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NAME OF SUPERVISOR/NOM DU DIRECTEUR DE THÈSE T.P. Wilkinson

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COGNITIVE DEVELOPMENT IN MAP STUDIES:
AN EXAMINATION OF COGNITIVE OBJECTIVES AND SEQUENCE IN A SCHOOL
MAP STUDIES CURRICULUM

BY

Barbara E. Farrell

■ A thesis submitted to the Faculty of
Graduate Studies in partial fulfillment
of the requirements for the degree
of Master of Arts

Department of Geography
Carleton University
Ottawa, Ontario
1978

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The undersigned recommend to the Faculty of Graduate Studies
and Research acceptance of the thesis

"COGNITIVE DEVELOPMENT IN MAP STUDIES: AN
EXAMINATION OF COGNITIVE OBJECTIVES AND
SEQUENCE IN A SCHOOL MAP STUDIES CURRICULUM"

submitted by Barbara Eileen Farrell, B.A., in partial
fulfilment of the degree of Master of Arts.

.....
Supervisor of Thesis
Department of Geography

.....
Supervisor of Graduate Studies
Department of Geography

.....
Chairman, Department of Geography

Carleton University

August 1, 1978

ABSTRACT

This paper is concerned with graphic education. It seeks to study the relationship between graphicacy and cognitive development by examining a typical school map studies curriculum. The curriculum is examined for its potential for contributing to cognitive development initially from the point of view of the cognitive challenge inherent in its objectives, and secondly, from the point of view of the sequence of its map education tasks. An alternative framework for map studies curricula is suggested which attempts to apply to map education the ideas of recent research in cognitive development. The importance of the early topological and projective stages of development becomes evident, and it is suggested that a more adequate teaching programme during these stages might forestall many of the misconceptions which result from traditional map studies programmes in schools. A more graphicate population, able to cope more effectively with the spatial needs of the modern world, might thereby result.

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"He loved maps, and in his hall there hung a large one of the County Round with all his favourite walks marked on it in red ink." Bilbo Baggins in The Hobbit.

CHAPTER 1

MAP STUDIES AND COGNITION

1.1 Introduction

This thesis falls into two sections. It commences with an examination of the potential of a school map studies curriculum for developing cognitive abilities, and subsequently proposes an alternative structure on which curriculum planning for map studies in schools can be based. In the initial stage a selected map studies curriculum, the South Carleton Family of Schools, Geography Curriculum 1974, was tested against an established taxonomy of cognitive objectives (Bloom, et al. 1956) in order to determine the level of cognitive challenge inherent in its objectives. The Curriculum was chosen because of its relatively structured approach and its specific statement of objectives (Chapter 1).

As a result of this first phase of the study, (Chapter 2), it became evident that, although the Curriculum appeared defective, the taxonomy itself had deficiencies which affected its value for testing the educational objectives of a map studies curriculum (Chapter 3). These deficiencies are discussed and attention is given to psychological, as distinguished from educational, ideas about the development of cognition, particularly in relation to maps (Chapter 4).

The Curriculum is re-examined in the light of these ideas, and major shortcomings are revealed. A structure for developing map studies curricula is then outlined using, tentatively, four basic periods, and the kinds of map studies and materials suitable for each period are suggested (Chapter 5).

Before considering in detail the first phase of the study and its results, it is necessary to explain the assumptions concerning map studies, and to examine the nature of cognition and its relation to curriculum planning in the identification and classification of cognitive objectives.

1.2 Map Studies

1.2.1 Definitions

The term 'map studies' is used in this thesis to cover all those activities in schools which involve the use of graphic language. Within this term are included air photographs, field sketches, models, diagrams and graphs, as well as maps: that is, all methods pertaining to the visual representation of data relating to the earth's surface and spatially distributed phenomena, and to the development of visual-spatial ability. Because all of these graphic forms are essential to the visual representation of spatially distributed phenomena they are included when the terms 'map studies' and 'maps' are used.

'Visual thinking' refers to that form of reasoning in which "perceiving and thinking are indivisibly intertwined" (Arnheim 1969, v.).

When the term 'visual thinking' is used it is used only in relation to that part of visual thinking involved in the representation and analysis of the features of, or phenomena associated with the earth's surface. The relatively freer visual thinking of artistic imagination and expression is excluded.

Graphic language is viewed as the formal expression of visual thinking. It does not have a linear, sequential, pattern like verbal languages, but is a two-dimensional language using point, line and area symbolism to represent and analyse real world distributions and relationships, which, in many cases, have spatial connotations. The distributions and relationships involved may be concrete, visible elements of landscape, both natural and man-made, such as hills, valleys, rivers, coasts, forests, cities, buildings, bridges, roads; they may also be intangible or frequently changing phenomena such as boundaries, land-ownership patterns and recreational activities.

1.2.2 Map Types

The kind of phenomena depicted, and map scale, combine to form three fundamental types of maps with which education usually deals:

a) Reference maps depict relatively extensive areas and are concerned only with the basic political or physical characteristics of a region. They are used mainly for locational and very generalized information. Reference maps in atlases are a good example, and the typical school use of globes is

included in this category.

b) Topographical maps show detailed landscape characteristics at relatively large scale (as used here, 1:50,000 or larger), and are used for the analysis of limited areas. Although they are available for most parts of the world, numbers and cost often preclude their use in schools except in work concerning the specific school locality or as samples of more distant areas. Examples typifying the characteristics of particular areas of the world are often collected into books of maps and associated exercises for teaching purposes.

c) Thematic maps are used to represent data concerning a particular topic. They are used in the analysis of either one, or a very limited number of particular distributions. At small scales they are found in both atlases and textbooks; large scale thematic maps, although often in existence, are not widely available in the schools.

1.2.3 Operations of Map Learning

In discussing the nature of maps, Robinson and Petchenik (1976) have pointed out that, although maps are frequently used as an analogy for disciplines other than cartography, the precise nature of the mental operations involved in the use of this visual language is still not clearly understood.

The operations performed when students learn to use maps are similar in many respects to those involved in the learning of a foreign literary language. There are two basic components. First, it is necessary to learn the grammar and structure of the language, in this case the visual symbols for information,

and the constraints on their usage. Secondly, the rules of the language are then applied to understanding spatial information in either a map-creative or a map-interpretative mode.

Map interpretation involves the analysis of an existing map, and translation from visual to verbal explanation. It may be carried out on either topographic or thematic maps. Map creation, on the other hand, requires the analysis, symbolization and translation of data into two-dimensional map form. Creative map making in schools does not normally involve the design and production of printed maps but is represented in relatively independent sketch map production ranging from the perceptual, scale-free representations of the young child to the more sophisticated thematic analyses of later years.

It must be emphasized, however, that there are fundamental ways in which map studies are quite unlike any literary study. In the first place map making requires an ability to conceptualize distance and area, and to depict these in terms of a given scale ratio by the process of generalization. In thematic maps a third dimension of quantity is frequently added to increase the complexity of the process. Secondly, as Muehrcke (1974) has shown, a highly developed visual imagination is required which allows the mind to project beyond the lines and symbols shown on the map, in order to recreate, mentally, the real world phenomena depicted. This is a much more complex and important process than is normally appreciated in education. Both of these activities may be described as aspects of visual thinking.

1.2.4 Role of Map Studies in Education

Of what value, then, are map studies considered to be in education? Map learning has traditionally been taught both in North America and Britain as part of the geography/social studies curriculum. The literature of geographical education, more than that of any other discipline, has continually stressed the fundamental importance of map learning (Fairgrieve 1937, Warman 1954, Scarfe 1956 and 1965, Long 1964, Garnett 1965, Bunge 1966, Harvey 1969, Balchin 1970 and 1973, Graves 1971, Gopsill 1973), and emphasized its role in the development of visual-spatial ability.

Balchin has coined the word 'graphicacy' to indicate the "...educated skill that is developed from the visual-spatial ability of intelligence, as distinct from the verbal or numerical abilities " (Balchin 1970, p.28). Balchin considers graphicacy to be of basic importance and argues that articulatory, literacy, numeracy and graphicacy should become the core of the educational curriculum: English, Math and Geography would then become the foundation school subjects. That this has not been recognized by the educational system is clear. There is, too, an ambivalent attitude on the part of many geographers towards maps. Hughes (1975) has most recently commented on the inconsistency between principles and practice with regard to maps. The history of maps clearly illustrates that visual-spatial ability is evident in primitive man, and recent studies have indicated that it also exists in very young children (Blaut and Stea, 1971). There is, however, no clear indication

that the educational system serves well the purpose of educating this inherent ability. (It should be noted that there may be hereditary differences in the extent of this ability but consideration of such differences is beyond the scope of this thesis.)

It is for these reasons that this thesis is concerned with the cognitive rather than the affective or psycho-motor aspects of map education, and that the decision was made to select a map studies curriculum for testing in terms of its cognitive objectives.

1.3 Cognition

1.3.1 Definition

Cognition refers to the mental or intellectual processes by which knowledge is acquired. It has been defined by Rowland, et al. (1971, p.2) as "...knowledge-ordering behaviour which integrates a number of sensory, imaginal and symbolic cues...." Bloom (1956, p.2) defines it as comprising 'such mental activities as "... remembering and recalling knowledge, thinking, problem solving, creating...."

1.3.2 Developing Cognitive Abilities

An increase in the efficiency of cognitive processes, that is, the development of whatever innate cognitive ability exists, can come about in two ways:

a) by the practice of intellectual skills. The educational system is but one component of the total formal, and informal, learning environment of an individual, and it is the part of

this environment in which a conscious, and structured, attempt is made to practice and develop cognitive skills. This is the only aspect of the practice of intellectual skills which is considered here.

b) By the natural maturing process of human growth. This process takes place regardless of the effects of education, but, if the practice provided by education is to be effective, then educational curricula must be devised within the constraints imposed by maturation. Thus the sequence, as well as the intellectual content, of educational tasks becomes important. The effects of both practice and maturation on the map studies curriculum are considered in the thesis.

The initial stages, however, are concerned only with the former: the deliberate attempt to increase the cognitive complexity of educational tasks in order to develop cognitive ability. The method which Bloom advocates, and which South Carleton adopted, in order to achieve this goal is the provision of specific objectives.

1.3.3 Educational Objectives and Bloom's Taxonomy

The term 'objectives' is accepted here in the sense defined by current educational practice, that is, as distinguished from the overall aims, or goals of education (Wheeler 1967, Marsden 1976, Graves 1975, Bennetts 1973 and 1972). Aims have been subject to criticism on the grounds that, although admirable in intent, they are vaguely expressed. Thus they are open to widely differing interpretations, are difficult to attain, and their achievement even more difficult to measure. They are,

perhaps, more appropriately discussed with reference to the affective or psychomotor domains.

The principal statement of the role of objectives is contained in Bloom's Taxonomy of Educational Objectives, Book 1. The Cognitive Domain.

Bloom's purpose is to promote cognitive development by encouraging teachers to evaluate the cognitive potential of their objectives by using the taxonomy. The taxonomy is an hierarchical classification of educational objectives based upon the kind and quality of mental activity required of the student. By classifying an objective in accordance with the taxonomy, that objective's potential for encouraging cognitive development can be assessed.

In order, however, that the taxonomy may be used, objectives must be stated in precise, behavioural terms. Bloom is therefore concerned to encourage the use of objectives which state explicitly in what ways a student is expected to change, (in this case cognitively), as a result of each learning experience (Bloom 1956, p.12). He argues that, if educational objectives are expressed in terms of these cognitive behaviours, then it will be possible to measure whether or not an objective has been achieved. It might be noted that this latter statement of Bloom's refers to change in the efficiency of cognitive processes rather than to changes over time. The taxonomy does not address the question of the sequence of objectives.

But the taxonomy is more than a simple set of classes of parallel value. Each class of objectives is intended to

represent a set of more complex skills than the preceding class, and the higher categories include elements of the lower. Bloom's purpose therefore is to encourage teachers to use objectives which involve the use of higher, that is, most intellectually challenging, levels of the taxonomy.

An outline list of Bloom's taxonomy is shown in Table 1.1.*

The declared purpose of the taxonomy is to assist teachers to define objectives for their own subject area in such a way that:

1. the range of ideas concerning the cognitive aims for any particular subject area can be extended;
2. the development of intellectual abilities and skills, rather than rote memory learning, can be encouraged;
3. the particular cognitive behaviour expected of the student is clearly expressed, and words open to widely differing interpretations, such as 'understanding', 'thinking', 'problem solving', may either be avoided or made explicit;
4. the attainment of the objective can be easily measured by the evaluation process.

Bloom considers that, since the taxonomy is descriptive, it is applicable to widely differing types of schools and philosophies of education. In addition, it is claimed that the

*Bloom's summary of the characteristics of each of these classes is included as Appendix 1.

CATEGORIES OF THE TAXONOMY

1.00 Knowledge

1.10 Knowledge of Specifics

1.11 Knowledge of Terminology

1.12 Knowledge of Specific Facts

1.20 Knowledge of Ways and Means of Dealing with Specifics

1.21 Knowledge of Conventions

1.22 Knowledge of Trends and Sequences

1.23 Knowledge of Classifications and Categories

1.24 Knowledge of Criteria (Standards of Judgment)

1.25 Knowledge of Methodology

1.30 Knowledge of the Universals and Abstractions in a Field

1.31 Knowledge of Principles and Generalizations

1.32 Knowledge of Theories and Structures

INTELLECTUAL ABILITIES AND SKILLS

2.00 Comprehension

2.10 Translation

2.20 Interpretation

2.30 Extrapolation

3.00 Application

4.00 Analysis

4.10 Analysis of Elements

4.20 Analyses of Relationships

4.30 Analysis of Organizational Principles

5.00 Synthesis

5.10 Production of a Unique Communication

5.20 Production of a Plan, or Proposed Set of Operations

5.30 Derivation of a Set of Abstract Relations

6.00 Evaluation

6.10 Judgments in Terms of Internal Evidence

6.20 Judgments in Terms of External Criteria

taxonomy is useful for all types of subject matter and for all levels of the educational system.

1.4 The South Carleton Curriculum

1.4.1 Background

Bloom's taxonomy has been described in a text for students of education as "... one of the most influential books in curriculum development" (Hooper 1971, p.281). It has had a widespread influence on curriculum planning by providing a milieu in which the specification of detailed objectives for learning in a particular subject field became highly commendable. Evidence of this can be found in much of the work in curriculum design in geography being undertaken in Ontario at about the time when the South Carleton Curriculum was being prepared.* Senathirajah and Weiss (1971), in a book highly influential in geography curriculum planning, advocated the use of behavioural objectives and stressed their relevance to evaluation. Mills (1973), in addition, stressed the importance of teacher involvement in curriculum planning. There was a general atmosphere in Ontario education which promoted the value of objectives and of evaluation. This influence is expressed in the South Carleton Curriculum (South Carleton, 1974, Appendix 2. p.140) as an "observed need" which prompted the development of the Curriculum.

The South Carleton Curriculum itself indicates the advantages which the teachers involved in its preparation perceived:

*Evidence of ongoing work in curriculum design in geography in Ontario can be found in such studies as: Elliott and Sager Eds. Curriculum Design in Geography; H. Mills "Programme Developments in Geographic Education" The Monograph, 1973; and Senathirajah and Weiss Evaluation in Geography, 1971.

the precise formulation of objectives would indicate to other teachers in the 'family' exactly what they were expected to achieve at any given time. The individual teacher would then be able to devise learning experiences directly related to the given objectives. The total exercise would help to reduce variations in standards between individual teachers and the several schools of the 'family' (South Carleton, 1974, Appendix. 2, pp. 140-143).

