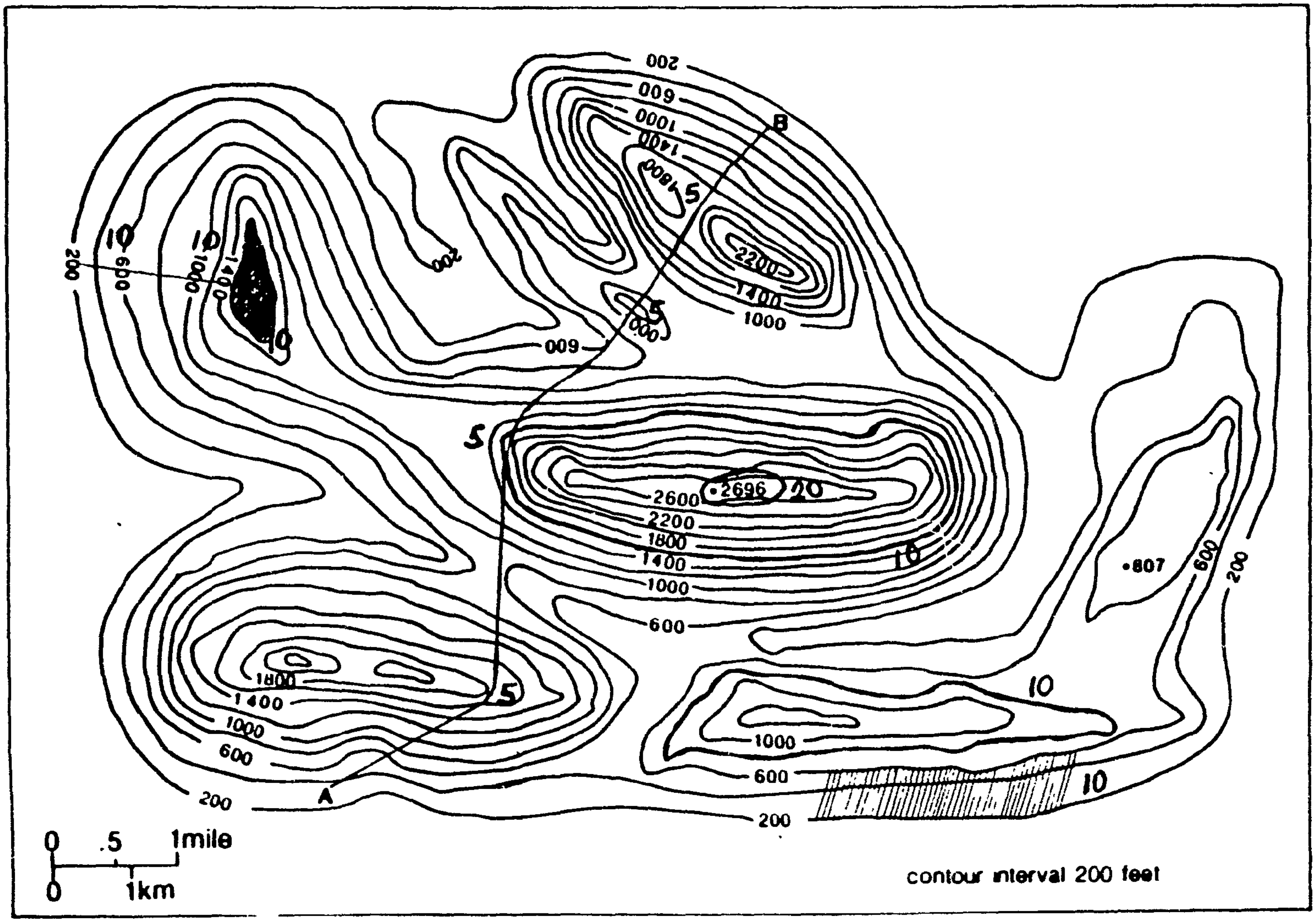


Figure 5.4

shaded an area above 1600 feet and an area below 600 feet were awarded ten points respectively.

With question four, participants were expected to identify and trace a 2000 foot contour and a 800 foot contour which were not labelled. Correct identification of these contour lines was rewarded with ten points each.

The last question was also scored over twenty points. Participants who correctly identified the highest point on the map were awarded twenty points.

Summary

A simple experiment has been developed to explore the possibility of integrating the field of teaching English as a Second Language with cartography. Two groups received twenty minutes of instruction. The intervention involved teaching geographic lexicons. The test questions covered the three levels of map use tasks proposed by Olson (1979).

CHAPTER SIX

RESULTS OF THE EXPERIMENT

To provide a basis for a comparison of the performance of the various groups involved in the test, a spatial abilities test was administered (Appendix 1). Analysis of variance did not show any significant difference between geography and psychology students, $F(1,63) = 0.270$, $p > 0.05$, or between the taught and untaught students, $F(1,63) = 0.319$, $p > 0.05$.

The remainder of this chapter examines the performance of participants on each test question individually. Groups are compared using a 2 x 2 factorial analysis of variance with discipline of study and teaching as independent variables.

The mean scores of participants in each question showed that, overall, those who received instruction did better than those who were not instructed (Table 6.1). Each question had a maximum score of twenty.

	QUESTIONS				
	1	2	3	4	5
Entire Group	12.65	16.71	17.97	18.43	19.37
Psychology Taught	12.86	17.14	18.57	17.86	20.00
Psychology Untaught	6.43	2.86	17.14	14.28	14.28
Geography Taught	14.63	20.00	18.33	18.89	20.00
Geography Untaught	11.87	16.87	17.19	20.00	20.00

Table 6.1: Mean scores in each question.

Question 1

Mark on the map the shortest route from A to B when flying an ultra-light aircraft whose maximum flying height is limited to 1800 feet above sea level and whose minimum flying height is set at 800 feet above sea level.

The first question deals with the highest level task question. Students were therefore expected to use such concepts as contours-indicating height- and col (a pass between highlands) to answer the question correctly.

It was speculated that those subjects who became aware of certain concepts through teaching would perform better. Individual responses suggest that those who were instructed were more aware of the basic map concepts which could help them answer the question correctly.

For example, the psychology taught group recognized that there was a lowland area within a highland region that could be utilized for navigational purposes (Figure 6.1). About 75% of participants from the untaught psychology group did not recognize these features maybe because they did not understand what they meant (Figure 6.2). They therefore failed to plan short routes by taking advantage of these features. They planned their routes along lowland areas. This resulted in longer routes. Their responses show that they understood the concept of height, since their routes were far away from highland areas (Figure 6.2). Thus, they recognized and differentiated between highlands