1.4.2 Characteristics

The South Carleton Curriculum comprises three parts: a general introduction to the philosophy and structure of the geography/social studies courses from Kindergarten to Grade 13 (K-13); two flow charts* for Globe Skills and Map Skills and Concepts (K-13); and the Sequence Chart of Map and Globe Skills and Understandings which is made up of numerous 'behavioural' objectives for Kindergarten to Grade Six.

The introduction to the Curriculum asserts that the discipline of geography is founded of nine conceptual frameworks,**

* In rather confusing terminology both the flow chart and the list of objectives are referred to in the Curriculum as sequence charts.

** This philosophy is derived from the Ontario Ministry of Education, Intermediate Division, Geography 1973, 'Interim Guideline: Man and the Earth which indicates the following nine basic ideas in Geography: 1) Regionalism 2) Areal Differentiation 3) Spatial Interaction 4) The Support of Life 5) Resources 6) Man the Chooser 7) Constant Change 8) A Global Viewpoint 9) The Round Earth. The same framework is retained in Curriculum Guideline for the Intermediate Division Geography, 1977.

although only the last of these, the Round Earth is dealt with in this Curriculum. It is made clear that it is intended that behavioural objectives be derived from the conceptual frameworks, viz: "Geography as a discipline is built around NINE CONCEPTUAL FRAMEWORKS. To give our studies a sense of direction and clear cut BEHAVIOURAL OBJECTIVES, each of us must remind ourselves of these frameworks and the concepts and skills contained in each" (South Carleton, 1974). Within each 'framework' the committee defines a core of material ('MUST KNOWS') which is to be taught at the grade levels indicated on the Sequence Charts (Flow Charts) K-13 provided. The task of integrating the material into the regional framework for geography courses identified by the Ontario Ministry of Education* is left to the teacher.

The flow charts Globe Skills and Map Skills and Concepts indicate the 'must knows', i.e. the "overall sequence of skills and concepts which form the nucleus of Geographical Understanding". They show the "very latest" grade at which a particular skill is to be introduced and those at which it is to be "maintained, reinforced and extended".

The Sequence Chart of Map and Globe Skills and Understandings is a much more detailed list of behavioural objectives applying only to Grades K-6. The objectives for each grade are listed under the following concepts:

1. The Earth - Size, Shape and Motion

*K-1 Family 2 Neighbourhood 3/4 Other Communities 5 Eastern Hemisphere 6 Western Hemisphere 7 North America 8 Southern Lands 9 Europe and Asia 10 Canada 11/12 Specific Specialized Area 13 Canada.

2. Direction - Orientation
3. Location
4. Scale - Distance
5. Symbols
6. Use - Interpretation

These concepts are claimed to be those "most consistently recognized by authorities [unnamed] in the teaching of maps and globes". The purpose of the chart is to:

Provide a framework for teachers from which pupils may be guided to learn the language necessary for reading and interpreting maps and globes. This is achieved through participation in appropriate learning activities.

In the primary grades the reading of simple globes and maps, along with informal interpretive experiences, comprises the major emphasis.

In order to assess the potential of these objectives for encouraging cognitive development, they were classified by the author according to Bloom's taxonomy. The results of this analysis are described in Chapter 2.

CHAPTER 2

CLASSIFICATION OF SOUTH CARLETON OBJECTIVES

2.1 Introduction

This chapter falls into three main sections: First, the characteristics of the various levels of Bloom's taxonomy are described and their meaning in terms of typical map studies is given. In order to establish that Bloom's taxonomy had relevance for map studies, these examples were not drawn from the South Carleton Curriculum but were deliberately derived from the author's experience without reference to the Curriculum objectives. To facilitate comparison, this section, with the exception of the descriptive introduction to each class, is shown in Tables 2.1 - 2.8. In the tables Bloom's classes are shown in the left column and the author's map studies equivalents in the right.

After this determination of the meaning of Bloom's taxonomy, the behavioural objectives of the South Carleton Curriculum from Grades K-6 are classified according to the taxonomy. and the distribution of objectives by class is analysed.

The distribution is commented on in the final section and some problem areas are introduced which help in formulating an alternative or rational curriculum (Chapter 3, 4, and 5).

2.2 The Classes of Bloom's Taxonomy Applied to Map Studies

2.2.1 Knowledge (Level 1.00)*

A fundamental distinction is made in the taxonomy between Knowledge (L 1.00) and Intellectual Abilities and Skills (Ls 2.00-6.00). Knowledge is information "filed or stored in the mind" ** (Bloom, et al., 1956, p. 29). The cognitive processes involved in the acquisition of knowledge are, according to Bloom, simply remembering and recall: "For taxonomy purposes we are defining knowledge as little more than the remembering of the idea or phenomena in a form very close to that in which it was originally encountered " (pp. 28-9). The detailed meaning of 'knowledge' in the taxonomy is identified in Tables 2.1 to 2.3, in which are demonstrated the wealth of map studies material which can be assigned to this class. How suitable this level is for dealing with map studies has, however, to be considered. In some cases memory and recall are a vital foundation for future use as, for example, in the recall of map symbolism (L 1.21), or in the proper sequencing of tasks (L 1.22). In other cases memorization can lead to mere 'busy-work', as in the location of places (L 1.12), or become an unnecessarily tedious way of learning material, for example, trends in map-making (L 1.22).

* Subsequent references to the levels of Bloom's taxonomy will be made in the form of L 1.00, L 2.00, etc.

** In this chapter, because frequent reference is made to Bloom, et al., 1956, subsequent references will be abbreviated to a simple page number.

TABLE 2.1

KNOWLEDGE OF SPECIFICS (L 1.10)

TAXONOMYAPPROPRIATE MAP STUDIES
MATERIAL FOR THE TAXONOMY1.11 Knowledge of Terminology

"Knowledge of the referents for specific verbal and non-verbal symbols."
(p. 63).

Includes no more than a memorized definition of the term.

Recall of terms and simple concepts particularly appropriate to work with maps and globes; i.e. the acquisition of a technical 'map' vocabulary: globe, scale, contour, choropleth, bathymetry... and so on.

1.12 Knowledge of Specific Facts

"Knowledge of dates, events, persons, places, sources of information, etc.".

N.B. This includes knowledge of sources as well as the information itself. The facts involved are those "which can be isolated as separate, discrete elements in contrast to those which can be known only in a larger context."
(p. 65).

Recall of specific facts such as location, shape, distance; simple concepts.

Knowledge of atlases, indexes and gazetteers as sources of locational information.

TABLE 2.2

KNOWLEDGE OF WAYS AND MEANS OF DEAL-
ING WITH SPECIFICS (L 1.20)

TAXONOMY

APPROPRIATE MAP STUDIES
MATERIAL FOR THE TAXONOMY

1.20 Knowledge of Ways and Means of
Dealing with Specifics

"Knowledge of ways of organizing, studying, judging, and criticizing ideas and phenomena."

This involves knowledge of, and potential use of, the ways and means rather than their actual use.

1.21 Knowledge of Conventions

Knowledge of "characteristic ways of treating and presenting ideas and phenomena", i.e., ways which are "...true only as a matter of definition and practice rather than as a result of discovery and observation." (p. 69).

Recall of conventional symbols of maps, the basic element of map language, form the bulk of objectives in this category; e.g., point, line, and area symbols on topographic and thematic maps. In addition, conventions for describing the various parts and characteristics of the spherical globe: poles, hemispheres, latitude/longitude, Great Circles, grid systems.

1.22 Knowledge of Trends and
Sequences

"Knowledge of the processes, directions and movements of phenomena with respect to time (p. 70). The emphasis here is on events, a time-sequence, and a cause-effect relationship.

Recall of such topics as: the history of cartography; trends in map-making; development of drafting and scribing techniques; of technological processes such as printing and photography; of techniques and equipment for measuring the earth's surface; the effects of exploration and discovery, trade and war on the development of cartography. The sequence of tasks in making a map; the stages in data processing preparatory to symbolization. The knowledge of geographical and geomorphological processes which must be understood prior to topographic map interpretation, e.g., the development of river valleys, the effect of glaciation upon landscape.

TABLE 2.2 (Cont'd. 2)

TAXONOMY	APPROPRIATE MAP STUDIES MATERIAL FOR THE TAXONOMY
1.23 <u>Knowledge of Classifications and Categories</u>	
"Knowledge of the classes, sets, divisions and arrangements which are regarded as fundamental or useful for a given subject, field, purpose, argument or problem". (p. 71).	Recall of data classification: nominal, ordinal, interval and ratio; types of maps, such as topographic, thematic, road, bathymetric; types of thematic symbolization, such as: isopleth, choropleth, proportional symbols. Classification of symbols, e.g., point, line, area. Classification of phenomena by means of symbols, e.g., roads, cities. Classes of map projection. Class intervals for thematic maps.
1.24 <u>Knowledge of Criteria</u>	
"Knowledge of criteria by which facts, principles, opinions and conduct are tested or judged." (p. 72).	Recall of criteria for evaluating various types of maps: Internal criteria such as accuracy, legibility, simplicity, design, contrast, colors, reduction (quality of), projection properties, generalization of data, selection and representation of symbols, selection of class intervals, quality of execution. External: criteria such as the suitability of the map for its purpose; assumptions on which the map is based, validity of data sources; date of information.
When used criteria become Level 6 activity. Criteria are "...likely to appear complex and abstract to students and to acquire meaning only as they are related to concrete situations and problems."	
1.25 <u>Knowledge of Methodology</u>	
"Knowledge of the methods of enquiry, techniques and procedures employed in a particular subject field as well as those employed in investigating particular problems and phenomena." Recall of method only. Practice is L 2.00 and use L 3.00 or higher (p. 73).	Recall of methodology of map interpretation: measurement of distance, area, direction, gradient; drawing profiles; transects, intervisibility; place location by grids; latitude/longitude; scale changing; construction of projections; landscape sketches; block diagrams. Methodology of map creation: design; layout; drafting techniques; lettering; reproduction; sketch map techniques. The use of equipment.

TABLE 2.3

KNOWLEDGE OF THE UNIVERSALS AND
ABSTRACTIONS IN A FIELD (L 1.30)

<u>TAXONOMY</u>	<u>APPROPRIATE MAP STUDIES MATERIAL FOR THE TAXONOMY</u>
1.30 <u>Knowledge of the Universals and Abstractions in a Field</u>	
"Knowledge of the major ideas, schemes and patterns by which phenomena and ideas are organized".	
They are "...concepts which bring together a large number of specific facts and events, describe the processes and inter-relations among these specifics..." (p. 75).	
1.31 <u>Knowledge of Principles and Generalizations</u>	
"Knowledge of particular abstractions, which summarize observations of phenomena." (p. 75).	Recall of the map as a model; the principles of generalization; principles of the transportation from spherical to flat surface; principle of scale (large scale/small scale) and its relationship to information content; relative location; time/cost distance, quantity/area transportation.
1.32 <u>Knowledge of Theories and Structure</u>	
"Knowledge of the body of principles and generalizations together with their inter-relations which present a clear, rounded and systematic view of a complex phenomenon, problem or field." (p. 76).	Recall of the theory of cartographic communication; cartology; metacartography. (Bunge, 1962).

Attention must be drawn particularly to knowledge of methodology (L 1.25), where simple recall is of little value, because practice of methodological skills is required before they become knowledge in any real sense. Knowledge of universals and abstractions (L 1.30), represents material which would appear suitable at only relatively advanced stages of secondary education.

2.2.2 Intellectual Abilities and Skills (Ls2.00 - 6.00)

"Clearly it is impossible to give the individual all the knowledge which he will ever need for every new situation he will encounter. It is possible, however, to help him acquire that knowledge which has been found most useful in the past, and to help him develop those intellectual abilities and skills which will enable him to adapt that knowledge to the new situations" (p. 41).

These intellectual abilities and skills are, then, those which will enable the student to use knowledge to solve new problems; to cope with new materials; to analyze or understand new situations, and to see the relationships between previous experience and new situations. They are the skills which are generally discussed under the headings of critical thinking, reflective thinking, problem solving and creative thinking. Intellectual abilities and skills are considered by Bloom, ^{are} and generally agreed, to have greater transfer value and greater permanence than memorized knowledge.

- a) Comprehension (L 2.00) - Whereas knowledge refers to recall of specifics, means of dealing with specifics, and ideas, comprehension is concerned with grasping the "...literal message contained in a communication" (p. 89). A communication, in this sense, may be understood to include a verbal, numeric or visual communication. Its sense is more limited than in general usage and does not include "...a complete understanding or even...the fullest grasp of a message." (p. 89).

Comprehension is demonstrated on three levels by the ability to perform certain activities when asked to do so. These are:

- i) translate, that is, give the meaning of various parts of a communication in a different form;
- ii) interpret, that is, re-order the ideas in a communication including "...thinking about the relative importance of the ideas, their interrelationships, and their relevance to generalizations implied or described in the original communication."
- iii) extrapolate from the information given in the communication (rather than extrapolate from principles, procedures or abstractions), to make estimates or predictions. Interpolation is included in this category.

The meaning of comprehension for map studies is detailed in Table 2.4 along with the kind of material which is the basis of much school work dealing with initiation into the use of graphic language. Many objectives at Levels 2.10, 2.20, 2.30 would be required to develop the necessary basic skills before work at higher levels of the taxonomy could be expected.

- b) Application (L 3.00) - The hierarchical nature of the taxonomy begins to become evident in this category. The skills developed in Comprehension (L 2.00) are a necessary basis for the activities described under Application (L 3.00), and shown in Table 2.5.
- c) Analysis (L 4.00) - The activities described under Analysis (Level 4.00, Table 2.6), are relatively complex, requiring a thorough familiarity with map media, with various analytical methodologies, and with concepts in related areas of study such as geography.
- d) Synthesis (L 5.00) - The activities described in the class Synthesis (L.5.00, Table 2.7), require an even greater understanding of all aspects of graphic media. Rather than the ability to break down a given communication, even one not seen before, the requirement here is to assemble disparate information, make decisions about what to include or omit (there is an inconsistency here as Evaluation (Level 6.00) is required as an

TABLE 2.4

COMPREHENSION (L 2.00)

TAXONOMYAPPROPRIATE MAP STUDIES
MATERIAL FOR THE TAXONOMY2.10 Translation

Transitional between knowledge and interpretation, extrapolation, application, analysis, synthesis and evaluation "...unless an individual can give the denoted meaning to each of the various parts of a communication and/or in terms of immediate or adjacent context, he will be unable to engage in more complex thinking about communication." (p. 91).

This involves the ability to 'read' a map only in the sense of being able to translate the various components of the graphic communication when asked to do so. It can involve the translation of individual components of statistical data to verbal, graphic or map form; of verbal statements to graphic or map form; of map information to diagrammatic, verbal or numeric form. It includes the drawing of symbols or sketches to illustrate specific meanings and simple exercises which require the use of grid references to identify map phenomena. The practice 'how to' of various methods is included in this category.

2.20 Interpretation

This involves seeing the communication as a 'configuration of ideas' and emphasizes the ability to understand the meaning of the whole communication to be able to summarize it and relate it to one's own experiences and ideas (p. 93).

Included in this level is the ability to understand the literal message of a map and to put it into context; to summarize the information contained in data, graph or map; to derive generalizations from particulars.

Includes sketch maps drawn for the purpose of summarizing the meaning of a communication.

2.30 Extrapolation

Extrapolation involves the ability to draw conclusions, make inferences, to see the implications and consequences resulting from a communication. It is still dealing only with the literal message of a communication and does not use generalizations, rules of procedure or analysis to reach conclusions (p. 95).

The ability to draw conclusions from data, graphs or maps; to make estimates or predictions based on understanding conditions or trends shown on a given map; to extend what is given on the map to a neighbouring area or to similar situations; to interpolate when there are gaps in information (such as interpolation of contours). A consciousness of the limitations of inferences and the factors which make predictions inaccurate is required.

TABLE 2.5

APPLICATION (L 3.00)

TAXONOMYAPPROPRIATE MAP STUDIES
MATERIAL FOR THE TAXONOMY3.00 Application

Application is concerned with the ability of a student to apply techniques, procedures, methods of inquiry, generalizations and principles to new situations. It involves "remembering and bringing to bear upon given material the appropriate generalizations and principles". It may deal with either "the meaning a communication has for other generalizations, situations, phenomena" or the "meanings that generalizations known to the student have for the communication". (p. 144).

Application of knowledge of map reading to the study of a new map (e.g., the ability to interpret a new area depicted on a topographic sheet without detailed guidelines).

The ability to use maps in the solution of geographical or other problems.

The ability to use geographical concepts to understand the map more fully (e.g., the development of river systems to understand drainage patterns/relief).

Application of map knowledge to new situations such as use in a field exercise or for recreation.

Use a thematic map of a new area.

Use previously learned drafting technique to make a map (but one which is not a completely new communication).

Use principles of generalization to reduce the scale of a map.

Use sketch map methodology in working situations such as field work.

Use principles of map projection to transform one projection to another.

Use principles of scale to transform linear distance to, e.g., time-distance, cost-distance.

TABLE 2.6

ANALYSIS (L 4.00)

<u>TAXONOMY</u>	<u>APPROPRIATE MAP STUDIES MATERIAL FOR THE TAXONOMY</u>
4.00 <u>Analysis</u>	
4.10 <u>Analysis of Elements</u>	
<p>"Analysis emphasizes the breakdown of the material into its constituent parts and detection of the relationships of the parts and of the way they are organized." (p. 144). In comparison with comprehension the emphasis is on the "...form, logic, organization and effectiveness" of a communication and how well it serves its purpose, i.e., it deals with organization and structure and, although it may stand on its own as an exercise, is probably more justified educationally as a preparation for evaluation (p. 144).</p>	<p>The breakdown of a new map into its component parts to provide a detailed account of such characteristics as relief, settlement, route-ways - it may eventually lead to regional synthesis or evaluation (Levels 5 and 6). The analysis of source maps and statistical data as one step in the process of a new map, a model or the specifications for a map. Analysis of landforms by profiles, morphological mapping, relative relief and similar techniques.</p> <p>Analysis of settlement by nearest neighbour analysis. Use of sketch maps and landscape sketches in the analysis of landscapes.</p>
4.20 <u>Analysis of Relationships</u>	
<p>The analysis of relationships among elements and between the various parts of the communication (p. 146).</p>	<p>Detailed examination of the relationship between e.g., rocks, river system, relief in a drainage basin as revealed on a topographic map.</p> <p>Analysis of relationships revealed by thematic maps.</p> <p>The use of sketch maps in analysing relationships.</p>
4.30 <u>Analysis of Organizational Principles</u>	
<p>The analysis of the structure and organization of a communication.</p>	<p>Analysis of the techniques, processes and sequences involved in the production of a printed map.</p> <p>Analysis of the relative merits of different ways of representing phenomena, e.g., relief. Analysis of techniques of representation used in a thematic map.</p> <p>Use of 'thumb nail' sketches in map design.</p> <p>Use of computer maps for class analysis in thematic map design.</p>

TABLE 2.7

SYNTHESIS (L 5.00)

TAXONOMYAPPROPRIATE MAP STUDIES
MATERIAL FOR THE TAXONOMY5.00 Synthesis

Synthesis involves putting together elements from many sources to form a "...structure of a pattern not clearly there before." The "efforts should yield a product ... something that can be observed through one or more of the senses and which is clearly more than the materials he began to work with." (p. 162).

5.10 Production of a Unique Communication

Communication of either ideas and experiences, or of expression for its own sake, with the purpose of informing, describing, persuading, impressing, or entertaining. Controlling factors are the:

- effects desired
- intended audience
- effectiveness of using the medium of communication;

input of ideas and experiences of author as well as contents (p. 168).

5.20 Production of a Plan or a Proposed set of operations

Production of a plan or set of operations which fulfils the requirements of the task (p. 170).

Production of a new map involving compilation from a variety of source materials.

Production of a regional synthesis (in map and/or written form).

This includes the production of the specifications for a new map or map series; production of a set of procedures for map interpretation or map construction; production of a plan or specifications for completion of a map project; ability to design a map according to given specifications.

TABLE 2.7 (Cont'd.)

<u>TAXONOMY</u>	<u>APPROPRIATE MAP STUDIES MATERIAL FOR THE TAXONOMY</u>
5.30 <u>Production of a Set of Abstract Relations</u>	The ability to formulate, for example, hypotheses of landscape origin/evolution based on map analysis, and to modify such hypotheses in the light of new factors and considerations is included, as well as the ability to formulate a theory of map learning applicable to classroom teaching and the ability to make cartographic discoveries and generalizations.

integral part of this process), and produce a new communication, plan or model. This is the only class in the taxonomy which leaves room for creative activity and therefore it could be argued that creative efforts which use visual expression but which lack technical and methodological expertise should be included in this category. Because of the nature of Bloom's definition, however, map studies tasks which involve creativity are difficult to classify.

e) Evaluation (L 6.00)

Evaluation objectives are detailed in Table 2.8. The criteria which are listed under knowledge of criteria (L 1.25) in Table 2.4, are here used to evaluate a communication.

2.3 Classification of South Carleton K-6 Objectives According to Bloom's Taxonomy

The South Carleton Curriculum objectives for grades K-6 are listed in Appendix 2, pp 144-158. The appropriate level number from the taxonomy has been identified for each objective. The distribution of objectives by level in the Curriculum is presented in Table 2.9 and Figures 2.2 to 2.4.

In some instances objectives were difficult to classify because of vagueness in the wording. Interviews with approximately twenty five teachers in the schools of the South Carleton 'family' indicated the context and manner in which the objectives were taught and aided in their classification.

TABLE 2.8

EVALUATION (L 6.00)

TAXONOMYAPPROPRIATE MAP STUDIES
MATERIAL FOR THE TAXONOMY6.00 Evaluation

"Evaluation is defined as the making of judgements about the value for some purpose, of ideas, works, solutions, method, material, etc. It involves the use of criteria as well as standards for appraising the extent to which particulars are accurate, effective, economical, or satisfying. The judgement may be either quantitative or qualitative, and the criteria may be either those determined by the student or those which are given to him." (p. 185).

6.10 Judgements in Terms of Internal Evidence

"Evaluation of a communication from such evidence as logical accuracy, consistency, and other internal criteria (p.188).

Evaluation of a map or other graphic communication in terms of external criteria, e.g., integrity; degree to which it fulfils purpose; technical competence (Table 2.2).

CATEGORIES OF THE TAXONOMY

1.00 Knowledge

1.10 Knowledge of Specifics

1.11 Knowledge of Terminology

1.12 Knowledge of Specific Facts

1.20 Knowledge of Ways and Means of Dealing with Specifics

1.21 Knowledge of Conventions

1.22 Knowledge of Trends and Sequences

1.23 Knowledge of Classifications and Categories

1.24 Knowledge of Criteria (Standards of Judgment)

1.25 Knowledge of Methodology

1.30 Knowledge of the Universals and Abstractions in a Field

1.31 Knowledge of Principles and Generalizations

1.32 Knowledge of Theories and Structures

INTELLECTUAL ABILITIES AND SKILLS

2.00 Comprehension

2.10 Translation

2.20 Interpretation

2.30 Extrapolation

3.00 Application

4.00 Analysis

4.10 Analysis of Elements

4.20 Analyses of Relationships

4.30 Analysis of Organizational Principles

5.00 Synthesis

5.10 Production of a Unique Communication

5.20 Production of a Plan, or Proposed Set of Operations

5.30 Derivation of a Set of Abstract Relations

6.00 Evaluation

6.10 Judgments in Terms of Internal Evidence

6.20 Judgments in Terms of External Criteria

TABLE 2.9

CLASSIFICATION OF SOUTH CARLETON K-6 OBJECTIVES
ACCORDING TO BLOOM'S TAXONOMYNUMBER OF
OBJECTIVES
BY GRADE

	1.11	1.12	1.21	1.22	1.23	1.24	1.25	1.31	1.32	2.10	2.20	2.30	3.00	4.00	5.00	6.00
K (28)	4	7	2	-	-	1	-	5	-	6	3	-	-	-	-	-
1 (32)	4	7	3	-	-	-	2	3	-	8	3	-	1	-	1	-
2 (34)	1	7	11	-	-	1	3	3	-	3	2	-	3	-	-	-
3 (34)	3	10	7	-	-	1	5	-	-	5	2	1	-	-	-	-
4 (29)	1	5	10	1	-	-	-	2	-	5	-	1	4	-	-	-
5 (43)	2	7	14	4	-	-	2	2	-	5	1	3	3	-	-	-
6 (41)	1	9	5	6	-	-	4	-	-	4	9	4	2	-	-	-
GRAND TOTAL	241	16	52	11	0	3	16	15	0	36	20	6	13	0	1	0

NUMBER OF
OBJECTIVES
IN EACH
CLASS
32.

CATEGORIES OF THE TAXONOMY

1.00 Knowledge

1.10 Knowledge of Specifics

- 1.11 Knowledge of Terminology
- 1.12 Knowledge of Specific Facts

1.20 Knowledge of Ways and Means of Dealing with Specifics

- 1.21 Knowledge of Conventions
- 1.22 Knowledge of Trends and Sequences
- 1.23 Knowledge of Classifications and Categories
- 1.24 Knowledge of Criteria (Standards of Judgment)
- 1.25 Knowledge of Methodology

1.30 Knowledge of the Universals and Abstractions in a Field

- 1.31 Knowledge of Principles and Generalizations
- 1.32 Knowledge of Theories and Structures

INTELLECTUAL ABILITIES AND SKILLS

2.00 Comprehension

- 2.10 Translation
- 2.20 Interpretation
- 2.30 Extrapolation

3.00 Application

4.00 Analysis

- 4.10 Analysis of Elements
- 4.20 Analyses of Relationships
- 4.30 Analysis of Organizational Principles

5.00 Synthesis

- 5.10 Production of a Unique Communication
- 5.20 Production of a Plan, or Proposed Set of Operations
- 5.30 Derivation of a Set of Abstract Relations

6.00 Evaluation

- 6.10 Judgments in Terms of Internal Evidence
- 6.20 Judgments in Terms of External Criteria

FIGURE 2.1 TOTALS FOR GRADES K-6 BY CLASS

FIGURE 2.2 TOTALS FOR GRADES K-6 BY SUBCLASS

CATEGORIES OF THE TAXONOMY

1.00 Knowledge

1.10 Knowledge of Specifics

- 1.11 Knowledge of Terminology
- 1.12 Knowledge of Specific Facts

1.20 Knowledge of Ways and Means of Dealing with Specifics

- 1.21 Knowledge of Conventions
- 1.22 Knowledge of Trends and Sequences
- 1.23 Knowledge of Classifications and Categories
- 1.24 Knowledge of Criteria (Standards of Judgment)
- 1.25 Knowledge of Methodology

1.30 Knowledge of the Universals and Abstractions in a Field

- 1.31 Knowledge of Principles and Generalizations
- 1.32 Knowledge of Theories and Structures

INTELLECTUAL ABILITIES AND SKILLS

2.00 Comprehension

- 2.10 Translation
- 2.20 Interpretation
- 2.30 Extrapolation

3.00 Application

4.00 Analysis

- 4.10 Analysis of Elements
- 4.20 Analyses of Relationships
- 4.30 Analysis of Organizational Principles

5.00 Synthesis

- 5.10 Production of a Unique Communication
- 5.20 Production of a Plan, or Proposed Set of Operations
- 5.30 Derivation of a Set of Abstract Relations

6.00 Evaluation

- 6.10 Judgments in Terms of Internal Evidence
- 6.20 Judgments in Terms of External Criteria

FIGURE 23 CLASSIFICATION OF OBJECTIVES BY GRADE LEVEL

2.4 Comments on the Classification of South Carleton Grade K-6 Objectives

From a total of 241 objectives 165 are classified in level 1.00, and all but 14 fall into L 1.00 and L 2.00. Only one objective is classified in L 4.00 - L6.00. Of the 227 objectives in L 1.00 and L2.00, 52 fall into the level of Knowledge of Specifics (L 1.12), 52 into the level of Knowledge of Conventions (L 1.21) and 36 into Translation (L 2.10). Comments on these results are given below in terms of Bloom's levels.

1.11 Terminology

Total 17..	K	1	2	3	4	5	6
	4	4	1	4	1	2	1

In Kindergarten and Grade 1 terminology development was in terms of fundamental relational concepts such as up/down, left/right, near/far. At Grade 2, there was an abrupt switch to world scale terminology associated with the globe (for example, 'ocean', 'continent').

1.12 Specifics

Total 52.	K	1	2	3	4	5	6
	7	7	7	10	5	7	9

A large number of 'specifics' objectives was found at each grade level. One group of kindergarten objectives dealt with location of oneself in relation to the environment and location of objects in relation to one another. Apart from this, specifics objectives dealt almost exclusively with two aspects of

'globe facts':

- a) the sphericity (K), rotation (Grades 1 and 2), revolution (Grade 3), and size (Grade 4) of the globe are progressively introduced. Rotation and revolution of the globe are reviewed in Grade 5 and planets and time zones introduced in Grade 6 (14 objectives).
- b) the ability of students to locate places on the globe (Grades K-2) and on small scale maps (Grades 3-6).
There is a great deal of repetition of this theme (28 objectives). It is almost exclusively concerned with shape recognition - a blatantly 'capes and bays' approach.

1.21 Conventions

Total 52.	K	1	2	3	4	5	6
Globe	0	2	6	3	3	11	4
Map	2	1	5	4	7	3	1
Total	2	3	11	7	10	14	5

The distribution indicates that learning of conventions is concentrated in Grades 2-5. Two prime aspects of conventions are dealt with:

- a) globe conventions (29) of which no less than 11 in Grade 5 deal with latitude and longitude.
- b) Map symbolism which is strongly emphasized in Grades 2-4, and clearly considered to be known by Grade 6.

1.22 Trends and Tendencies

Total 11.	K	1	2	3	4	5	6
	0	0	0	0	1	4	6

In most of these objectives the student 'becomes aware of' 'learns about', 'begins to understand' the influence of earth motion on time, climate, vegetation; ocean currents on climate. exploration, development, etc. There is little evidence that maps are used in the attainment of these understandings.

1.24 Criteria

Total	3.	K	1	2	3	4	5	6
		1	0	1	1	0	0	0

Two of the three involve the significance of, or the purpose of, maps. Although so many objectives are classified as L 1.00, there is a marked neglect of criteria, the standards by which judgements are made.

1.25 Methodology

Total	16.	K	1	2	3	4	5	6
		0	2	3	5	0	2	4

A much higher number of objectives concerning methodology would have been expected as this is the foundation on which many higher level skills are based. Those identified involve using shadow, magnetic compass and stars to find direction (9 objectives); the measurement of distance (2 objectives in Grade 6); the use of grids to establish location (two objectives, one in Grade 3 and one in Grade 6).

1.31 Principles and Generalizations

Total	15.	K	1	2	3	4	5	6
		5	3	3	0	2	2	0

Objectives concern globe (5) and map (2) as a model, and principles of scale (3) and projection (2). This distribution indicates a relatively high number of objectives in view of the level of abstraction.

2.10 Translation

Total 36.	K	1	2	3	4	5	6
	6	8	3	5	5	5	4

An emphasis on interpretation as opposed to map creation is revealed; translates from globes 2 objectives; translates from map 19 objectives; translates to map form 4 objectives.

2.20 Interpretation

Total 20.	K	1	2	3	4	5	6
	3	3	2	2	0	1	9

A sudden influx of interpretation expectations in Grade 6 without adequate methodological training via 1.25, 2.10 and 2.20 in Grades 2 - 5 is noticeable here.