SAMPLE TEST RESPONSE OF TAUGHT PSYCHOLOGY STUDENTS IN QUESTION 1

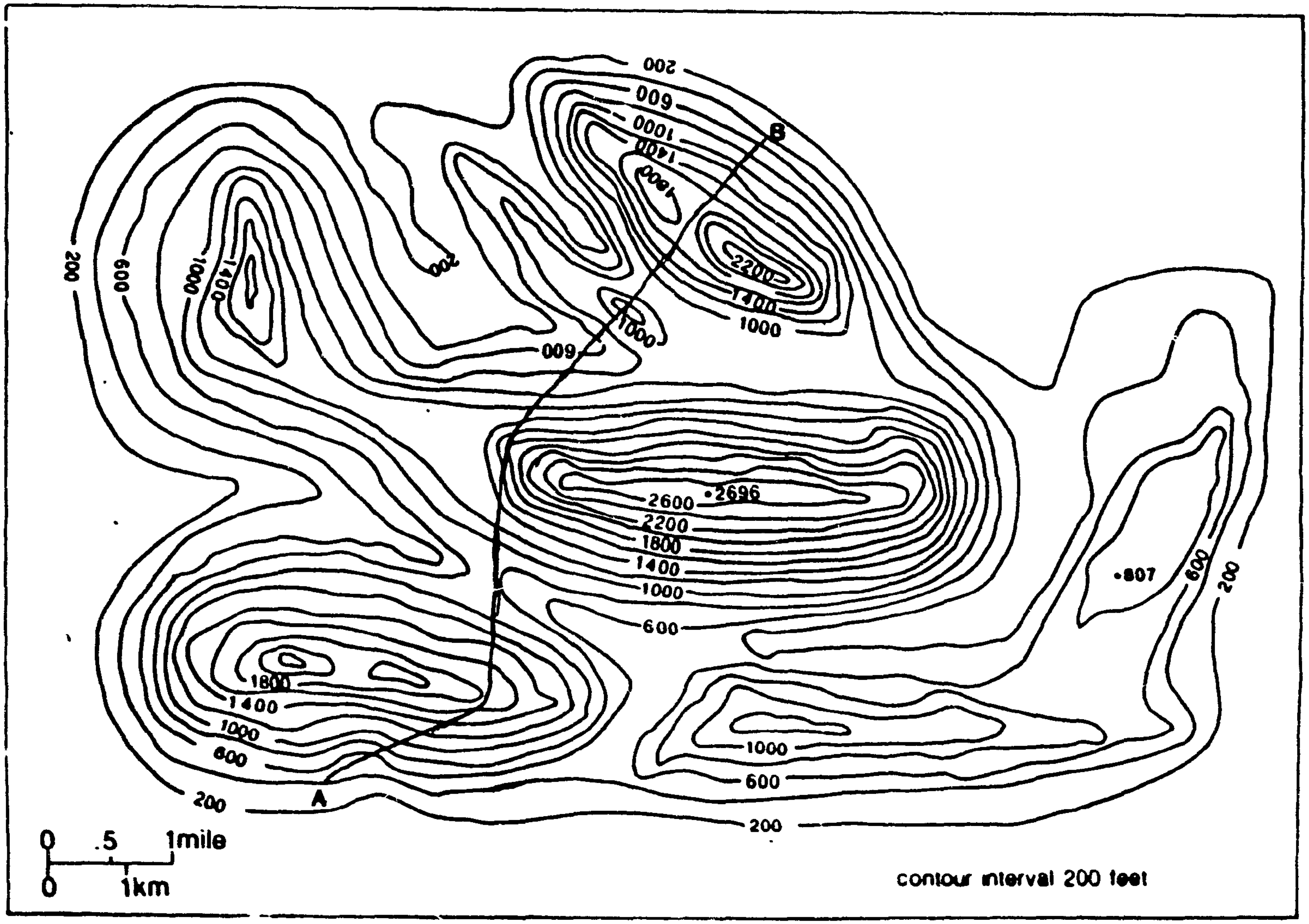


Figure 6.1

SAMPLE TEST RESPONSE OF UNTAUGHT PSYCHOLOGY STUDENTS IN QUESTION 1

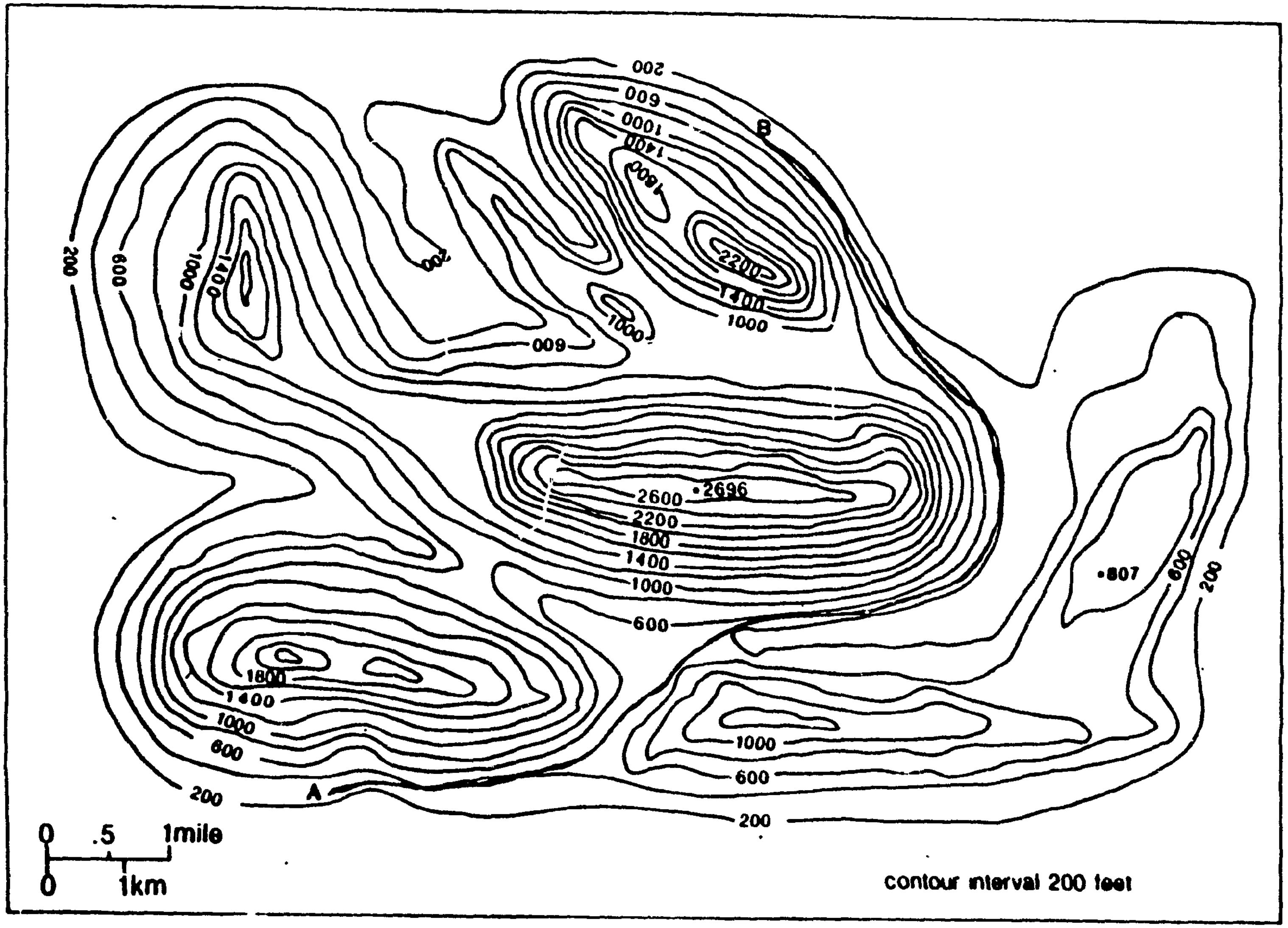


Figure 6.2

and lowlands.

The analysis revealed a significant effect of the type of student, $F(1,60) = 4.41$, $p < 0.05$ (Appendix 5). This reflects the finding that geography students performed better on this question than did psychology students by approximately 18%.

There was a significant effect of teaching, $F(1,60) = 7.13$, $p < 0.05$ (Appendix 5). This reflects the finding that those who were instructed performed better on this question than those who were not instructed. The difference between the two groups was 23%.

The interaction of class and training was not statistically significant, $F(1,63) = 1.14$, $p > 0.05$ (Appendix 5).

Also of interest was the time taken in answering the question. The assumption was that those who received instruction would spend less time looking for clues that could help them answer the question than those who were not instructed.

The responses indicate that the time taken by students to answer the question ranged from one minute to four minutes (Table 6.2).

Time (minutes)	No. of Participants	Percentage
One	1	4.1
Two	9	37.5
Three	11	45.8
Four	3	12.5

Table 6.2: Time taken by selected participants to complete question one.

Because there were few assistants during the experiment, it was impossible to time all participants. Each individual who helped during the experiment could time only two people at a time. Almost 46% of those who were timed completed the task within three minutes. The question then is which group of students completed the task within the shortest possible time?

The student who answered the question within one minute is from the psychology taught group. Other participants belonging to either taught or untaught groups of both disciplines spent between two and four minutes answering the question. In considering psychology taught and untaught students, there was no significant effect on time spent in answering question one, $F(1,19) = 0.20$, $p > 0.05$. This is contrary to the prediction that those who were instructed would perform the task faster. The nature of the data did not allow us to test for the significant difference between geography and psychology students.

Question 2

Outline on the map an area whose lower elevation is gently sloping and higher elevation steeply sloping.

Participants responded more accurately to this question than to question one. The question requires that students know the difference between lower and upper elevations but, in addition, are able to chunk individual contour lines to produce the concept of "slope" and to differentiate between steep and gentle slopes.

Taught geography students did exceptionally well in this question. All participants responded correctly to the question. Comparatively, taught psychology students did far better than untaught psychology students. About 80% of responses of untaught psychology students showed that they were not aware of the concepts of steep and gentle slopes as shown on the map (Figure 6.3). They were not aware that areas with contours closed together represented steep slopes and contours widely spaced represented gentle slopes. However, they knew the difference between high and low elevations. Untaught geography students performed quite well in this question as well. Since this group was not instructed it is assumed that their performance was enhanced by their knowledge in geography.

The results of the analysis of variance showed a significant effect of the type of student, $F(1,60) = 30.72$, $p < 0.05$ (Appendix 5). This reflects the finding that geography students performed better on this question than did psychology students. The mean scores for geography and psychology students in this question were 18.4, and 10.0, respectively. This is not surprising because geography students are in a better position to understand such terms as gentle and steep slopes from their lessons in geography.

A majority of participants in this group recognized steep and gentle slopes (Figure 6.4)

SAMPLE TEST RESPONSE OF UNTAUGHT PSYCHOLOGY STUDENTS IN QUESTION 2

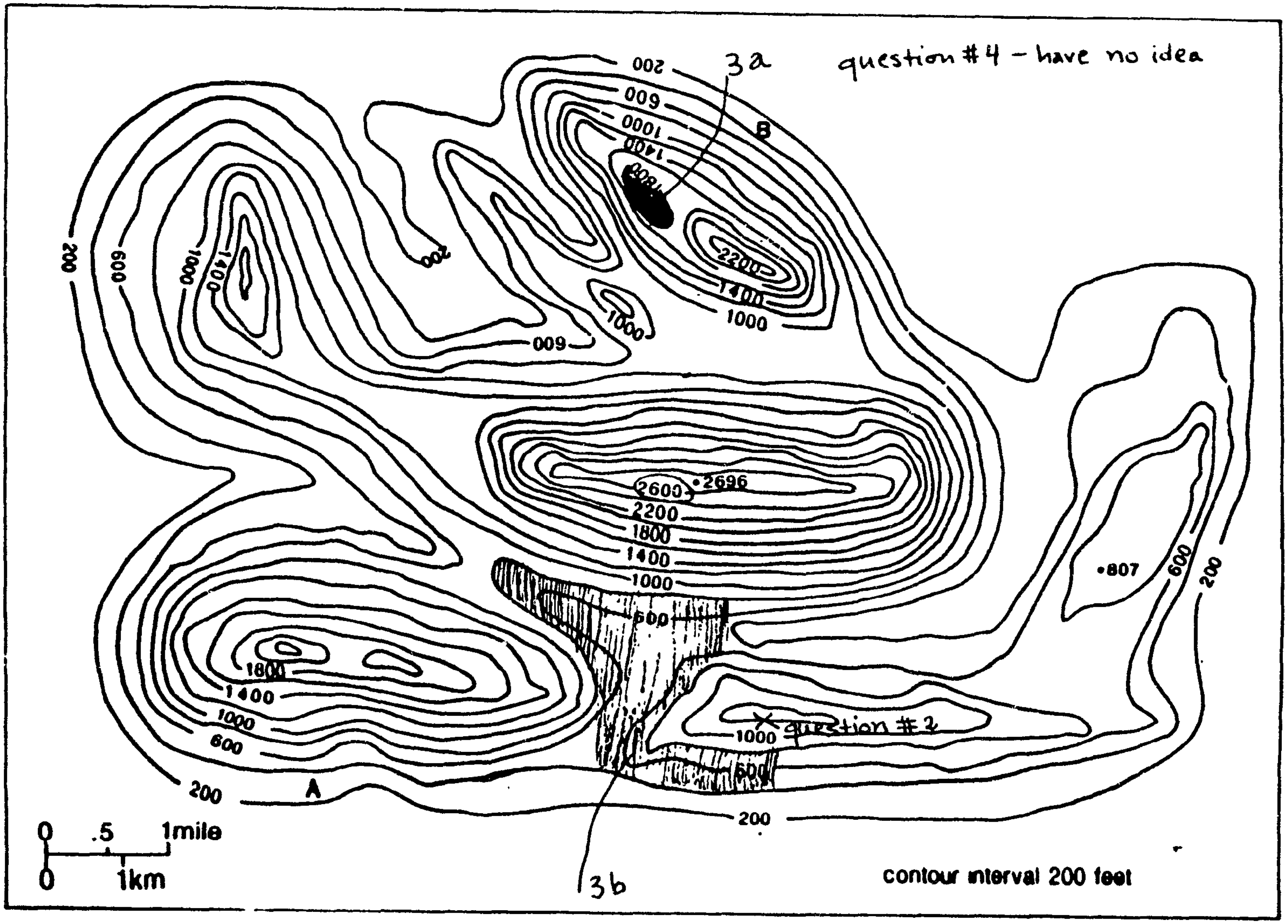


Figure 6.3

The performance in this question was also affected by teaching of map lexicon because there was a significant difference between groups which received and did not receive training, $F(1,60) = 32.70$, $p < 0.05$ (Appendix 5). This effect reflects the finding that those who were instructed performed better than those who were not instructed. The mean values for the taught and untaught groups were 18.5 and 9.9, respectively.

The interaction of the type of student and teaching was statistically significant, $F(1,60) = 13.44$, $p < 0.05$. This reflects the finding that the psychology students benefitted much more from the training session than did the geography students. However, the data do not allow us to draw a definitive conclusion about this difference because the untaught geography students were already at 84% accuracy, thereby leaving little opportunity for geography students to improve following the instruction. No clue was provided as to what makes a slope gentle or steep in this question. In the next question, some quantitative clues are provided.

SAMPLE TEST RESPONSE OF TAUGHT PSYCHOLOGY STUDENTS IN QUESTION 2

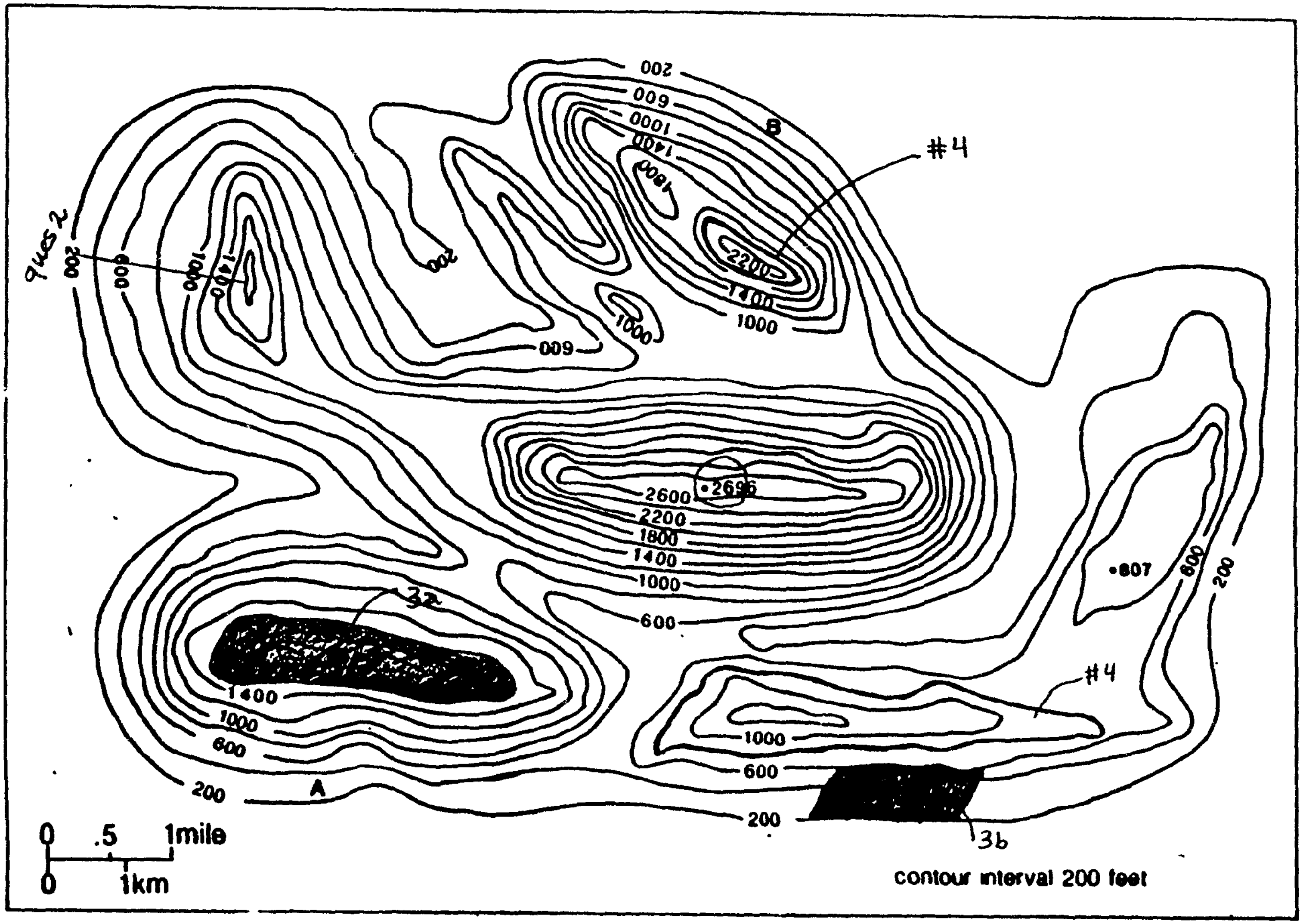


Figure 6.4

Question 3

a) Shade an area of land that is completely at and above 1600 feet above sea level.

b) Shade an area of land that is completely at and below 600 feet above sea level.