2.30 Extrapolation

Total 6.	K	1	2	3	4	5	6
	0	0	0	1	1	3	1

These objectives involve making inferences from maps. Although a 'variety' of scale of maps is frequently mentioned, the concerns are those to be found in the study and interpretation of small scale, generalized, thematic maps.

3.00 Application

Total 13.	K	1	2	3	4	5	6
	0	1	3	0	4	3	2

Some of these are vaguely expressed: the student is to use 'maps as a source of information' (Grade 1); 'a variety of maps for different purposes' (Grade 4); and 'different maps for different purposes' (Grade 6).

4.00 Analysis

No objectives were classified at this level indicating a lack of analytical objectives in the K - 6 Curriculum.

5.10 Synthesis

Total 1	<u>K</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
	0	1	0	0	0	0	0

Only one objective which could be considered Level 5.00 was identified. "Interprets his environment in pictures painted", as expressed, was likely to be a free creative activity in which the child used his concepts of the environment to produce a unique communication.

6.00 Evaluation

No objectives were classified at this level. This is not surprising in view of the lack of emphasis on criteria (L 1.24).

Finally the language of the objectives was considered. Table 2.10 indicates the number of objectives in which the words "knows", "locates", and "uses" were employed. The word "locates" has already been mentioned. It was found in 27 Level 1.12 objectives and used, in total, 39 times. In addition 98 objectives included words which, although on first glance they seemed to be significant, were, on examination of the material and context, found to be knowledge objectives: there were such words as describes...observes... discovers... recognizes...

generalizes...begins to learn about... begins to learn that (and definition)...becomes aware of... learns about some ways in which... extends familiarity with.... In addition, understands that... begins to understand that... understands the need for... maintains understanding of... extends understanding of... were often used merely in the sense of knowing a definition. Even "begins to use" and "uses" were frequently used in objectives which either required definition of terms, or translation of symbols, or which did not specify in any way either what the specific item was to be used for, or how it was to be used.

In 135 objectives out of 241 it seemed that language did more to obscure than to clarify the meanings.

TABLE 2.10

LANGUAGE OF THE OBJECTIVES

<u>GRADE</u>	<u>TOTAL NUMBER OF OBJECTIVES</u>	<u>KNOWS</u>	<u>LOCATES</u>	<u>USES</u>
K	28	12	4	2
1	32	12	3	6
2	34	19	7	5
3	34	15	4	7
4	29	12	5	5
5	43	16	6	6
6	41	<u>14</u>	<u>10</u>	<u>4</u>
		100	39	35

2.5 Summary

1. The majority of objectives are classified as Knowledge (L 1.00).
2. Very few Knowledge (L 1.00) objectives are concerned primarily with criteria or methodology.
3. Comprehension (L 2.00) objectives are concerned primarily with learning elementary map language.
4. Only 14 objectives are identified as Application, Analyses, Synthesis, Evaluation (L 3.00-L 6.00); 13 of these are in L 3.00.
5. Despite their behavioural intent, the language in which objectives are expressed is vague and confusing. Behavioural objectives need to be carefully formulated if they are not to be proliferations of words without meaning.

The classification of South Carleton K-6 objectives, therefore, raises questions concerning both the taxonomy and the curriculum:

1. Although knowledge is a valid objective in education, the preponderance of Level 1.00 objectives may be due as much to Bloom's definition of knowledge as to the nature of the subject matter.

2. The hierarchical nature of the taxonomy is also questioned. The kinds of cognitive goals identified in Classes 2.00 - 6.00 may not be the most appropriate ways of distinguishing the degree of cognitive challenge in map studies.
3. The problem of sequencing objectives is raised by the kinds of activities identified for Classes 2.00 - 6.00. Whatever the cognitive goal identified in the objective, the teaching of concepts out of phase with the cognitive development of the child may lead to rote-learning methods and hence to the high number of 'knowledge' objectives as classified in accordance with Bloom's definition.

These topics are considered in detail in Chapter 3.

CHAPTER 3

THE TAXONOMY FROM A MAP STUDIES PERSPECTIVE

3.1 Introduction

If the taxonomy is to be useful as a basis for determining cognitive goals for map studies curricula three problems (raised in Chapter 2) must be resolved.

First is the question of whether Bloom's definition of knowledge is, in fact, useful in the identification of map studies objectives. This is discussed in the light of psychological definitions of knowledge (3.2).

Second, the question of whether Bloom's hierarchical subdivisions of intellectual abilities and skills are the most appropriate ways of subdividing cognitive skills, is considered by reference to some map studies examples (3.3).

Third, the question of sequencing objectives is outlined and conclusions are reached concerning the usefulness of Bloom's structure in the development of a map studies curriculum (3.4).

3.2 Knowledge (L 1.00)

3.2.1 Definition and Acquisition of Knowledge

Learning involves the acquisition of knowledge. Any approach to describing objectives for learning will be conditioned by the

definition of knowledge adopted and the view held of the processes involved in its acquisition.

Knowledge is defined in the taxonomy as a product stored or filed in the memory and accessed by recall. It is relevant to ask whether the memory-recall process is the only way in which knowledge may be acquired, or whether it is merely one process, emphasized in the taxonomy because of Bloom's familiarity with the way knowledge is generally taught in American schools (Bloom, et al., 1956, p.30).

The distinction between 'knowledge' and 'information' should be considered:

Information generally applies to knowledge, commonly accepted as true, of a factual kind usually gathered from others or from books... Webster's 3rd New International Dictionary, 1968.

Knowledge applies to any body of facts gathered by study, observation, etc. and to the ideas inferred from these facts, and connotes an understanding of what is known...

Webster's New World Dictionary, 1970.

These distinctions reveal that Bloom's "product stored or filed in the mind..." has more in common with 'information' than with 'knowledge'. The distinction is important because the validity of a major emphasis on 'information' in schools is questionable, whereas knowledge in its broader sense may be regarded as one of the primary functions of education, and its acquisition involves all of the levels of Bloom's taxonomy.

The acquisition of knowledge, therefore, may be more appropriately regarded as part of an integrated cognitive process by which learning takes place. Cognitive learning involves both the

acquisition of knowledge and the ability to reason (Stones 1970, p. 5). Reasoning (or thinking) leads to an extension of knowledge, which then forms the basis for further cognitive activity. The process is cyclical, rather than hierarchical, in which knowledge is both a component and an outcome of the process.

...the mind, in order to cope with the world must fulfil two functions. It must gather information, and it must process it. The two functions are neatly separated in theory, but are they in practice? (Arnheim 1969, p. 1).

Because of the ways in which knowledge is acquired when using a graphic language an understanding of the component data gathering and organizing processes is fundamental. Each of these component processes, perception, conceptualization and generalization will be discussed in turn, and its relevance to map studies and to Bloom examined.

3.2.2 Perception

The operations involved in the acquisition of knowledge in map studies, whether in the map-creative or the map-interpretative modes, are dependent, initially, on observation and perception of either real-world phenomena or secondary stimuli such as visual, statistical, diagrammatic or map materials. The development of perceptual abilities in Grades K-6 is the foundation on which later map studies skill can be based.

That perceptual objectives do have a considerable role to play in the development of cognitive abilities can be shown by reference to psychological studies concerning the acquisition

of knowledge. (Vernon, 1962, Ellis, 1972, Arnheim, 1969, Gagne, 1970, Holloway, 1967.)

Arnheim (pp. 1-53), Vernon (pp. 11-30) and Ellis (pp. 156-168) have demonstrated that perception is the foundation of all knowledge in the sense that all fundamental information is filtered through the senses. Arnheim has emphasized the particular contribution of visual perception to intelligence and has described the eye as "...the most effective organ of human cognition". All three stress the close interaction between the eye and the brain. Ellis describes perceptual tasks such as direction, discrimination, recognition and identification in such a way that their component of selection, classification and generalization is clear. Arnheim indicates that cognitive operations are the essential ingredients of perception rather than "...mental processes above and beyond perception." (p. 13).

The operations involved in perception, he says, include: active exploration, selection, grasping of essentials, simplification, abstraction, analysis/synthesis, completion, connection, comparison, problem solving, combining, separating and putting into context. All of these processes are involved when maps are studied. They are very similar to those described in the formation of concepts. The evidence indicates that there is much less distinction between perception and conceptualization than was once thought.

Perceptual tasks, therefore, are shown to involve more complex cognitive structures than memory and recall, and objectives designed

to develop perceptual learning should not be properly classified at Bloom's level 1.00. The few objectives identified in the South Carleton Curriculum which would tend to develop these skills had to be classified as knowledge of specifics (1.12) because there is no provision for them elsewhere in the taxonomy. However, they involve much more complex mental processes than simple memory and recall.

TABLE 3.1

PERCEPTUAL OBJECTIVES (L 1.00)

- K/5* Locates specific areas within the school.
- K/10 Begins to orient self as to location in relation to things in the environment.
- 1/6 Observes landmarks in the community.

Provision for the development of perceptual abilities must be made when a map studies curriculum is designed, and a taxonomy for classifying objectives should identify this cognitively valid activity. Indeed, as long as 25 years ago, Long (1953 and 1961) urged greater efforts to develop children's perceptual skills.

3.2.3 Conceptualization

Ellis (p. 138) has defined a concept as "...a class of stimulus or events that share in one or more characteristics". The formation of concepts involves the ability to generalize within classes. The supporting processes are those of differentiation and integration. The element of classification and generalization is common to both conceptualization and perception.

* Indicates Objective 5 at the Kindergarten level.

Not all concepts are, however, the same. They may be identified at various levels of abstraction and inference. This is shown in diagrammatic form in Figure 3.1 where the transition from simple to inferred concepts (generalization) may be observed.

It is significant for map studies that Vernon (1962 p.34) and Sapir (1920, pp. 33-34) have drawn attention to the importance of mental images for concept identification and evaluation. Mental images are usually classes of objects, such as house, street, route, rather than individual objects. When referring to perceptual information these classes are often called schema rather than concepts although they are clearly quite similar. Ellis (p. 164) describes a schema as an "...inferred concept, based upon the responses that are made to classes of stimuli." The main difference between a schema and a concept is that the schema is not usually tied to a single feature or dimension, but to a complex set of dimensions and is therefore more like a higher order concept or principle than a basic concept. Since the map is a two-dimensional language used in the learning and transmission of information concerning three-dimensional space the potential relevance of image and schema in concept formation related to map studies is suggested. This would seem to indicate that maps may be the ideal medium for the formation and transmission of spatial concepts. An intermediate stage of verbal language need not necessarily be involved. Rhys (1972, pp.101-2), drawing on Vinacke (1952), notes that:

FIGURE 3.1

CONCEPTUALIZATION

After: Thomson 1959
Gagné 1970

A map, as a system of communication, employs a complex artificial language to describe selected aspects of man's environment. The transmitted data, expressed in codified form, represent a simplified structure of reality. If a student can translate its symbolism into tangible imagery, the map may then act as an analytical tool, helping him to discern causal relationships amongst the spatial distributions it describes. But the interpretation of symbolized material can only take place on the conceptual level, making use of those cognitive structures which link the individual's present perception and learning to his previous experience (Vinacke 1952).

Some objectives in the South Carleton Curriculum which would tend to encourage the development of schema formation had to be classified at L 1.00 (Table 3.2), because Bloom's definition of knowledge precludes their location elsewhere. It can be concluded that the acquisition of concepts in map studies has little to do with memorization and recall. Part of the potential value of map studies in developing cognitive abilities is obscured by following a scheme which defines knowledge so narrowly.

3.2.4 Principles

Whereas simple concepts are derived from observations of reality, and inferred concepts are derived by progressive abstraction, principles may be described as concepts by definition (Gagné, 1970, pp. 67-82). They must be learned by way of "...verbal statements that provide cues to the desired ordering" of component concepts.

The learning of principles by way of verbal statements has considerable relevance to Bloom's definition of knowledge.

TABLE 3.2

CONCEPTUAL OBJECTIVES (L 1.00)

- K/4 Begins to describe relative location of various objects in the environment (near, far, up, down, right, left, over, under, back, front, here, there).
- K/11 Begins to place objects in relationship to one another.
- K/12 Becomes familiar with street addresses and the names of cardinal directions: north, south, east, and west.
- K/24 Describes features of the environment verbally; understands that they can be described through pictures and other materials.

Verbal learning is a necessary and valuable component of education but the method by which it is acquired, and the stage of education at which it is appropriate, must be considered.

Ausubel (1970, pp.93-206) distinguishes between 'reception learning' and 'rote learning' and indicates that verbal, deductive learning is dependent on developmental maturity. It is therefore more suitable to the secondary stage of education. Gagné stresses the danger of definition at early stages in learning and claims that use, (the ability to place an object in a class and to exclude one which does not belong), rather than verbal definition, is the appropriate test of whether or not a concept has been attained. Use, therefore, is the more suitable method of concept formation in the early years of education.

Piaget's (1969) studies, too, have shown that children can learn the definition of a concept, and give the appearance of knowing it, without really understanding it. For this reason a teaching process based on memorization and recall is dangerous. Bloom's knowledge (L 1.00) objectives have a tendency to encourage the use of verbal definitions. Objectives for principles can be found in the Curriculum (Table 3.3) but some of these may in fact lead to the formation of pseudo-concepts. Many of the globe skills indicated in Table 3.4 deal in such abstractions, or are so remote from the normal young child's experience that it seems likely that they would lead to pseudo-concept formation. Further testing would be necessary to confirm this.

TABLE 3.3

PRINCIPLES OBJECTIVES

- K/19 Generalizes that some toys are small-scale models of real things.
- K/18 Begins to understand that places on earth which are far apart appear to be close together on maps.
- 4/2 Understands that portraying the earth's surface on a flat map involves distortion of land and water areas.
- 5/2 Begins to understand the concepts of the earth's rotation on its axis and the earth's revolution around the sun.
- 5/3 Understands the relationship between the rotation of the earth and time.
- 4/16 Understands that large-scale maps show more detail than small-scale maps.

TABLE 3.4

POTENTIAL PSEUDO-CONCEPTS

- K/3 Begins to understand that the earth turns.
- 2/4 Understands the relationship between the earth's rotation and day and night.
- 3/4 Begins to understand that the position of the earth with relationship to the sun changes, causing the seasons to change.
- 2/8 Understands that a globe contains (sic) all the countries in the world but may not show all their boundaries.
- 1/29 Understands that the North Pole is the point farthest north on the earth and on globes, and that the South Pole is the point farthest south on the earth and on globes.

3.3 Intellectual Abilities and Skills (Ls 2.00 - 6.00)

One of the primary motivations for the production of the taxonomy was Bloom's concern to ensure that the more complex cognitive skills would be practised and developed in schools. By devising an hierarchical scheme incorporating comprehension, application, analysis, synthesis and evaluation, Bloom's intention was to encourage teachers to identify objectives which would develop the higher level cognitive skills.

The significance of this approach for map studies is developed below.

The higher levels (2.00 - 6.00) of the taxonomy assume knowledge as a prerequisite, something to be completed before the practice of intellectual activities and skills can begin: "What is needed is some evidence that the students can do something with their knowledge, that is, that they can apply the information to new studies and problems" (Bloom, et al, p.38). (This statement coincidentally identifies that Bloom equated knowledge with information.).

Intellectual abilities and skills are subdivided into an hierarchical pattern which makes very fine distinctions between the component skills. It is often difficult to distinguish the appropriate level for a particular activity. Comprehension (L 2.00) and Analysis (L 4.00) as related to topographic map interpretation provides a good example of this. There are very

close relationships between interpretation (L2.20), extrapolation (L2.30), analysis of elements (L 4.10) and analysis of relationships (L 4.20) when applied to topographic interpretation exercises. Many activities which are generally referred to as 'map interpretation' are, in fact, if Bloom's definitions are used, map analysis, i.e. L4.00 rather than L2.00.