Performance on this question was quite high. This is not surprising because the contours are labelled and it is easy to identify them. About 17.2% of the subjects failed to respond correctly to this question. They shaded just slightly above 1600 feet and not even up to the 1800 foot contour. They also shaded below 600 feet but not up to the 400 foot contour. The question is, was it possible for those who were instructed to recognize the dimension involved?

There was no statistically significant effect of the type of student, $F(1,60) = 0.79$, $p > 0.05$ (Appendix 6). This reflects the finding that geography students did not perform better than psychology students in this question. Also, there was no statistically significant effect of training, $F(1,60) = 0.79$, $p > 0.05$ (Appendix 6). This reflects the finding that those who were instructed did not perform better than those who were not instructed. Both taught and untaught groups might have performed well because the question required identification of contour lines which had been labelled. Labelling could have provided a clue. The type of clue provided in the next question is different.

The interaction of discipline of study and training was not statistically significant, $F(1,60) = 0.01$, $p > 0.923$ (Appendix 6). This shows that the geography and psychology students did not differ in terms of the effects of the training session on performance.

Question 4

Trace with a pencil or a pen any 2000 foot contour and any 800 foot contour.

Participants were expected to use their knowledge of contour interval to answer this question correctly. This is because the two contour lines were not labelled. Performance on this question overall was quite good.

Geography students were assumed to be more familiar with this concept. The excellent performance of geography untaught students suggests that geography students are familiar with the concept. Results of the analysis of variance indicated that there was a statistically significant effect of the type of student, $F(1,60) = 6.83$, $p < 0.05$ (Appendix 7). This reflects the finding that geography students performed better in this question than did psychology students.

There was however no significant effect of training, $F(1,60) = 0.91$, $p > 0.05$ (Appendix 7). Those who were instructed did not do better than those who were not instructed. This is not surprising because the question was simple and it is expected that students should be able to identify the contours through simple arithmetic calculations. Does that mean that there is no need for participants to go through any instruction before performing in the lower task questions? This question can be answered after considering question five.

The interaction of the type of student and training was not statistically significant, $F(1,60) = 3.29$, $p > 0.05$. The training session had no differential effect on the performance of geography and psychology students.

Question 5

Circle the highest point on the map.

In this question, three of the four groups showed perfect performance, therefore there was no variability within the data for these groups. It is therefore not possible to analyze the data from this question with inferential statistics.

Participants were expected to use their knowledge of spot height in answering the question. Before the test was conducted, it was expected that all participants would be able to respond correctly to it. Indeed, only two sudents from the psychology untaught group failed to respond correctly. The fact that their counterparts, psychology taught students, were able to respond correctly to the question suggests that these two students failed to read the map accurately by not recognizing that such a height existed.

Summary

The analyses showed that geographic experience affected performance in questions one, two and four. Also, teaching of geographic lexicon items improved performance on questions one and two. This means that the teaching had a significant impact when the map use tasks required higher level map reading processes. The interaction of discipline of study and teaching was statistically significant in question two only. However, the nature of the data did not allow meaningful conclusion.

CHAPTER SEVEN

GENERAL CONCLUSIONS

For about three decades now, various theories have been developed concerning map use. We still have much more to learn, however, about these processes of cartographic communication. "Most early research in map use concentrated on psychophysical studies and because of that, the fundamental concern of how people actually acquire or process information has been largely unattended" (Griffin 1983, p 101).

To address this problem, emphasis was shifted to the understanding of the cognitive processes in map use. Olson (1979, p 41) emphasized the need for this research, and suggested that "the mental construct is far more important in the development of spatial knowledge than is any physical product from which it develops". Both psychophysical and cognitive researchers concentrated on the abilities of participants to perform map use tasks. They failed to address issues related to what needs to be taught and how it can be taught.

Head (1984, p 2) more recently proposed the natural language analogy and concluded that "there are basic underlying structures to our cartographic expression which are utilized by experienced map users". He noted that formal instruction in these structures could improve map use. Head went further to provide a relationship between natural language and map reading which subsequent researchers, among them Eastman (1987), complemented.

Head (1984) claims that natural language, be it written or spoken, can be divided into a series of morphological units which can be related to map language. According to him, in natural language the smallest unit is the grapheme or phoneme (distinctive sound). Head believes that the grapheme or phoneme equivalent is missing from cartographic language, with the graphic variables being more like the "distinctive features" which distinguish one phoneme from the next (Eastman 1987, p 90). "By linking a content to a graphic form, either by convention, or by means of a legend, a graphic sign may be created" (p 90).

Graphic symbols are compound graphic signs that most closely correspond to words (lexemes) in natural language (Eastman, 1987). Eastman noted that the locational attributes of symbols make them comparable to words in natural language.

In natural language, syntagmes are clusters larger than words (Head, 1984). "Graphic syntax is established when form and content are linked to produce the graphic signs from which map symbols are composed" (Eastman 1987, p 91). Eastman further stated that, like natural language, there are definite rules from which this syntax is formed and also like natural language, it is possible to ignore these rules and produce ambiguous, meaningless or misleading statements.

The carto-linguistics paradigm has recognized the essential components of map language which can be identified and instructed. Yet little work has been done to provide empirical data to support arguments of the usefulness of this paradigm. Head and Elgood (1988) provided data to support the idea that instruction in syntax of map language can enhance map use.

This thesis attempted to probe the other basic part of the structure of map language: its units, largely at an intermediate level, that we have called lexemes. We assume that map readers call upon such units from a mental "lexicon". These lexicons may be learned from long experience with maps, or perhaps they can be taught. The objectives of the thesis were to determine the extent to which "geographic experience" and a simple instruction in "lexicon of map language" can affect map communication. This instruction is done within the context of teaching English as a Second Language.

Participants of the experiment consisted of second year honours geography students and second year honours psychology students. The two groups were divided into intervention and control groups. The intervention groups received a twenty minute instruction on geographic lexemes in a classroom setting. All participants were then tested on questions related to the three levels of map use task proposed by Olson (1979). Olson claimed that at level one, map users focus more on individual symbols. Level two requires subjects to recognize properties of group of symbols. Level three is where information from the map is obtained for content-knowledge-building.

The responses showed statistically significant differences between geography and psychology students in questions one, two and four. This suggests that geographic experience does have an impact on map use performance in the higher level task questions and in some cases the lower level task questions.

There was also evidence supporting the fact that participants who were instructed did better than those who were not instructed. This was illustrated by the fact that the taught groups performed better in the questions measuring their abilities in the higher level tasks. In the higher level tasks, participants were expected to use information from the map for decision making. It was found that in question 1 about 60% of those who received instruction were able to identify the shortest and safest route for a low-flying aircraft through a complex topography. They seemed to have utilized such cartographic syntagmes- higher-level lexical items- as "col", "slope" and "height as indicated by contours". Statistical analysis of participants' responses in questions one and two that were designed to measure the subjects' abilities to visualize topography and slopes indicate statistically significant difference between the answers of taught and untaught groups.

There was very little difference between the performance of taught and untaught groups in questions three and four. Although there was no statistically significant difference in their mean values, the scores for the taught groups were marginally higher than the untaught. Thus there is some suggestion that overall performance in even these simpler tasks was improved by the teaching. The interaction of discipline of study and teaching was not statistically significant except in question two.