The examples in Table 3.5 to illustrate this, and the examples in Tables 3.6 - 3.7, are taken from a school text (Dobson and Virgo, Vol. 3, 1967) because there are no detailed objectives at these levels in the South Carleton Curriculum. These examples were taken from topographic map interpretation exercises, but topographic map interpretation is only one aspect of map studies. Even when Comprehension (L2.00) alone is considered there are different degrees of cognitive challenge in translation and extrapolation.

The degree of difficulty is also conditioned by the size of the cognitive 'leap' required in the translation. Small scale maps are further removed from reality and are therefore more difficult to translate than large scale maps. Thematic maps deal with more abstract concepts than topographic and hence provide a greater cognitive challenge. Thematic cartograms, based on distance and area transformations represent yet another

TABLE 3.5

COMPREHENSION AND ANALYSIS OBJECTIVES

Translation (L 2.10)

- a) What man-made feature is to be found at 495190?
- b) What is the significance of the old mines at 562180?
- c) Give the grid reference for a nucleated village on the A19(T).

Which of the following landforms - plain, dry valley, knoll, gap, spur, is to be found at 262075, 263110, 185135, 200080?

- 2.20 Describe the relief, drainage, and natural vegetation of the area to the west of Southampton Water.

Describe the site and situation of Llangollen on an annotated sketch map.

Describe the relief and drainage of the area to the west of easting 94.

- 2.30 Account for the routes taken by the A625 and the railway.

Comment on the presence of a) a castle at 185107, b) a golf course at 283095, and c) a television relay station at 225107.

Quote, giving grid references, two pieces of evidence for prehistoric life, and two for Roman life on the map.

Account for the presence of housing at 470195.

Give any evidence from the map that the lake at 859682 is man-made.

- 4.10 In what ways does the highland mass of Edale Moor differ from the highland region south of the A625 and west of B6049? Give reasons for these differences.

Draw a sketch map of Bracknell New Town, on the same scale as the extract, marking on it: a) the main roads and railway b) the principal factories in the western and eastern industrial areas, and c) the housing areas and the old town centre. Does your sketch map show the advantages of living in a New Town?

Draw a sketch section along a line from 340170 to 350140; mark and name on it any feature which you associate with glaciation. Explain the origin of this feature.

TABLE 3.5 (Cont'd).

- 4.20 Study the geological map on this page, and also the Ordnance Survey extract; and then make a comparison of the area on the London clay with those on the Bagshot sand, in respect of
a) their relief and drainage b) the use of the land.

The land use on geological maps on this page cover a small part of the Ordnance Survey extract including Downham Market, on a scale of $2\frac{1}{2}$ inches to 1 mile. Study these maps and then construct an annotated cross section from east to west across the centre of the area to show the geology, relief, and main features of the land use. Why does the land use to the east of the Great Ouse differ from that to the west?

Examples: Dobson and Virgo, 1967.

stage of abstraction and difficulty.

It would seem that, if distinctions are to be made, those based on the type of map communication are at least as significant as those based on the cognitive level of the objective.

Application objectives represent a different type of cognitive activity and may be viewed in two different ways.

- a) Application of the map to a practical problem (Table 3.6A)
- b) Application of knowledge gained from the map to a wider problem (Table 3.6B)

These are two different kinds of activities classified under the same heading. A logical connection occurs between Application (L 3.00) and the production (Synthesis L 5.00) of a new communication, plan or model. Analysis (L 4.00) occurs, sometimes implicitly sometimes explicitly, as an intervening stage.

Synthesis (L 5.00) is the only level in the taxonomy to make room for creative activity (Bloom, et al., 1956, pp. 162-5), and it seems that the implementation of the taxonomy would provide little encouragement for those creative map tasks which are only one part of the total process of the production of a new communication (e.g., design). Since visual creativity is such an important component of map studies this is seen by the author as a major deficiency in the taxonomy.

Synthesis objectives are to be found in the Curriculum whenever a complete and independent map 'interpretation' is

TABLE 3.6

APPLICATION OBJECTIVES

Type A

- 3.00 Give directions to a walker who wishes to climb Helvellyn from the main road, keeping to marked footpaths. He has a compass but no map.
- Describe a boat trip from beside the vehicle ferry at Fowey to Port Harbour, mentioning the directions steered, distance covered, and views of the land.
- Describe the routes a) a pedestrian using Hythe Ferry and b) a motorist would take from Hythe railway station to Southampton Civic Centre.
- If your car broke down at Treesmill crossroads (O88554) how far would you have to walk to the nearest A.A. telephone box?
- How far is it from Castleton Youth Hostel via Hope to Rowland Cote Youth Hostel? Include the distance from the unclassified road along the footpath to your destination. Give the answer in miles and furlongs.

Type B

What are the main differences between the chalk and Jurassic limestone hills in respect of the nature of the rock and the physical and human features of the landscapes? (after a sample map has been studied).

From your knowledge of the region describe the various occupations possible in the Lake District.

Examples: Dobson and Virgo, 1967.

required, thus resulting in a new verbal communication, or where a new map is compiled from different sources or gives a new visual interpretation of phenomena. It is stressed that, at the school level, sketch map techniques are as appropriate as formal cartographic techniques for achieving those ends.

In addition, there are many map studies activities which are difficult to classify in any single level of the taxonomy. Examples are given in Table 3.7.

Bloom recognizes the problems raised by one objective including more than one level of the taxonomy and suggests that such objectives be placed in the highest appropriate category. But an even more fundamental question is ignored. Is it really useful to subdivide integrated activities in so detailed a manner and particularly to try to fit them into a hierarchical scheme?

The examples of thematic map interpretation, and sketch map creation in Tables 3.8 -3.10 devised by the author to fit Bloom's categories, provide specific sequences related to sample map topics. Not all the examples can be regarded as useful map learning activities (see, for example, L 2.10, 2.20, 4.10 for Route Maps). The overlap and fineness of distinctions becomes evident.

A hierarchy also implies a judgement about the relative cognitive value of objectives, and, applied to the educational system can lead to the inflation of expectations in objectives. For instance, there is a temptation to include application

TABLE 3.7

COMBINED OBJECTIVES

Draw a profile along the road from Lostwithiel to Fowey (by the most direct route), using a vertical scale of 1 inch to 400 feet. Describe briefly the route followed by the road in relation to the physical features, and state why a more direct route was not used. If you were driving along the road towards Fowey, at what point (approximately) would Polruan come into view?
(Ls. 2.10, 2.20, 2.30, 3.00).

Study the photograph of Shoreham Cement Works on this page and find the Works on the map extract. Give the grid reference of the position from which the photograph was taken, and state in which direction the camera was pointing. Explain, with the aid of a simple sketch map, why this is an excellent site for a cement works. A clay pit, at 207123, supplies the works.
(Ls. 2.10, 2.30, 4.10, 5.10).

Draw a map of the area on a scale of $\frac{1}{2}$ inch to 1 mile, to show a division into three geographical regions. Name the regions, insert the 250 feet contour, River Aden, and print the words SCARP SLOPE and DIP SLOPE in the correct places. Describe the distribution and type of settlement in each of the three regions you have marked. Study the geological section on this page, and then explain how the physical geography has influenced the settlement.
(Ls. 4.10, 5.10).

Examples: Dobson and Virgo, 1967.

TABLE 3.8

THEMATIC MAP INTERPRETATION
SAMPLE WEATHER MAP

- 2.10 Translate weather map symbols. For example: give weather conditions at a specific station.
- 2.20 Summarize the conditions shown on a particular weather map.
- 2.30 Describe the sequence of weather to be expected at A with, for example, a warmer front passing at a given speed.
- 3.00 Write a weather forecast for radio or television based on a given map.
- 4.10 Analyze the elements of the weather system depicted on a map.
- 4.20 Analyze the weather shown on a map in terms of relationships of, e.g., air masses.
- 5.10 Write a weather forecast for radio or television based on a new map.
- 5.20 Write the specifications for a weather map.
- 5.30 Formulate a hypothesis concerning the origin and evolution of the weather system shown on the map.
- 6.10 Evaluate the map itself in terms of its accuracy.
- 6.20 Evaluate the map in terms of validity of its data and sources of information.

TABLE 3.9

THEMATIC MAP INTERPRETATION
SAMPLE ROUTE MAP

- 2.10 Translate individual symbols, e.g., roads.
- 2.20 Summarize the information on map.
- 2.30 Estimate time taken to travel A-B at given speed and method of transport.
- 3.00 Describe two alternative routes from A-B. Say which you would select and why given certain constraints or requirements.
- 4.00 Analyze the network of minor roads.
- 4.20 Analyze relationship of roads to survey system or settlement pattern.
- 4.30 Analyze the cartographic methods and symbolism used in the map.
- 5.10 Produce a route map.
- 5.20 Plan the schedule and routes for a travelling holiday giving method of transport, distances, stopping times and places./Or write the specifications for a series of route maps.
- 5.30 Formulate a theory of road map communication.
- 6.10 Evaluate the map itself in terms of information and design.
- 6.20 Evaluate the map itself as compared with similar maps produced in other countries.

TABLE 3.10

MAP CREATION: SAMPLE SKETCH MAPS

- 1.00 Direct copy from test or board. Complete a printed outline map.
- 2.10 Learn method of producing simplified continent outlines. Draw map symbols. Learn how to draw field sketches.
- 2.20 Summarize simple information by means of a sketch map, e.g., town site; relief by means of profiles.
- 2.30 Draw sketch map to illustrate influence of relief on routeways, for example.
- 3.00 Draw a sketch map in the field to summarize relationships observed.
- 4.10 Use, e.g., morphological mapping techniques to analyse landforms.
- 4.20 Draw sketch map to illustrate relationships in an area.
- 4.30 Draw a layout sketch for map design.
- 5.10 Produce a sketch map to mark regional analysis of an area; produce a contiguous area cartogram.
- 5.20 Draw a sketch map plan for the development of a new community.
Produce a set of procedures for the production of a sketch map.
- 5.30 Formulation of a theory of sketch map communication.
- 6.10 Evaluation of sketch map in terms of its legibility.
- 6.20 Evaluation of sketch map in terms of quality of its sources and suitability for purpose.

objectives in situations where it is clear that the appropriate skills have not been learned or where the precise nature of the problem, or the use to which information is to be put, is not specified. Examples of this can be seen in such South Carleton Curriculum objectives as:

TABLE 3.11

OBJECTIVES SUGGESTING INFLATED EXPECTATIONS

K/27	Uses simple globes showing land and water areas.
1/16	Makes maps showing the distribution of schools in a given part of the neighbourhood.
1/17	Begins to use maps as a source of information.
3/19	Uses inset maps.
4/25	Uses a variety of maps and globes (political, physical, economic, topographic, weather).
6/39	Uses various kinds of maps for different purposes.

This problem raises the issue of sequencing of objectives.

3.4 Sequencing of Objectives

The taxonomy is claimed to be suitable for all stages of education and yet there are indications that this is not so, at least if the definitions provided by Bloom are followed:

- a) In the South Carleton Curriculum, at the K-6 grade levels, analysis, synthesis and evaluation were represented by only one objective

- b) Bloom's own examples, in the taxonomy, drawn from a wider range of subject matter are derived "...mostly from the upper educational levels " (Bloom, et al., p.2).
- c) Nearly all the map studies examples identified in Chapters 2 and 3 for taxonomy levels 4.00 - 6.00, were applicable to the higher levels of education.
- d) Psychological studies quoted in 3.2 indicated that certain operations are fundamental to learning and more appropriate in the early school years. Yet others indicated that the higher level intellectual skills may be more suitable in the phase of secondary education.

Graves (1975 p. 93) states that

In broad terms it is generally accepted that only a limited number of students below the age of fifteen can think in a hypothetical-deductive manner, yet hypothetic-deductive reasoning is implied in most of the objectives classified under analysis, synthesis and evaluation; consequently any such sets of objectives may be too difficult for younger students.

This suggests that the sequence of activities is at least as important as the internal cognitive quality of the objectives and must be taken into account when developing map studies curricula.

3.5 In Summary

- a) Bloom's definition of knowledge, as information acquired by memory and recall, a 'thing' to be acquired before intellectual abilities and skills can be practised may lead to the encouragement of rote learning.
- b) The knowledge basic to the further development of intellectual abilities and skills is not rote-learned information, but that knowledge which is both a component, and an outcome, of the acquisition and efficient functioning of the basic mental skills of perception, conceptualization and generalization.
- c) Knowledge with regard to maps is acquired through these complex, interacting mental processes and is far removed from memory and recall.
- d) It must, therefore, be concluded that Bloom's knowledge (L 1.00) is too limited and is of little use in defining map studies objectives. It is particularly unsuitable for the kinds of map studies tasks undertaken at the K-6 stages of education.
- e) The subdivisions of the taxonomy beyond Knowledge (L 1.00) although identifying cognitively valuable activities which should certainly be encouraged, are in many respects unnecessarily detailed and confining.

f) There is little evidence that the divisions are truly hierarchical

- i) Several parallel but overlapping strands representing different modes of thinking, for example, L 2.00 - L 4.00 (analytical), L 3.00 - L 4.00 - L 5.10/L 5.20 (creative or problem solving), L 4.30 - L 5.30 (deductive), L 4.30 - 6.00 (evaluative) can be identified.
- ii) That Bloom himself was concerned about the hierarchical nature of his system is revealed by the following quotation (Bloom, et al., p. 185).

Although Evaluation is placed in the last cognitive domain because it is regarded as requiring to some extent all the other categories of behaviour, it is not necessarily the last step in thinking or problem solving. It is quite possible that the evaluation process will in some cases be the prelude to the acquisition of new knowledge, a new attempt at comprehension or application, or a new analysis or synthesis.

This quotation is good evidence that an integrated cyclical approach to cognitive processes and cognitive objectives is more appropriate.

- g) Bloom's taxonomy fails to consider sequencing of objectives and is therefore an inadequate basis for curricula development regardless of the inherent cognitive level of the objectives.

- h) Curricula such as that of South Carleton, even if incorporating an optimal distribution of Bloom's levels, result in illogical work prescription in map studies unless based on sound developmental principles.

An alternative outline for map studies curricula is established in the next two chapters, based on the ideas of developmental psychology and on map education research. An outline combining Bloom's hierarchical objectives and accepted theories of developmental psychology is not attempted because the conclusion is reached that Bloom's ideas are applicable, if at all, only at the classroom level where precise content and teaching method can be incorporated.

CHAPTER 4

BASES FOR THE ESTABLISHMENT OF A MAP STUDIES CURRICULUM

4.1 Introduction

Bloom's taxonomy fails to provide any guidance as to the sequence in which map studies should be ordered if they are to contribute to the development of cognitive abilities.

Map education research was, therefore, examined to see what light it could throw on the development of an appropriate sequence for map studies activities (Section 4.2). Apparent contradictions in the results of this research led to an examination of relevant aspects of developmental psychology (Section 4.3) and particularly to studies concerning the development of spatial cognition (Section 4.4).

These three areas of research provide the bases on which a map studies curriculum sequence can be established.

4.2 Map Education Research

The greater part of map education research, (for example many of the map education items listed in the bibliographies by Ball (1969), Lukehurst (1972), Wise (1974) and Saveland (1975)), has dealt with particular aspects of map reading skills rather than providing an overview of both map interpretation and map creation in terms of cognitive development.

Many recent reports on map learning, such as Larkin (1976), McCallum and Botley (1976), Harris (1975), Ferguson (1976), Hawkins (1977), and Stoltman (1973) have concentrated on providing teachers with specific strategies for dealing with particular map learning topics. They have not been concerned, in any detail, with the place of that topic within the total map curriculum.