These results provide an indication that potential exists in teaching lexemes of map language. The fact that a twenty-minute instruction had an impact on performance of participants suggests that carefully-developed and well-planned teaching of such geographic lexemes over a period of time can indeed be useful.

The operational significance of the language analogy is demonstrated in the results of this study especially in the higher level task questions. In order to provide more convincing evidence, it is suggested that subsequent studies should incorporate teaching of both syntax and lexicons. This should be done within the paradigm of teaching English as a Second Language. The concept of teaching cartography as a Second Language appears to be operationally valid.

BIBLIOGRAPHY

1. Abler, R., J. S. Adams and P. Gould (1971). "Spatial Organization: The Geographer's View of the World. Prentice-Hall, New Jersey.

2. Ackerman, E. A. (1957). "Resources for the Future and Resources use Education." Journal of Geography, 51:3, 103-109.

3. Anastasi, A. (1982). Psychological Testing, Macmillan Publishing Company, New York.

4. Anderson, J. M. (1987). "The Relation of Instruction, Verbal Ability, and Sex to the Acquisition of Selected Cartographic Skills in Kindergarten." Unpublished Ph.D. Thesis, University of Wisconsin, Madison.

5. Arnold, E. (1969). Modern Newspaper Design. Harper and Row Publishers, New York.

6. Atkins, C. L. (1981). "Introducing Basic Map and Globe Concepts in Young Children." Journal of Geography, 80:6, 228-233.

7. Balchin, W. G. V. (1972). "Graphicacy." Geography, 57:3, 185-195.

8. Balchin, W. G. V. and A. M. Coleman (1966). "Graphicacy should be the Fourth Ace in the Pack." The Canadian Cartographer, 3:1, 23-28.

9. Balogun, O. Y. (1978). "Cartographic Information Transferral: A New Look at Communication in Cartography." Paper Presented at the Third Australian Cartographic Conference, Brisbane.

10. Barber, G. M. (1988). Elementary Statistics for Geographers. The Guilford Press, New York.

11. Blades, M. and C. Spencer (1986). "Map Use by Young Children." Geography, 17:1, 47-52.

12. .... (1987). "How Do People Use Maps to Navigate Through the World?" Cartographica, 24:3, 64-75.

13. Bluestein, M. and L. Acredolo (1979). "Developmental Changes in Map Reading Skills." Child Development, 50:3, 619-697.

14. Blaut, J. M. and D. Stea (1971). "Studies of Geographic Learning." Annals of the Association of American Geographers, 61:2, 387-393.

15. .... (1974). "Mapping at the Age of Three." Journal of Geography, 73:7, 5-11.

16. Board, C. (1975). "Map Reading Tasks Appropriate in Experimental Studies in Cartographic Communication." Paper Presented to the First International Symposium on Cartographic Communication, London.

17. .... (1978). "Map Reading Tasks Appropriate in Experimental Studies in Cartographic Communication." The Canadian Cartographer, 13:1, 1-12.

18. .... (1981). "Cartographic Communication". Cartographica, 18:2, 42-70.

19. .... (1984). "Higher Order Map-using Tasks: Geographical Lessons in Danger of Being Forgotten". Cartographica, 21:1, 85-97.

20. Board, C. and R. M. Taylor (1977). "Perception and Maps: Human Factors in Map Design and Interpretation." Transactions: The Institute of British Geographers, 2:1, 19-36.

21. Boardman, D. (1983). Graphicacy and Geographic Teaching. Croom Helm, London.

22. .... (1989). "The Development of Graphicacy: Children's Understanding of Maps". Journal of Geography, 74:4, 321-331.

23. Brandes, D. (1976). "The Present State of Perceptual Research in Cartography." The Cartographic Journal, 13:2, 172-176.

24. Brookfield, H. C. (1952) "Cartographical Appreciation." in Map Interpretation. G. H. Dury ed., Pitman Publishing, London.

25. Brown, H. D. (1987). Principles of Language Learning and Teaching. Prentice-Hall, New Jersey.

26. Byrne, R. W. (1979). "Memory for Urban Geography." Quarterly Journal of Experimental Psychology, 31:1, 147-154.

27. Campbell, D. and J. Stanley (1972). Experimental and Quasi-Experimental Designs for Research. Rand McNally and Company, Chicago.

28. Carrol, J. B. (1983). "Studying Individual Differences in Cognitive Abilities: Through and Beyond Factor Analysis." in Individual Differences in Cognition, Dillon, F. and R. R. Schmeek eds., Academic Press, New York.

29. Castellan, N. J. Jr. and F. Restle (1979). eds., Cognitive Theory, Hillsdale, New Jersey.

30. Castner, H. W. (1973). Electro-oculography in Cartographic Research. A Paper Presented at Canada Association of Geographers

Annual Meeting, Queens University, Kingston.

31. .... (1979). "Viewing Time and Experience as Factors in Map Design Research." The Canadian Cartographer, 16:2, 145-158.

32. Castner, H. W. and J. R. Eastman (1985). "Eye-movement Parameters and Perceived Map Complexity: 2". The American Cartographer, 12:1, 107-118.

33. Chang, K. and R. Antes (1987). "Sex and Cultural Differences in Map Reading." The American Cartographer, 14:1, 29-42.

34. Chaudron, C. (1988). Second Language Classrooms: Research on Teaching and Learning. Cambridge University Press, Cambridge.

35. Clarke, J. I. (1959). "Statistical Map Reading." Geography, 44:2, 96-104.

36. Corsini, R. J. (1984). Encyclopedia of Psychology. John Wiley and Sons, New York.

37. Cole, D. G. (1981). "Recall vs. Recognition and Task Specificity in Cartographic Testing." The American Cartographer, 8:1, 55-66.

38. Crawford, P. V. (1973). "Perception of Graduated Squares as Cartographic Symbols." The Cartographic Journal, 10:2, 85-88.

39. Cuff, D. J. (1974). "Impending Conflict in Color Guidelines in Maps of Statistical Surfaces." The Canadian Cartographer, 11:1, 54-58.

40. Dacey, M. F. (1970). "Linguistic Aspects of Maps and Geographic Information." Ontario Geography, 5, 71-80.

41. Dale, P. E. (1971). "Children's Reactions to Maps and Aerial Photographs." Area, 3:3, 170-177.

42. DeLucia, A. (1972). "The Effect of Shaded Relief on Map Information." The Cartographic Journal, 9:1, 14-18.

43. .... (1976). "How People Read Maps: Some Objective Evidence." Technical Papers ACSM, 36, 135-144.

44. Dent, B. D. (1970). "Perceptual Organization Research Report 5." Department of Geography, Clark University, Worcester.

45. Dent, O. (1965). "Map comparison Survey." Department of Sociology, Australian National University, Canberra.

46. .... (1985). Principles of Thematic Map Design. Addison-Wesley, Don Mills, Ontario.

47. Dobson, M. W. (1977). "Eye Movement Parameters and Map Reading." The American Cartographer, 4:1, 39-58.

48. Dornbach, J. E. (1967). "An analysis of the map as an information system display." Unpublished Ph.D. thesis, Clark University, Worcester.

49. Eastman, R. J. (1985). "Graphic Organization and Memory Structures for Map Learning." Cartographica, 22:1, 1-20.

50. .... (1987). "Graphic Syntax and Expert Systems for Map Design." Technical Papers, ASPRS-ACSM Annual Papers, 4, 87-96.

51. Elgood, R. J. (1986). "Impacts of Teaching on Cartographic Language Acquisition." Unpublished B.A. thesis, Department of Geography, Wilfrid Laurier University, Waterloo.

52. Ellis, R. (1986). Understanding Second Language Acquisition. Oxford University Press, Oxford.

53. Ericsson, K. A. and H. A. Simon (1984). Protocol Analysis. MIT Press, Massachussetts.

54. Evans, B. D. and R. T. Pezdek (1980). "Cognitive Mapping: Knowledge of Real-World Distance." Journal of Experimental Psychology: Human Learning and Memory, 6:1, 13-24.

55. Eysenck, H. J. and W. Arnold (1972). Encyclopedia of Psychology, Search Press, London.

56. Faerch, C. and G. Kasper (1983). eds., Strategies in Interlanguage Communication. Longman, London.

57. Finocchiaro, M. (1969). English as a Second Language: From Theory to Practice. Simon & Schuster, New York.

58. Flannery, J. J. (1956). "The Graduated Circle: A Description, Analysis and Evaluation of a Quantitative Map Symbol." Unpublished Ph.D. Dissertation, University of Wisconsin, Madison.

59. .... (1971). "The Relative Effectiveness of some common Graduated Point Symbols in the Presentation of Quantitative Data." The Canadian Cartographer, 8:2, 96-109.

60. Forgus, R. H. and L. E. Melamed (1976). Perception: A Cognitive-Stage Approach, McGraw-Hill, New York.

61. Fry, C. M. (1988). "Maps for the Physically Disabled." The Cartographic Journal, 25:1, 20-29.

62. Gerber, R. (1982). "The Young Map User and the Positioning of

Names on Maps." Cartography, 12:3, 162-167.

63. .... (1984). "Factors Affecting the Competence and Performance in Map Language for Children at the Concrete Level of Map-Reasoning. Cartography, 13:3, 205-213.

64. Giannangelo, D. M. and B. M. Frazee (1977). Map Reading Proficiency of Elementary Educators." Journal of Geography, 76:1, 63-65.

65. Gilmartin, P. P. (1981). "The Interface of Cognitive and Psychophysical Research in Cartography." Cartographica, 18:3, 9-20.

66. .... (1985). "The Design of Journalistic Maps: Purposes, Parameters and Prospects." Cartographica, 22:4, 1-18.

67. Gilmartin, P. P. and J. C. Patton (1984). "Comparing the sexes on spatial abilities: Map-use skills." Annals of the Association of American Geographers, 74:4, 605-619.

68. Graham, H. (1968). Reading Topographic Maps, Holt, Rinehart and Winston of Canada, Toronto.

69. Griffin, T. L. C. (1983). "Problem Solving on Maps- The Importance of User Strategies". The Cartograpahic Journal, 20:2, 101-109.

70. Guelke, L. (1977). ed., "The Nature of Cartographic Communication." Cartographica, Monograph 19, Toronto.

71. .... (1979). "Perception, Meaning and Cartographic Design", The Canadian Cartographer, 16:1, 61-69.

72. Hartshorne, R. (1939). "The Nature of Geography", Annals of the Association of American Geographers, 29:3&4.

73. Head, C. G. (1972). "Land-water Differentiation in Black and White Cartography." Cartographica, 9:1, 25-38.

74. .... (1981). "Cartographic Communication as a Natural Language." Provisional Discussion Paper, Wilfrid Laurier University, Waterloo.

75. .... (1984). "The Map as a Natural Language: A Paradigm for Understanding." Cartographica, 21:1, 1-32.

76. Head, C. G. and R. J. Elgood (1988). "Impacts of Teaching on Cartographic Language Acquisition: Applying the Linguistics Paradigm to the Process of Map Use." in Report on the First North American Working Seminar on the concepts of Cartographic Language, C. Grant Head ed., Wilfrid Laurier University,

Waterloo,

77. Hill, L. A. (1974). Selected Articles on the Teaching of English as a Foreign Language, Oxford University Press, Oxford.

78. Hodgkiss, A. G. (1981). Understanding Maps: A Systematic History of their Use and Development. Dawson and Son Ltd, London.

79. Hunt, J. (1981). "Communication and Cartography: Some Developments." The Bulletin of the Society of University Cartographers, 15:1, 37-44.

80. Jenks, G. F. (1973). "Visual Integration in Thematic Mapping: Fact or Fiction"? International Yearbook of Cartography, 13.

81. Jolliffe, R. (1974). "An information Theory Approach to Cartography." Cartography, 8:4, 175-181.

82. Keates, J. S. (1982). Understanding Maps. Longman Group, Harlow, Essex.

83. Kolacny, A. (1969). "Cartographic Information- A Fundamental Concept and Term in Modern Cartography." The Cartographic Journal, 6:1, 47-49.

84. Krashen, S. D. (1982). Principles and Practice in Second Language Acquisition. Pergamon Press, Oxford.

85. Lawrence, G. R. P. (1971). Cartographic Methods. Methuen, London.

86. Leimer, J. A. (1982). "The Influences of the Technical Constraints and Personnel Limitations on the Quality of Maps in American Newspapers." Unpublished Master's thesis, University of Wisconsin, Madison.

87. Liben, L. S. and R. M. Downs (1986). "Children's Comprehension of Maps: Increasing Graphic Literacy." Pennsylvania State University, Final Report to the National Institute of Education, Grant NIE-G-83-0025, Pennsylvania.

88. Littlewood, W. T. (1984). Foreign and Second Language Learning: Language-Acquisition Research and Its Implications for the Classroom. Cambridge University Press, London.

89. Lloyd, R. (1989). "Cognitive Maps: Encoding and Decoding Information." Annals of the Association of American Geographers 79:1, 101-124.

90. Lloyd, R. and T. Steinke (1981). "Cognitive Integration of Objective Choropleth Map Attribute Information." Cartographica, 18:1, 13-23.

91. .... (1985). "Comparison of Quantitative Point Symbols: The Cognitive Process." Cartographica, 22:1, 59-77.

92. Maccoby, E. E. and C. N. Jacklin (1974). The Psychology of Sex Differences. Stanford University Press, Stanford.

93. MacEachren, A. M. (1979). "Communication Effectiveness of Choropleth maps: The Influence of Visual Complexity." unpublished Ph.D. Dissertation, Department of Geography-Meteorology, University of Kansas, Kansas.

94. Mackay, J. R. (1954). "Experiments with some Symbols and Map Projections." Annals of the Association of American Geographers, 44:2, 225-226.

95. McDermott, P. D. (1967). "Map Use in our Schools." Journal of Geography, 61:2, 74-78.

96. McGee, M. G. (1979). Human Spatial Abilities. Praeger, New York.

97. McNaughton, R. B. (1986). "The Making and Use of Maps By Orienteers." Ontario Geography, 28, 19-29.

98. Marino, J. S. (1979). "Identification of Characteristic Points Along Naturally-Occurring Lines: An Empirical Study." The Canadian Cartographer, 16:1, 70-79.

99. Mark, D. W. and M. McGranaghan (1988). "Map Use and Map Alternatives: An Experiment In Intraurban Navigation." The Canadian Geographer, 32:1, 69-75.

100. McCarty, H. H. and N. E. Salisbury (1961). "Visual Comparison of Isopleth Maps as a Means of Determining Correlations Between Spatially Distributed Phenomena". State University of Iowa, Iowa City.

101. Meux, A. H. (1961). Reading Topographical Maps, University of London Press, London.

102. Miller, J. W. (1967). "Measuring Perspective Ability." Journal of Geography, 61:4, 167-171.

103. Moar, K. L. and L. A. Bower (1983). "Inconsistency of Spatial Knowledge." Memory and Cognition, 11:2, 107-113.

104. Modley, R. (1966). "Graphic Symbols for World-Wide Communication in Sign, Image, Symbol, G. Kepes ed., George Braziller, New York.

105. Monkhouse, F. J. and H. R. Wilkinson (1964). Maps and Diagrams. Metheun, London.

106. Morrison, J. L. (1974). "Testing the Effectiveness of Road Speed Maps and Conventional Road Maps." The Cartographic Journal, 11:1, 102-116.

107. .... (1978). "Towards a Functional Definition of the Science of Cartography." American Cartographer, 5:2, 97-100.

108. .... (1984). "Applied Cartographic Communication: Map Symbolization for Atlases." Cartographica, 21:1, 1-32.

109. Muehrcke, P. C. (1973). "The influence of Spatial Autocorrelation and Cross Correlation on Visual Map Comparison." Proceedings of the American Congress on Surveying and Mapping, 33rd Annual Meeting, Washington, D.C. 315-325.

110. .... (1973). "Visual Pattern Comparison in Map Reading." Proceedings of the Association of American Geographers, 5, 190-194.

111. .... (1978). Map Use, Reading, Analysis and Interpretation. J. P. Publications, Madison.

112. .... (1981). "Maps in Geography." Cartographica, 18:2, 1-37.

113. .... (1982). "An Integrated Approach to Map design and Production." The American Cartographer, 9:2, 109-122.