One significant exception to this is Meyer (1973) who does provide an overview and proposes a sequence for 'map skills instruction'. In her review, however, maps are understood in a limited sense as illustrative tools and sources of information rather than in the broader sense of graphicacy and the development of children's ability to manipulate spatial ideas as understood in this thesis. Meyer considers sequence only in terms of distance, direction, location, and identity, that is, in terms of Euclidean abilities, and the role of maps in logical operations is not considered.

Other research has been reported which is based on relatively broadly based classroom tests aimed at ascertaining children's levels of map comprehension at various ages. Over a considerable number of years this research, dealing with a wide variety of map materials, has reported consistently that children do not have the ability to cope with map comprehension tasks routinely presented to them at various stages in their school careers. A number of these are

commented on below.

Prior's (1959) study of primary school children's map drawing and interpretation abilities demonstrated that children up to 11 years of age were unable to use conventional symbols to produce a truly diagrammatic layout, or to understand a six inch to one mile map of a neighbouring farm. It was therefore concluded that a realistic concept of a 'map' was not attained before 11 years of age and that no real understanding of maps could consequently be expected before this age. Satterly (1964) reached a similar conclusion as a result of his work with students between the ages of 14 and 15. His experience indicated that although children of 11 to 13 could rapidly learn to use conventional symbols, they nevertheless had difficulties, even at 16 years of age, in visualizing reality from maps (particularly from contours), and in correlating oblique air photographs with maps. His tests for conceptual, spatial, and perceptual abilities demonstrated that perception, especially the perception of embedded shapes, is a major factor influencing success in many aspects of map work. He argued that teaching programmes should be designed to increase perceptual skills but even so doubted the value of any mapwork before about 14 years of age. His conclusion agreed substantially with that of Brown (1960) that children under 14 years of age cannot understand (i.e., interpret) topographical maps.

Another important aspect of map education research has been that conducted into children's ability to understand atlas and small scale maps. Graves (1975) refers to an I.G.U. study which reveals that children under 10 years of age cannot understand scale or cardinal directions. Sandford (1972) reports on Bartz' research concerning children's difficulties in understanding scale, latitude and longitude, compass direction, insets and symbolism, particularly relief symbolism and lettering, on atlas maps. Not only was there difficulty in translating the immediate meaning of symbols, but also incorrect concepts about the world were developed as a result of interpreting the map too literally and having no real understanding of scale implications. Sandford's own research with students ranging in age from 11 to 18 years, confirmed two inter-related controls, perception and conceptual understanding, over the quality of atlas map interpretation abilities. He concluded that a majority of students have a "...mental map of the world that is as small as it is uncomplicated. For many of them coastlines are smooth, railway lines straight, towns few and terrain level. Features are compact and unchanging over time, and distant ones are relatively small, especially when compared with similar features in the homeland" (Sandford, 1972, p.89.).

In addition to this research specifically directed towards understanding of maps, related research, indicates problems which occur in the understanding of remote areas prior to about fourteen years of age. Examples of this are the research by

Rhys (1966) into the development of cognition in geography; by Jahoda (1962) and Carnie (1972) into children's attitudes to other nationalities, by Stoltman, et al. (1972 and 1976) into the concept of political territory. Research in perception (Veness, 1972) indicates that, about the same age, there is difficulty in visualizing a map as a whole.

In view of the large body of material expounding children's difficulties in dealing with maps up to fourteen and even sixteen years of age it is initially somewhat surprising to consider the conclusions of Blaut and Stea's research (1971 and 1974) that "Mapping is, therefore, developmentally primitive and formal map learning can begin at the age of school entrance. Blaut and Stea's studies reveal air photo interpretation abilities in five to seven year old children (an ability which Blaut and Stea claim is fully developed by the age of nine) and mapping abilities, using toy blocks to construct a physical representation of a very simple cognitive map, at the age of three. What is notable in their study from the point of view of map studies curriculum is that the youngest children (three to five year olds) were asked to use action to demonstrate their mapping abilities, whereas those a little older (five to seven year olds) were dealing with iconic, non-linguistic maps (air photographs) in which mapping conventions such as scale, projection and symbolism were not formally explained and therefore did not have to be mediated by verbal language.

It seems that the critical difference between this study and the work reported above lies in the mapping tasks which Blaut and Stea asked of their subjects: the tasks were appropriate for the stage of development reached. Perhaps the tasks normally demanded in school map studies which have caused so many difficulties are developmentally inappropriate. It therefore seemed necessary to examine what is known about the stages of cognitive development and the development of spatial cognition before a tentative sequence of map studies activities could properly be proposed.

4.3 Basic Stages of Cognitive Operations as Related to Maps

4.3.1 Introduction

A massive body of evidence concerning cognitive development has accumulated over the last 40 years. The bulk of this evidence derives from the work of Piaget and others in Geneva (summarized by Flavell 1963 and by Piaget and Inhelder 1969) or from those in other areas who have replicated the Genevan studies (e.g., Sigel 1968 and Dassen 1977). That part of the research particularly relevant to map studies assesses the types of cognitive tasks children can accomplish at different ages, the kinds of mental representations they form about their environment and the mental mechanisms they acquire for dealing with remote space. A diagrammatic representation of this research and the ages to which it relates is included as Figure 4.1.

MAJOR ELEMENTS OF SPATIAL

COGNITION

REFERENCE SYSTEMS

Guide to understanding of orientation
and co-ordinate systems

COGNITIVE MAP

TERRITORIAL DECENTRATION

Guide to after

Piaget Werner Jahoda Elias Stea

SPATIAL RELATIONS

Spatial operations: Guide to types of maps

Piaget Inhelder Flavell Holloway
Lauricenden Finard Shemiyakin

STAGES OF SPATIAL ORGANIZATION

Basic stages: Guide to mental operations
relating to space

Werner Piaget Inhelder

All of the components of spatial cognition represented are very important for children's map learning, even though the precise nature of all of the links between a mental representation of space and a physical representation, a map, is not yet clearly understood (Robinson, 1976).

In order to put ideas concerning the development of spatial cognition and the understanding of a spatial representation into an appropriate setting, Piaget's basic operational stages are considered and their relevance to map studies established. Bruner's (1960, 1966, 1973) research helps to relate Piaget's more theoretical studies to practical educational concerns. Together they indicate the kinds of thought processes children use and the modes of learning suitable at various ages, and therefore allow suggestion of the kinds of map concepts, materials and activities with which children can be expected to deal during various phases of their primary and secondary school years.

4.3.2 Piaget

Piaget's fundamental contribution, as identified by Flavell (1963), is the emphasis he placed on activity rather than language as the mediator of mental development. He considers remembered activity to be the foundation of image formation and concept development. This internalization of action is called an 'operation' and children's

development goes through a series of operational stages. (Fig. 4.1).

Of particular significance for map education are the stages of intuitive thinking (ages approximately four to seven years), concrete operations (ages approximately eight to eleven years), and formal operations (ages approximately eleven to fifteen years). The characteristics and relevance to map education of these stages must be briefly explained.

The main characteristic of the period of intuitive thought is the child's inability to appreciate that something can retain the same substance, quantity, length, weight, or volume, even if its appearance changes: The ability to conserve these properties (conservation) develops gradually. Until conservation of, for example, length has been achieved the study of the relationship between map distance and real-world distance is not a useful learning activity. The only valuable measuring exercises prior to conservation of length are those which are specifically designed to aid its attainment. It is notable that Blaut and Stea do not incorporate measurement and this may account for the success of their map tasks.

The period of concrete operations is that in which conservation is gradually achieved: of substance at approximately seven to eight years of age, of weight at approximately nine to eleven years of age, and of volume at approximately

eleven to twelve years of age (Stones, 1966). This is also the stage in which the child is able to think about actions, but not in any abstract manner: he is still dependent on concrete examples as the basis of thought. Hall (1976, p. 234) has summarized the characteristics of concrete operations as follows: "Concrete operational thought is an isolated form of thinking, based largely on concrete experiences which provide the means of seeing abstract relationships in a particular context only... Operations can be reversed, ideas of conservation of number, of substance, of mass and volume appear in that order, separate classes of objects can be combined to make a more comprehensive class (that is, sandstone and limestone = sedimentary rocks) and a quantity can be multiplied by combining it with its opposite (that is x with $-x$)." At this stage, then, distance, scale, symbolism and classification in maps become appropriate learning tasks providing they are introduced gradually and are constantly related to concrete examples and to reality.

The formal operation stage is reached only when the student is able to think in abstract terms so that operations can be removed from real action, objects, or space. Reasoning by hypothesis is then possible. Problems can be posed and solved verbally. At this time it becomes possible to deal analytically with abstract map concepts such as those used in quantitative thematic mapping.

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Several points concerning these stages are significant to this study:

1. Even though approximate ages for the attainment of the different stages have been given, age is not, for Piaget, the critical factor in development, but rather changes in the level of organization.* Followers of Piaget working in many parts of the world (Sigel, 1968**, Dassen, 1977) have noted wide variations in the actual ages at which these developments take place. Many suggest that the stages are reached considerably later than Piaget indicates and are influenced by such factors as location, culture, education and socio-economic status. However, of more significance is the fact that the invariant sequence of the stages has been widely accepted (Sigel 1968, Rowland 1971, Hart and Moore 1973).
2. Although it is indicated that the ability to think logically develops during the early teens, Stones (1966) indicates that in any group of students between 11 to 14 years of age only a small percentage will have achieved logical thought. Some students such as those

* It should be noted that in this study also wherever specific age is mentioned it is to be understood in approximate rather than absolute terms.

** Sigel's book of readings of research based on Piaget's theory includes studies from, among others, Rochester, Clark University, U. of Georgia, U. of California, John Hopkins, U.S.A.; Queen's University, Kingston, Canada; Leeds, Sheffield and Bristol, England; U. of Oslo, Norway; and State University of Utrecht, Netherlands.

who leave school at any early age and some more primitive societies never attain this level. Even when logical thought has been achieved it is not used alone and students dealing with new problems, situations or stress tend to revert to the simpler mode.

This being so, it must be concluded that the concrete mode of operations is dominant for a large proportion of the school years, i.e., ages eight to fourteen. The kind of map studies which deal with measurement, representation and interpretation of concrete phenomena would seem to be particularly appropriate to this stage and the map itself, (particularly the large-scale map concerned with the accurate representation of the earth's surface), a concrete object, can act as a surrogate for reality when dealing with remote areas.

A great deal of thematic mapping is of small scale and is based on abstract notions and on relationships between several variables. The outcome of the research noted above would be to suggest that detailed consideration of quantitative and abstract thematic maps is more appropriate at the formal operations stage from 14 to 15 years of age onwards.

4.3.3. Bruner

Bruner's major emphasis is upon "...literate, numerate and graphic expression in written form both as aids to reflection and as instruments of communication and cultural

transmission". (Hall, 1976, p. 238). The child, according to Bruner (1966, p. 11), internalizes his past experience first by means of action, enactive representation; secondly, by means of images, iconic representation; and ultimately by means of language (which may be visual or spatial), symbolic representation. Although these modes are sequential and have temporal implications they are not conceived by Bruner as specifically age-related stages like those of Piaget, but rather as the means the mind uses to cope with new materials and ideas at any age. Bruner suggests, therefore, that concepts may be represented by all three modes and advocates a spiral curriculum returning to concepts at progressive levels of representation.

In all of the modes Bruner stresses the importance of integration of hand and eye (a subject of great relevance to map creation) in the development of intelligence, and regards the growth of manual intelligence as a prerequisite to problem solving.

Bruner's ideas would suggest that map studies can be a very effective means of developing cognition because there is room for making use of all three modes. It also suggests why map studies experiences should begin, for example, with active experiences in the playground, the 'field', the route to school; should involve active measurement of, for example, direction from the sun's shadow, the keeping of meteorological records (enactive); and should

proceed with the use of pictures, models and air photographs (iconic) before dealing with the purely symbolic language of the map. Bruner's stress on hand and eye coordination, and on enactive, iconic and symbolic representation also draws attention to the importance of the creative aspects of graphicacy where the act of drawing itself can be considered as enactive, where hand/eye coordination receives especial training and where the mode of expression may be either iconic (as in landscape sketches, block diagrams) or symbolic (sketch maps, graphs, diagrams).

Whereas Piaget has been criticized by some educators (e.g., Stones 1966, p. 135, Sullivan 1967, p. 26) on the grounds that his work, being based on genetic-epistemology, is concerned with understanding natural processes rather than with attempting to modify them, Bruner's approach emphasizes the role of education in accelerating development by the deliberate structuring of the learning environment.

Together the ideas of Piaget and Bruner can be considered as providing the fundamental characteristics of the various stages of development in children. The ways in which specifically spatial aspects of cognition develop in children needs further consideration.

4.4 Development of Spatial Cognition

4.4.1 Introduction

In addition to the fundamental characteristics of the various stages of development, the ways in which children develop a concept of their environment (initially their immediate surroundings, but later in relation to remote areas) is of vital importance to their understanding of maps. Piaget's (1969, 1960) studies of spatial relations provide the foundations for knowledge of the kinds of maps children can be expected to understand, of the areal extent they can conceptualize and of the kind of orientation and map coordinate system they can use (Fig. 4.1). Piaget's work in this field has been supplemented by that of many other workers. Hart and Moore (1973) have contributed significantly to an understanding of the subject by their comprehensive account of psychological and geographical work relating to the ways in which children gradually build up the idea of space as a "...geometric entity with certain properties irrespective of transformations...."

From reviewing the literature concerning spatial cognition it would seem that there are three basic elements of spatial cognition which need to be considered and are particularly relevant for understanding maps: spatial relations, reference systems, and the concept of territory. A final topic in this section deals with perception of the physical representation of space - a map.

4.4.2 Spatial Relations

Sauvy and Sauvy (1974) have noted that space can be conceived as infinitely large or infinitely small. Adults are used to the idea of identifying space by measuring length, areas, and volumes, thereby delimiting components of space and providing a framework for action. Children, however, do not have this conceptual framework. As Piaget (1960) has shown, they develop a Euclidean idea of space, that is, one based on measurement of its properties, only after progressing through two earlier stages, those of topological and projective relations (Figure 4.1). Euclidean concepts of space are dependent upon the establishment of conservations during the concrete operations stage.

a) Topological Relations

Topological relations are concerned with the study of place and position, not in terms of measurement of precise location, distance or direction, but in terms of more fundamental general relationships such as connection, closeness, inclusion and neighbourhood. They deal with spatial relationships which remain the same even when the space is stretched or compressed and the shape thereby distorted.* Flavell (1963, p. 329), notes that it takes until about seven years of age for topological relationships to be integrated

*Jean and Simone Sauvy provide an excellent detailed explanation of topological qualities in The Child's Discovery of Space, Penguin Education, 1974.pp. 27-61.

into stable operational systems (except for that of continuity which, being dependent on the abstract notion of infinity, is not mastered until the formal operations stage.)

The basis for these conclusions was Piaget's extensive measurements of children's haptic perception (that is perception by touch when the object cannot be seen) of various shapes, surfaces, volumes and boundaries. During the stage of topological relations a circle and a square, for example, are perceived (haptically) as the same figure, i.e., a closed shape, and distinctions are made on the basis of open or closed, smooth or irregular, inside or outside, disjointed or connected, with or without holes.

In addition, children at the topological stage can appreciate only isolated topological shapes or one-to-one relationships so that study of the integrated shapes and relationships of a total map surface are not appropriate. Thus, mapping activities should exclude the complicated visual field of a total map surface, and interpretation should be limited to consideration of isolated or linked forms with qualitative relationships. Emphasis should be placed on continuity, open and closed curves, boundaries, regions, interior, exterior, holes and connectivity. During this period, until about seven or eight years of age, distance, straight lines, angular measurement and

shape, none of which can be conserved under topological conditions, should be avoided.