114. Muir, S. P. M. and B. Frazee (1986). "A Developmental Perspective." Elementary Social Studies, 87:2, 199-203.

115. Needheim, J. (1959). Science and Civilization in China. University Press, Cambridge.

116. Neilson, W. A. (1934). ed. Webster's New International Dictionary of the English Language." G. and C Merriam Co., Springfield.

117. Neisser, U. (1976). Cognition and Reality: Principles and Implications of Cognitive Psychology. W. H. Freeman, San Francisco.

118. Olson, J. M. (1968). "Visual Comparison of Maps." Department of Geography, University of Wisconsin, Madison.

119. .... (1975). "Experience and the Improvement of Cartographic Communication." The Cartographic Journal, 12:2, 94-108.

120. .... (1976). "A Coordinated Approach to Map Communication Improvement." The American Cartographer, 3:2, 151-160.

121. .... (1979). "Cognitive Cartographic Experimentation." The Canadian Cartographer, 16:1, 34-44.

122. .... (1985). "Future Research Directions in Cartographic Communication and Design." in Progress in Contemporary Cartography, ed., D. R. F. Taylor, John Wiley and Sons, London.

123. Pearce, P. L. and N. Black (1984). "Dimensions of National Park Marks: A Psychological Evaluation." Cartography, 13:3 189-203.

124. Pei, M. (1966). Glossary of Linguistic Terminology. Anchor Books, New York.

125. Pellegrino, J. W. (1985). "Anatomy of Analogy." Psychology Today, 19:10, 49-54.

126. Petchenik, B. B. (1977). "Cognition in Cartography." Cartographica, Monograph 19, 117-128.

127. .... (1979). "From Place to Place: The Psychological Achievement of Thematic Mapping." The American Cartographer, 6:1 5-12.

128. .... (1983) "A Map Maker's Perspective on Map Design." in Progress in Contemporary Cartography, ed., D. R. F. Taylor, John Wiley and Sons, New York.

129. .... (1985) "Value and Values in Cartography." Cartographica, 22:3, 1-59.

130. Peterson, M. P. (1979) "An Evaluation of Unclassed Crossed-Line Choropleth Mapping." The American Cartographer, 6:1, 21-37.

131. .... (1987). "The Mental Image in Cartographic Communication." The Cartographic Journal, 24:1, 35-41.

132. Random House Dictionary of the English Language. (1966). Random House, New York.

133. Roberts, J. (1977). "An Essay in Communication." Cartography 10:2, 100-102.

134. Robinson, A. H. (1952). The Look of Maps; An Examination of Cartographic Design, University of Wisconsin Press, Madison.

135. .... (1977). "The Uniqueness of the Map." Cartography, 10:2, 73-74.

136. Robinson, A. H. and B. B. Petchenik (1976). The Nature of Maps: Essays Toward Understanding Maps and Mapping. Chicago

Press, Chicago.

137. Robinson, H. A., R. D. Sale, J. L. Morrison, and P. C. Muehrcke (1984). Elements of Cartography. John Wiley and Sons, New York.

138. Sandford, H. A. (1985). "Objectives of Non-Professional Map Use." The Bulletin of the Society of University Cartographers 19:1, 7-11.

139. .... (1980). "Maps Design for Children." The Bulletin of the University Cartographers, 14:1, 39-50.

140. Sauer, C. O. (1956). "The Education of a Geographer." Annals of the Association of American Geographers, 46:3.

141. Salichtchev, K. A. (1983). "Cartographic Communication: A Theoretical Survey." in Progress in Contemporary Cartography, ed., D. R. F. Taylor, John Wiley and Sons, New York.

142. Schaubel, E. V. (1971). "Mapping Expedients to Meet Military requirements." in Map design and the map user, ed., Castner, H. W. and G. McGrath, Cartographic monograph 2, 12-17.

143. Schlichtmann, H. (1985). "Characteristics Traits of the Semiotic System 'Map Symbolism'." The Cartographic Journal, 22:1, 23-30.

144. Schneider, D. O. (1976). "The Performance of Elementary Teachers and Students on a Test of Map and Globe Skills." Journal of Geography, 75, 326-332.

145. Serbert, L. M. (1984). Map Reading, Renouf Publishing (Ontario) Ltd, Toronto.

146. Sheskin, I. M. (1985). Survey Research for Geographers, Commercial Printing Inc., Washington, D.C.

147. Shimron, J. (1975). On Learning Maps. Technical Report, La Jolla, CA: Center for Human Information Processing, University of California, San Diego.

148. .... (1978). "Learning Positional Information from Maps." The American Cartographer, 5:1, 9-20.

149. Shortridge, B. G. and R. B. Welch (1980). "Are we Asking the Right Questions"? The American Cartographer, 7:1, 19-23.

150. Speak, P. and A. H. C. Carter (1970). Map Reading and Interpretation, Longman, London.

151. Steinke, T. R. (1979). "An Evaluation of Map Design and Map

reading using eye movement recordings." unpublished Ph.D. dissertation, University of Kansas.

152. .... (1987). "Eye Movement Studies in Cartography and Related Fields." Cartographica, 24:2, 40-73.

153. Stevens, B. D. and J. S. Coupe (1978). "Distortions of Spatial Relations." Cognitive Psychology, 10:4, 422-437.

154. Streeter, L. A. and D. Vitello (1986). "A Profile of Drivers' Map Reading Abilities." Human Factors, 28:2, 223-239.

155. Wardhaugh, R. (1965). "TESOL: Current Problems and Classroom Practices." in Teaching English as a Second Language, H. B. Allen and R. N. Campbell eds, McGraw-Hill, New York.

156. .... (1972). Introduction to Linguistics. McGraw-Hill, New York.

157. Thorndyke, P. W. and S. E. Golden (1981). Spatial Learning and Reasoning Skill, The Rand Corporation, R-2805-ARMY.

158. Thorndyke, P. W. and C. S. Hayes-Roth (1982). Differences in Spatial Knowledge." Cognitive Psychology, 14:4, 560-589.

159. Thorndyke, P. W. and C. Stasz (1980). "Individual Differences in Procedures for knowledge Acquisition from Maps." Cognitive Psychology, 12:1, 137-178.

160. Wilford, J. N. (1981). The Map Makers. Alfred A. Knopf, New York.

161. Williams, L. G. (1971). "Obtaining Information from Displays with Discrete Elements." Cartographica, Monograph 2, 14-36.

162. Win, W. (1987). "Communication, Cognition, and Children's Atlases." Cartographica, 24:1, 61-81.

163. Wolf, H. B. (1981). ed. Webster's New Collegiate Dictionary. Thomas Allen and Son Limited, New York.

164. Wood, M. (1972). "Human Factors in Cartographic Communication." The Cartographic Journal, 9:2, 123-134.

165. Yarnal, C. M. M. and Coulson, M. R. C. (1982). "Recreational Map Design and Map Use: An Experiment." The Cartographic Journal, 19:1, 16-27.

APPENDIX 1

VISUALIZATION PROBLEM SOLVING

Researchers in the field of spatial cognition and information processing have developed numerous tests which can be used to test individual spatial ability (Pellegrino, 1985). Among these are a variety of visualization problems which test the ability to sense and maintain geometric forms. The two tests used to examine participants spatial abilities are: Paper Form Board and Surface Development.

Paper Form Board

This test involves presentation of a geometric figure which is divided into different parts and five answer frames containing an assembled form (Figure 7.1). The task of the examinee is to select the one answer frame showing how the disassembled figure would look if the parts were fitted together (Anastasi, 1982, p. 444).

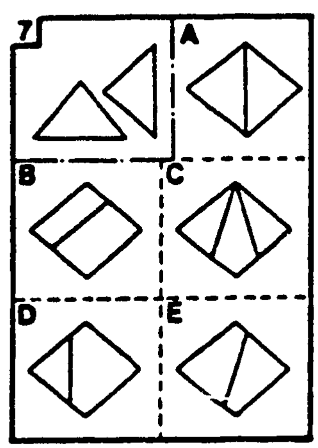


Figure 7.1 SAMPLE PAPER FORM BOARD QUESTION FRAME

Source: Anastasi, Psychological Testing, 1982, p. 444

Surface Development

The task requires the examinee to determine which of the completed three-dimensional patterns is consistent with the unfolded pattern (Figure 7.2).