It has been noted (Sauvy and Sauvy, 1974) that many adults continue to have problems with spatial relations because of gaps in their education. This may well be linked to problems described above (pp. 73-6) concerning children's difficulties in understanding maps.

Flavell (1963, p. 355) has reported Piaget's conclusion that geometry, the pre-eminently spatial branch of mathematics, has traditionally been taught in an order inverse to that in which spatial relations naturally develop. It seems likely that the same problem may be the cause of children's difficulty in understanding maps.

b) Projective^{*} Relations

At about the age of seven or eight Piaget (1969) shows that children begin to acquire the ability to conserve a straight line. This leads to an elementary

* It should be noted that this terminology is derived from projective geometry where it is understood that the "...projective properties of a figure are those that are not changed if the figure is projected on to any plane surface." (Piaget, 1969, p. 66). In projection a straight line always remains straight even though its length may be changed. A circle, however, does not remain a circle but becomes an ellipse. In dealing with projective spatial relationships then, Piaget is talking about relationships in terms of straight line connections as compared with circles, angles or areas. This is the only sense in which the term projective relations has anything to do with the cartographic topic of map projection.

understanding of spatial perspective, i.e., the capacity to imagine how an object will appear from different viewpoints. The child becomes capable of drawing an object first as seen from an egocentric viewpoint and later, as seen by an observer to the left or right or facing (perspective viewpoint). Understanding of left/right and in front/behind is developing at this stage.

The most appropriate ~~map~~ materials and exercises for the period of projective relations would seem to be those associated with one point of view, such as 'route' maps, with relationships between routes gradually being acquired by means of the introduction of large scale plans (at a scale of e.g., 1:2,500, i.e., at a scale large enough to show buildings in outline rather than symbolically.)

c) Euclidean Relations

Piaget (1969) indicates that from the age of nine or ten ("seldom before") children gradually acquire the ability to coordinate several viewpoints and then build up an overview of space. At this time, too, the child begins to conserve direction and acquires the ability to measure objects by means of a standard unit of measurement. This leads to the ability to view space as a coordinated system with Euclidean or metric relationships. With this development it becomes possible to view

the map as a coordinated representation of space. It is not until this stage is reached that the map as a formal system; and traditional map concepts of distance, direction and measurement of lines and areas should be taught.

Although Piaget (1960) states that this stage begins at around nine or ten years of age, it should be noted that he links the ability to produce a purely schematic plan with the development of abstract formal operations which, as was indicated, earlier, may well not occur in many cases until about 14 years of age.

4.4.3 Reference Systems

Much of the work following on from that of Piaget has concentrated on the development of concepts of orientation and coordinated reference systems. Hart and Moore (1973) noted that there are three stages of orientation as children build up a cognitive representation of their environment.

(Figure 4.1):

- i) From the ages of two to six years a child's orientation is in terms of the self only, that is, egocentric.
- ii) From six to ten years orientation is in terms of fixed familiar features, that is, domicentric.
- iii) Only from about ten years of age can the child understand a polar coordinate system with a freely transferable point of reading. This is very relevant for the teaching of cardinal directions.

The attainment of a two dimensional coordinate system, which is important for the understanding of grid systems and latitude and longitude, as well as for dealing with a total map document, is attained only after the prior achievement of perspectivism, i.e., the ability to incorporate more than one's own viewpoint and to visualize that which is not within one's own experience. Hart and Moore (1973, p.280) report Lee who doubts that a two dimensional reference system is something which develops naturally at all. It is not difficult to see why children continue to have problems with reference systems between the ages of 11 and 16 years.

4.4.4 Territorial Decentration

A further body of allied research which has relevance for the map studies curriculum is that relating to children's concept of political territory. Jahoda (1963) and Stoltman, et al. (1976) have studied children's ability to understand such concepts as class inclusion related to space (Figure 4.1): it is difficult for young children to understand the notion of city, county, province, for example, and to realize that one can, at the same time, be in all three. The attainment of this concept is basic to the understanding of small scale maps and maps of remote areas. Its lack can lead to misunderstanding of relationships between places and areas as shown on atlas and other small scale maps.

Research indicates that decentration can occur in children at any time from 9 to 14 years of age after passing through egocentric and domocentric phases. Stoltman suggests that the development and introduction of specific exercises to aid the achievement of decentration would be beneficial at approximately ages 10 to 11 years.

It would seem that unless this concept has been acquired cities and territories on globes and atlas maps would be viewed by children merely as shapes on paper or on a ball, rather than as models of reality. Early traditional location exercises would therefore seem to contribute little to a real understanding of the world's spatial organization.

4.4.5 Perception of a Physical Representation of Space

Robinson (1976, p. 88) has noted a possible time lag of several years between the development of a child's ability to act in space and his ability to form or use a representation of that space. Vernon (1967, p. 102) has noted that the ability to understand shapes on a flat surface is one which has to be learned, often with great difficulty. Thurstone (1944) has detailed the difficulties of perceiving embedded shapes. Veness (1972) reports Walter's study which shows that even at 15 years of age, only 25 percent of a group of students with above average intelligence were able to see a visual diagram as a whole. Graves (1975) has concluded:

"In the perception of secondary evidence, it seems clear that whether students are looking at photographs or maps, they tend to look at particular features, not at wholes or 'gestalt'. To get pupils studying macro-rather than micro-patterns requires careful training... Individuals differ significantly in their ability to perceive what is on a map, this being related partly to some perceptual speed factor and partly to their capacity to conceptualise space."

4.5 Summary

It has been shown in this chapter that there are a number of factors influencing the ages at which various aspects of map studies should be taught.

Piaget (1960) demonstrated the importance of topological relationships in the development of intelligence and their chronological sequence before the development of projective and Euclidean relationships. Sauvy and Sauvy add that topological relationships do not give way to projective and Euclidean, but, being more general, continue to underlie them. Whereas Blaut and Stea's studies indicate that children do not need to understand verbal language in order to be able to deal with maps, studies in spatial relations indicate that children do not have to understand Euclidean (metric) relationships before they can deal with mapping concepts. Children do not have to be able to define location by accepted adult standards or be able to measure distance and angles in order to study place and position as related to more general relational ideas.

It seems reasonable to conclude that the inclusion of Euclidean ideas and methods before a firm foundation of topological relationships has been established may well be a major reason for children's problems in understanding maps. The work on reference systems indicates that school map studies programmes tend to stress orientation and two dimensional coordinate systems at much too early an age.

The work on decentration indicates that small scale maps and the recognition of political territory on maps is taught too soon.

Research relating to perception of the map as a physical document indicates that understanding of the map as a total visual field should not be expected until about 10 to 14 years of age.

This review of map education research, Piaget's stages of cognitive development and studies in spatial cognition are combined to identify four major developmental phases, illustrated in Figure 4.2. In the following chapter these phases form the basis of a proposed outline map studies curriculum. Four phases only are suggested for the following reasons:

- a) On the basis of this chapter each of these is seen as a phase in which the approach to map studies is quite distinct from that which preceded and that which follows.

Figure 4 2

- b) In view of the diversity of research experience relating to age, it is considered necessary to allow sufficient latitude for the range of ages at which various components of development may be attained.
- c) It is also considered important to allow for sufficient flexibility of teaching approach such that the specific learning objectives which may be developed may fit into the overall curriculum, particularly in relation to geography/social studies and mathematics.

5.. MAP STUDIES CURRICULUM SEQUENCE

5.1 Introduction

On the basis of the ideas developed in Chapter 4 an Outline Map Studies Curriculum is proposed for the four major developmental phases: 1) Ages 5-7 years, 2) Ages 8-11 years, 3) Ages 12-15 years, 4) Ages 16 onwards. These phases are used to test the South Carleton sequence charts for map and globe skills from Kindergarten to Grade 13.

5.2 Map Curriculum Phases

The four phases are presented through consideration of an age range (for western culture groups), Piagetian and Brunerian stages, spatial cognition abilities, appropriate map studies aims and appropriate creative and interpretative map studies strategies for the age range.

5.2.1 Phase 1

Age: Approximately 5-7 years (Kindergarten to Grade 2).

Piagetian Stage: Pre-operational thought: no conservations are assumed. The basic processes operating are development of imagery, acquisition of language and pre-conceptual thinking..

Brunerian Mode: ENACTIVE with the environment by means of observation and verbal description leading to concept formation. ICONIC, using toy models to recreate very limited aspects of own environment; painting or drawing representation of the micro-environment, e.g., keeping a personal pictorial spatial diary to encourage the development and recording of the mental map.

Stage of Spatial Cognition:

Spatial Relations: TOPOLOGICAL only, i.e., dealing with qualitative relationships and the perception of isolated (rather than inter-related) shapes.

Cognitive Representation: is EGOCENTRIC; perspectivism has not been attained.

Reference System: is EGOCENTRIC; direction is relative (here/there, left/right) to the self.

Territory: 'Concept of territory is EGOCENTRIC' and DOMICENTRIC. Areas covered should be based on the self or the home.

Summary of Appropriate Map Studies Strategies

Basic Aim: Orientation of the self in relation to the immediate environment. All work is child-centred.

a) Creative

Emphasis should be placed upon the observation of the child-centred micro-environment. Spatial

relationships should be expressed only in terms of relative space, such as:

proximity separation	near/far
	up/down
	here/there
order (spatial succession)	near/nearer/nearest
	open/closed
enclosure	inside/outside
continuity	concept of a line as a sequence of points.

Many exercises are required in the development of topological abilities. These are extremely important as they will be the foundation for the later development of adequate concepts of distance, location, height, direction, classification, ranking, shape, symbolism, boundary and territory.

b) Interpretative

Concern should be with isolated topological forms and qualitative relationships, e.g., match-stick diagrams, inside/outside problem solving, enclosure and boundaries, and relationships. Maze solutions are valuable. Globes are useful only for their topological properties, (i.e., as a closed space or ball). The map as a total perceptual field should be avoided and also small scale maps, cardinal direction measurement and scale.

5.2.2 Phase 2

Age: Approximately 8-11 years (Grades 3-6)

Piagetian Stage: CONCRETE operations, conservations of substance, number, weight and volume are achieved gradually and sequentially. Concrete experience provides the means of seeing abstract relationships only in a particular context. Combination of classes into more comprehensive classes is possible.

Brunerian Mode: ENACTIVE: Involving observation and recording, active experimentation, and measurement of reality. ICONIC: Incorporating the use of pictures, local air photographs, and models wherever possible. SYMBOLIC: the large scale map viewed as a representation of the local environment.

Stage of Spatial Cognition

Spatial Relations: PROJECTIVE leading towards Euclidean: Relationships are seen initially in terms of one particular visual point of view. The invariance of a straight line and parallel lines under projective and perspective transformations is established. There is gradual development of an awareness of perspective, or the inter-rélations between elements seen from different points of view, and the gradual achievement of a viewpoint different from one's own.

The large-scale map as a total visual field is achieved only at the end of this process.

Cognitive Representation: An individual viewpoint as distinct from that of others is established leading to the attainment of a viewpoint other than one's own (PERSPECTIVISM).

Reference System: Orientation is to fixed familiar features. The attainment of a polar coordinate system with a freely transferable point of reading is not achieved until about Grade 5.

Territory: During this period the concept of class inclusion is achieved leading to the ability to appreciate that a place can, at the same time, be within a city, county, province and country.

Summary of Appropriate Map Studies Strategies

Basic Aim: Transition from topological relationships to comprehension of the large scale map document by means of one-perspective mapping. Work should be centred on the local area with later extensions in terms of journeys, trips, vacations and routes.

a) Creative

Continued development of observation of the environment with increasing emphasis on measurement and recording of observations; (for example, direction

from shadow stick to develop cardinal directions; measurement of bearing from fixed familiar features, weather measurements and recording). Development of the cognitive map by drawing sketch route maps starting from the self at bottom using only relative distance; drawing sketches, from field work, of buildings, obvious landscape features, etc. Emphasis should be upon separations, boundaries, inclusions, neighbourhoods, districts. Simple thematic work such as land use related to these concepts may be introduced at very large scale. Measurement of length, distance, leading to the development of the concept of scale should be gradually introduced, based on routes. Measurement of area is appropriate only towards this end of Phase 2.

b) Interpretative

Initially it is suggested that a vertical air photograph, school centred, should be used. Appropriate tasks include recognition of known features, establishment of routes, measurement of simple lengths on photographs and related to measured ground distance and size. Measurement of angular bearing from known places should be introduced. Later the largest possible scale map, cadastral or street plan of the local area showing individual fields, streets and

buildings and without abstract symbolism can be introduced. Exercises should be given to encourage concept of class inclusion (i.e., barn, in field, in farm), by means of such techniques as tracing boundaries, shading areas, verbalizing distinctions. Models on cardboard cut outs can be used to explain the concepts. Later it is possible to expand to larger areas and more remote territories.

In Grades 5 and 6 it may be possible to introduce smaller scale road maps (such as the Ontario County, 1" to 1 mile) if perspectivism and freely transferable coordinates have been achieved. Emphasis should still be on a single viewpoint and relationships to it rather than on an overview. Practice in measurement of distance along routes, route finding and description, based on a problem-solving approach, e.g., treasure hunts, orienteering, is appropriate.

5.2.3 Phase 3.

Age: Approximately 12-15 years (Grades 7-10)

Piagetian Stage: Transitional from CONCRETE operations to LOGICAL THOUGHT. Only a small percentage of students will have achieved logical operations by Grades 7/8 and some students will not even reach this level. It is unlikely below 13+. Teenage upheaval often causes

reversions, therefore most work will be at the concrete level with logical 'readiness' preparation. Therefore emphasis is on using maps as a means of breakthrough because it is a concrete medium symbolically representing abstract spatial ideas. The success of this effort depends upon the development of intensive map use at this stage,* first based on thorough familiarity with topographic maps and the study of relationships by way of topographic maps, and then proceeding beyond topographic to work with more abstract thematic concepts.

Brunerian Mode: ENACTIVE: Map drawing; measurement, profile diagram and model construction, related field work. ICONIC comparative use of air photographs, pictures; SYMBOLIC map study and interpretation.

Stage of Spatial Cognition

Spatial Relations: EUCLIDEAN, therefore relationships are metric and directional: distance, angles, straight lines, and proportions are conserved. All figures are coordinated within a whole and organized in terms of a common spatial structure throughout, therefore the map can be approached as a total document.

Cognitive Representation: PERSPECTIVE, the ability to understand a viewpoint other than one's own is attained.

* It should be noted that if topological and projective relations have not been adequately handled at earlier stages it seems necessary to ensure their establishment as a foundation if major problems in map understanding are not to accrue.

Reference System: POLAR COORDINATES with a freely transférable point of reading have been established. A TWO-DIMENSIONAL COORDINATE SYSTEM can be developed therefore work with grids and latitude and longitude is appropriate.

Territory: TERRITORIAL DECENTRATION is achieved and map studies can be extended to remote areas and to smaller scale maps.

Summary of Appropriate Map Studies Strategies

Basic Aim: Disassociation from concrete operations to deal with logical operations with regard to space. Work should extend from large scale topographic and thematic maps to smaller scale thematic and atlas maps. Air photo work can be extended from vertical to include oblique. Consideration of one variable can be extended to include several variables.

a) Creative

Observation and analysis of urban and rural landscape by means of field sketches and sketch maps should be emphasized and also data recording and analysis, e.g., weather, population movement, traffic count, shopping trips. Sketch map interpretations from topographic maps are appropriate.

b) Interpretative

Formal basic work with topographic maps including symbolism, grids, scale, distance, direction and relationships is necessary. Intensive work involving measurement and area should be included in order to develop scale concepts. The development of an understanding of relief representation and analysis, with profiles, intervisibility is important at this stage. Initially work should involve micro-examination of individual parts of the map and gradually be extended to develop the ability to see the map and relationships as a whole. The development of perception of embedded shapes on the map should be encouraged as well as the development of the ability to re-imagine the landscape (e.g., by verbal descriptions, drawings).