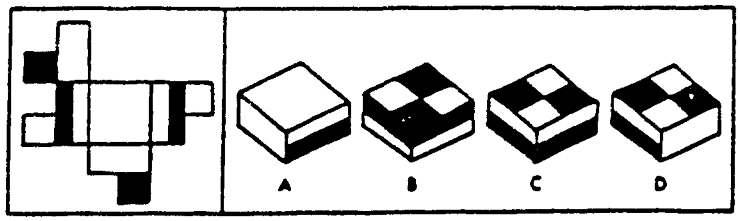


Figure 7.2 SAMPLE PROBLEM OF SURFACE DEVELOPMENT

Source: Pellegrino, "Anatomy of Analogy", Psychology Today, 1985, p. 54

These two tests were administered to the participants during the main test. The questions on spatial abilities were answered after participants had answered the main questions. The test took only a few minutes to complete. An individual was scored on the basis of choosing the correct answer. Each participant was awarded ten points for choosing the correct answer.

Analysis of the results

Analysis of variance revealed no significant differences between taught and untaught groups, $F(1,63) = 0.319$, $p > 0.05$, and between geography and psychology students, $F(1,63) = 0.270$, $p > 0.05$.

Table 7.1: Mean Scores of Participants in Spatial Abilities Test.

	No. of Participants	Range of Score	Mean Score
Taught Psychology Students	14	5-10	6.43
Untaught Psychology Students	7	5-5	5.00
Taught Geography Students	27	5-10	5.94
Untaught Geography Students	16	5-10	5.56

APPENDIX 2

INSTRUCTION GIVEN TO PARTICIPANTS

A contour is a line on a topographic map showing areas of the same elevation above sea level. The interval between successive contour lines is referred to as contour interval. It is always constant on a particular map.

Apart from contours, spot heights can be used to represent heights above sea level. They are points accurately surveyed and they represent specific points.

A group of contour lines denote the type of slope on the landscape. If the contour lines are widely spaced they represent a gentle slope and where they are closely spaced, they represent a steep slope.

A valley is a long depression between stretches of high ground usually occupied by a stream. The bend of valleys is towards highlands.

Other features represented by groups of contour lines include: hill or mountain, plateau, col and pass.

A hill or a mountain is a feature higher than its surroundings. We sometimes think of a mountain as generally higher than a hill, and it may often be more rugged, that is have more local difference in elevation.

A plateau is a highland with comparatively flat surface.

A col is a depression between two mountains.

A pass is a col that provides a route through a line of hills. This may be at a high or low level.

APPENDIX 3

TEST QUESTIONS ADMINISTERED TO PARTICIPANTS

INSTRUCTION

Study the map carefully and answer the following questions. Question 1 should be answered first and on a separate map (Figure 5.1). Questions 2, 3, 4, and 5 should be answered on the other map. You are allowed fifteen minutes to complete the test.

Question 1: Mark on the map the shortest route from A to B when flying an ultra-light aircraft whose maximum flying height is limited to 1800 feet above sea level and whose minimum flying height is set at 800 feet above sea level.

Question 2: Outline on the map an area whose lower elevation is gently sloping and higher elevation steeply sloping.

Question 3: a) Shade an area of land that is completely at and above 1600 feet above sea level.
b) Shade an area of land that is completely at and below 600 feet above sea level.

Question 4: Trace with pencil any 2000 foot contour and any 800 foot contour.

Question 5: Circle the highest point on the map.

APPENDIX 4

RAW DATA SET

	TEST QUESTIONS						SPATIAL ABILITIES TEST	
	1	2	3	4	5	Time (mins.)	A	B
PTA	10	20	20	20	20	2	5	0
PTB	0	20	20	20	20	2	5	0
PTC	10	20	20	20	20	2	5	0
PTD	10	20	20	20	20	3	5	5
PTE	20	20	20	20	20	1	5	0
PTF	20	20	20	20	20	3	5	5
PTG	20	20	10	10	20	2	5	0
PTH	15	20	20	20	20	3	5	0
PTI	15	20	20	10	20	2	5	0
PTJ	5	20	10	20	20	4	5	0
PTK	20	20	20	10	20	3	5	0
PTL	20	20	20	10	20	2	5	5
PTM	5	20	20	20	20	3	5	0
PTN	15	10	20	20	20	3	5	5
PUA	5	20	20	20	20	3	5	0
PUB	5	0	20	20	20	2	5	0
PUC	20	0	20	20	20	2	5	0
PUD	5	0	20	20	20	3	5	0
PUE	5	0	20	0	0	2	5	0
PUF	5	0	0	0	0	3	5	0
PUG	0	0	20	20	20	2	5	0

GTA	20	20	20	20	20	N/T	5	0
GTB	20	20	20	20	20	"	5	0
GTC	15	20	20	20	20	"	5	0
GTD	20	20	20	20	20	"	5	0
GTE	10	20	20	20	20	"	5	0
GTF	5	20	20	20	20	"	5	0
GTG	5	20	20	20	20	"	5	0
GTH	15	20	20	20	20	"	5	0
GTI	5	20	20	20	20	"	5	0
GTJ	20	20	20	20	20	"	5	0
GTK	15	20	15	20	20	"	5	0
GTL	10	20	15	20	20	"	5	0
GTM	10	20	20	20	20	"	5	5
GTN	10	20	0	20	20	"	5	0
GTO	15	20	20	20	20	"	5	0
GTP	15	20	20	20	20	"	5	0
GTQ	20	20	20	20	20	"	5	0
GTR	15	20	20	10	20	"	5	0
GTS	20	20	20	20	20	"	5	0
GTT	15	20	5	10	20	"	5	0
GTU	20	20	20	20	20	"	5	0
GTV	10	20	20	20	20	"	5	0
GTW	15	20	20	20	20	"	5	5
GTX	15	20	20	20	20	"	5	0
GTY	20	20	20	20	20	"	5	0
GTZ	20	20	20	20	20	"	5	0

GTAA	20	20	20	20	20	"	5	0
GUA	15	20	20	20	20	"	5	0
GUB	20	20	15	20	20	"	5	0
GUC	10	0	20	20	20	"	5	0
GUD	5	20	20	20	20	"	5	0
GUE	0	20	20	20	20	"	5	0
GUF	5	20	10	20	20	3	5	0
GUF	5	20	10	20	20	N/T	5	0
GUG	20	20	20	20	20	4	5	0
GUH	10	20	20	20	20	N/T	5	0
GUI	20	20	20	20	20	"	5	5
GUJ	0	20	10	20	20	3	5	0
GUK	20	20	20	20	20	N/T	5	0
GUL	10	20	20	20	20	3	5	0
GUM	15	20	20	20	20	N/T	5	5
GUN	15	20	20	20	20	"	5	5
GUO	10	10	20	20	20	4	5	0
GUP	15	0	0	20	20	N/T	5	0

Explanation to the abbreviations:

PT = Taught psychology
PU = Untaught psychology
GT = Taught geography
GU = Untaught geography
N/T = Not timed

APPENDIX 5
RESULTS OF 2X2 ANALYSIS OF VARIANCE FOR QUESTION 1

Source of variation	Sums of squares	df	Mean square	F	Significance
Class	166.06	1	166.06	4.41	0.040
Training	268.72	1	268.72	7.13	0.010
Class X Training	43.01	1	43.01	1.14	0.290
Residual	2261.47	60	37.69		

APPENDIX 6
RESULTS OF 2X2 ANALYSIS OF VARIANCE FOR QUESTION 2

Source of variation	Sums of squares	df	Mean square	F	Significance
Class	907.40	1	907.40	30.72	0.000
Training	965.92	1	965.92	32.70	0.000
Class X Training	396.92	1	396.92	13.44	0.005
Residual	1772.32	60	29.54		

APPENDIX 7
RESULTS OF 2X2 ANALYSIS OF VARIANCE FOR QUESTION 3

Source of variation	Sums of squares	df	Mean square	F	Significance
Class	0.12	1	0.12	0.00	0.947
Training	21.12	1	21.12	0.79	0.379
Class X Training	0.25	1	0.25	0.01	0.923
Residual	1612.72	60	26.88		

APPENDIX 8
RESULTS OF 2X2 ANALYSIS OF VARIANCE FOR QUESTION 4

Source of variation	Sums of squares	df	Mean square	F	Significance
Class	145.01	1	145.01	6.83	0.011
Training	19.29	1	19.29	0.91	0.344
Class X Training	69.87	1	69.87	3.29	0.075
Residual	1275.81	60	21.23		