At the beginning of this phase the map, for the first time, should be treated as a formal idea, that is, a code or language to represent other places and therefore as an aid in the understanding of places not known personally. Continual reference to reality should be made. In Grades 9 and 10 it would seem appropriate to extend map study to include large scale topographic maps of world areas under consideration - thus a greater sense of reality with reference to remote areas is developed.

Some particular notes relative to Phase 3 are:

The teaching of map studies at this stage is vital to a future understanding and use of maps. This involves a considerable investment of teaching time by specialized teachers.

At this stage there is still evidence (supra, pp. 74-76) of:

- a) problems with orientation and grids
- b) spatial distributions outside the personal frame of reference
- c) misinterpretations and too literal interpretations of small scale (particularly thematic) and atlas maps
- d) difficulties in viewing maps and diagrams as a whole rather than their individual parts.

Therefore work should be based first on:

- a) a 'reality' orientation and single items of evidence and then progress towards
- b) the combination of evidence and understanding of cause and effect; and only eventually should it lead to
- c) multivariate and abstract relationships.

It is important that the study of thematic maps at as large a scale as possible be included in this stage. Study of thematic maps will appropriately start with qualitative relationships and concrete phenomena such as geology,

vegetation, land use, and proceed by comparison, inference and analysis. Simple quantitative concepts such as population distribution can be introduced when relevant. An introduction to the interpretation of thematic maps is very important at this stage if effective map use in logical operations is to be possible.

5.2.4. Phase 4

Age: Approximately 15 years onwards (Grades 11-13)

Piagetian Stage: LOGICAL OPERATIONS. Spatial operations can be removed from real action, objects and space. Manipulation of abstract ideas is possible so that students can be expected to deal with the possible, the hypothetical and the infinite.

Brunerian Mode: SYMBOLIC: Without necessarily reverting to enactive and iconic modes but only if the student has a sufficient background of imagery to support him.

Stage of Spatial Cognition

Spatial Relations: Use of Euclidean space is attained.

Cognitive Representation: Perspective attained.

Reference System: Polar and two-dimensional coordinate system attained.

Territory: Decentration attained.

Summary of Appropriate Map Studies Strategies

Basic Aim: The use of the map as a model. It is possible to deal with maps at all scale ranges. Thematic maps can be understood, used and created including maps of intangibles, multi-variate relationships, and surfaces, both physical and conceptual. Physical, Euclidean space can be transformed and distance or area represented by time, cost or quantity, rather than by metric measurements. Both map and globe can be understood theoretically, as models. For the first time the globe, world climates and seasons, for example, can be understood deductively, i.e., it is appropriate to deal with the globe as a model of reality and deduce from its shape, angle, rotation, revolution around the sun, implications for time zones and climate.

5.3 The South Carleton Sequence Charts, Kindergarten to Grade 13, Related to the Proposed Four-Phase Curriculum Sequence

The four basic phases of map learning outlined above are used here to examine the two kindergarten to Grade 13 sequence charts included in the South Carleton Curriculum. These charts of Map Skills and Concepts, and Globe Skills and Concepts are to be found in Appendix 2, pp.138-9. Topics on the Maps Skills Chart have been rated appropriate or inappropriate according to whether or not they conform with the developmental periods identified in Section 5.2. The following events are noted:

- a) Phase 1/Grades K-2 - Eighteen topics were identified for this period of which eight were judged developmentally appropriate (Table 5.1). Appropriate activities encourage direct observation of the environment and visual interpretation of pictures. Inappropriate during this period were those which emphasized formal map concepts such as scale, direction, symbolism and the total map surface. According to developmental theory these were judged to be introduced too soon.
- b) Phase 2/Grades 3-6 - Thirty-two major topics were indicated for this period of which 24 were judged to be inappropriate (Table 5.2). These dealt with formal work with legend symbolism, scale, projection, orientation and particularly small-scale thematic maps. This was the most negative period judged by concepts in spatial development. It does not follow ideas concerning the development of projective and Euclidean relationships. The comparison of maps with oblique air photos, included here, has been demonstrated to be only suitable at the logical operations level (Graves, p. 182).

Although there is a separate chart for globe skills several globe concepts and longitude and latitude are introduced even in this list. There seems to be an overwhelming preoccupation with the globe in the South Carleton Curriculum.

TABLE 5.1

Grades K-2

DEVELOPMENTALLY APPROPRIATE AND INAPPROPRIATE TOPICS

APPROPRIATE

INAPPROPRIATE

Describes relative positions (near-far, high-low, etc.)	- Interprets pictorial symbols
Locates self in relation to environment	Maps show location
Street address	Maps on floor (horizontal)
Simple 3D maps using blocks	Scale
Painting pictures of local environment	Symbols stand for real things
Trace route taken	Simple maps of classroom, etc.
Bird's eye view	Lettering on all maps
Shadow stick	Interpret colour key
	Interpret non-pictorial symbols
	Trace route taken by others

TABLE 5.2

Grades 3-6

DEVELOPMENTALLY APPROPRIATE AND INAPPROPRIATE TOPICS

APPROPRIATE	INAPPROPRIATE
Use of compass	Legend
Up-down, North-South	Statement of scale
Road map	Compare maps with oblique pictures
Giving directions in response to query	Transfer globe to flat paper
Routes of Explorers and why (?)	Conventions of map
Use variety of symbols with skill	Rivers run downhill
	International colour scheme
	Linear scale
	Orient map
	Map abbreviations
	Maps for different purposes
	Maps show distribution
	Maps hung on north wall (vertical)
	Location of self to nation, continent, world
	Use of outline maps
	Wind and ocean currents
	Latitude
	Different symbols for same thing
	Intermediate points of the compass
	Satellite photos of earth
	Longitude
	Interrelationships between climate, ocean currents, altitude, etc.
	Map Index- gazetteer, grid systems
	Sketch map, correct area and shape with constant scale
	Interpretation of a variety of maps
	Open and closed scale

An additional reason for the listing of so many inappropriate activities at this level would appear to arise from the constraints imposed on map studies by adherence to the 'expanding horizons' theme of the Ontario geography curriculum guidelines. (See Chapter 1, p.14 and Appendix 2 p.136).

- c) Phase 3/Grades 7-10 - Fourteen topics were indicated for treatment at this level, one of which (orographic rainfall and rain shadow) was not a map topic (Table 5.3). The other topics were rated as being appropriate since they dealt with formal work on introductory topographic map interpretation. It is to be noted, however, that this is only one aspect of map studies judged important at this stage. Even within this aspect, grids and area, the study of relationships and the expansion to remote areas were omitted. Also neglected were map making, the gradual understanding of small scale maps and all consideration of thematic maps and mapping.
- d) Phase 4/Grades 11-13 - Six activities only were listed, of which four were judged to be appropriate at this level (Table 5.4). Two others, 'land use maps' and 'military town plans' were seen as being probably more appropriately introduced in Phase 3, although reinforcement work at this level is probably appropriate.

That there is very little map work indicated in Phase 4 leads to the suggestion that map use may not play an adequate role at the logical operations stage. There is inadequate treatment of logical operations and abstract thematic map concepts at this level. Perhaps it is assumed that maps are now 'known'.

Map drawing is mentioned only in Kindergarten (the classroom) and Grade 1 (tracing a route) prior to Grade 6 when students are suddenly expected to be able to draw sketch maps with "constant scale and correct area and shape". This would indicate that a vital aspect of map studies is being neglected.

5.3.2 Globe Skills and Concepts (Appendix 2 p.138)

The topics on this chart were not rated individually because none of the developmental ideas examined in this study suggested that formal Euclidean treatment of the properties of the globe was appropriate anywhere but in the later stages of education. Following the Ministry guidelines, the South Carleton Curriculum puts a major emphasis on globe skills, including latitude, longitude and map projections, at what seems to be far too early a stage in education. Because the 'round earth' concept is being taught at a time inappropriate to children's developing abilities its acquisition seems to require a monumental teaching effort all through the school years.

TABLE 5.3

Grades 7-10

DEVELOPMENTALLY APPROPRIATE AND INAPPROPRIATE TOPICS

APPROPRIATE	INAPPROPRIATE
Compare maps with vertical satellite photos	Orographic rainfall and rain shadow (non map topic)
Locator map(?)	
Compass rose	
Representative fraction	
Large and small scale map	
Local topographic map	
Foreign topographic map	
Contour lines	
Compass bearings	
Cross section / Profile	
Horizontal Scale	
Vertical Scale	
Vertical Equivalent	
Adjusting to various scales	
Aerial photographs	

TABLE 5.4

Grades 11-13

DEVELOPMENTALLY APPROPRIATE AND INAPPROPRIATE TOPICS

APPROPRIATE	INAPPROPRIATE
Various projections and theory	Land-use maps
Choropleth maps	Military town plans
Dot maps	
3D maps	

Globe skills would seem to contribute little to the development of a child's understanding of space, and valuable teaching time could more profitably be used in developing skills which are within an appropriate developmental phase.

A strong influence from the United States* can be perceived in this emphasis on the globe. One may be permitted to doubt the value of Warman's (1954) frequently quoted contention that "It probably needs no repeating but the globe is always paramount at all levels", and even suggest that his statement concerning projections "...the drawing of several projections by the school student of geography are excellent for humbling the learner..." reveals a somewhat sadistic approach to education. The principles of educational psychology listed in the South Carleton Curriculum (Appendix 2, pl36) would seem to be a more appropriate guide to action than the detailed specifications in the remainder of the Curriculum.

5.4 Summary

A tentative curriculum sequence for map studies from Kindergarten to Grade 13 has been developed in this chapter and has been used to examine the sequence charts for Kindergarten to Grade 13 provided as part of the South Carleton Curriculum.

* A study of the various influences on geography curricula in Ontario is to be found in: "The Development of Geography and History Curricula in the Elementary Schools of Ontario, 1846-1966", Edison J. Quick, unpublished Doctor of Education thesis, University of Toronto, 1967.

This examination revealed that, if the proposed phases are accepted, there are deficiencies in the sequencing of map learning tasks in the South Carleton Curriculum. There are major omissions in all four phases, and there are, in contrast, many topics emphasized which do not relate well to the developmental phase of the child. The problems are particularly acute after Kindergarten and until about 12 years of age.

On the basis, therefore, of tests concerning both the inherent cognitive challenge of its map learning objectives, and the sequence of its map learning tasks, the South Carleton Curriculum failed to demonstrate a high potential for developing cognitive abilities. This was seen to be due, not so much to the precision or lack of precision with which its objectives were formulated, as to the map concepts selected for study and their sequencing within the Curriculum. The emphasis on Euclidean map concepts at too early an age was seen. Other research has shown that problems with map studies are by no means peculiar to South Carleton, and that the teaching of map studies has gone seriously wrong at the school level.

CHAPTER 6

CONCLUSIONS

The relative importance of cognitive objectives, of the type advocated by Bloom, and of sequence of objectives, as indicated by developmental psychology, have been examined in relation to a school (South Carleton 'Family' of Schools) map studies curriculum. Cognitive objectives were found to be, by themselves, an insufficient basis for the development of map studies curricula and an attempt was therefore made to devise a curriculum more in accord with psychological and educational developmental principles of spatial and graphic cognition. Traditional map studies curricula have largely ignored consideration of such fundamental elements. As a result of this study a basic four phase curriculum outline has been proposed and certain conclusions have been reached.

6.1 Cognitive Objectives

- a) Although Bloom's taxonomy lists cognitive tasks which are valuable for increasing the inherent cognitive content of a particular learning activity, and for this reason should be encouraged, the taxonomy does have major disadvantages. Of particular significance is the limited definition of knowledge which would tend

to encourage rather than discourage rote-learning. In addition the other levels of the taxonomy cannot be regarded as a true hierarchy and do not define activities which are mutually exclusive. Too rigid an adherence to Bloom's cognitive tasks could easily lead to the segregation of isolated aspects of map learning, a failure to establish guiding principles, and consequently to the danger of misplaced emphasis on components of map learning.

- b) Behavioural objectives themselves can be almost meaningless unless they are very carefully worded whatever cognitive content is involved. Even if they are well formulated they can easily become too structured and detailed so that they are a constraint on teacher and student alike. A large number of such objectives handed to the classroom teacher for implementation can, as several South Carleton teachers indicated, be completely overwhelming. Detailed statements of objectives are likely to become self-defeating by being ignored.
- c) Given that professional development of teachers is considered desirable then it would seem more profitable to concentrate attention on the understanding of maps and the role of graphic language in the development of spatial cognition, rather than aiming at uniformity by providing detailed objectives. This is particularly true for the individual non-specialist teacher. However,

greater emphasis on graphicacy in teacher education would seem to be desirable since it is virtually impossible for a graphically illiterate teacher to teach map studies well.

- d) The place for detailed objectives, as advocated by Bloom, would seem to be at the classroom level, and established by the classroom teacher, where they can be a useful guide to the kinds of cognitive activities to be encouraged. However, this must be at the discretion of the individual teacher, who alone is able to relate such cognitive objectives to other learning conditions, the individual child or group of children, the particular geography or social studies curriculum, and the place of this within the overall learning environment.

6.2 Sequence of Learning Objectives

It is not, then, the inherent cognitive challenge of individual objectives which leads to cognitive development. Rather it is the gradual development of the ability to understand and use graphic language, a language which will allow the expression and communication of the developing mental representation of space, encourage its further development, and contribute to the capacity to manipulate spatial ideas.

In order to be able to achieve this, the curriculum should be structured around sequence rather than behavioural objectives. This is because the child's stage of development is one of the key factors in the success or failure of the

effort. Particular care must be taken not to be misled by the apparent success of verbal learning correctly regurgitated, as compared with the development of a real facility in using graphic language.

6.3 Proposed Curriculum Phases

- a) The sequence proposed has not been validated and is of sufficient detail to provide only very general guidelines. It has however revealed both the complexity and the progressive development of the child's ideas concerning space. At all levels of the school curriculum there is an urgent need for testing and for the development of suitable learning materials. Two aspects have been particularly neglected and would seem to hold the key to overcoming the deficiencies of the present system. These are the topological and the projective stages of development, which have been identified in the thesis as the first two phases, Grades K-2 and Grades 3-6.
- b) Further study of the nature of children's map concepts and learning prior to the age of about twelve, and within a non-Euclidean framework would seem to be urgently required. It is suggested therefore that the research should follow upon the positive base established by Blaut and Stea, and should consider all aspects of graphicacy, including aerial photographs and maps, and should maintain a close relationship with ideas in the development of spatial cognition as outlined in Chapters 4 and 5.

- c) Further study is also required into the links between cognitive representation and map learning; into the relationships between maps and geography in schools, particularly in relation to the introduction of the study of remote areas during the elementary years; and into the relationships between map learning and geometry.

6.4 Cognitive Value of Map Studies

- a) An underlying objective of this thesis was to examine the cognitive value of map studies in schools. Although the study revealed deficiencies in a particular curriculum the cognitive value of map studies themselves in leading to the development of graphicacy became clear. The analysis of the cognitive processes involved in the learning of a graphic language and in the study of its developmental sequence revealed that graphicacy can add an essential dimension to communication. In the study of cognitive processes the close connection between perception and conceptualization was revealed indicating that visual language (graphic language) can be a direct method of representing spatial ideas without necessarily involving the mediation of verbal language. Thus the importance of graphicacy is emphasized and the use of this visual-spatial language can itself be presumed to lead to the development of cognitive abilities by means of visual thinking.

- b) The study of the development of spatial cognition showed that map learning should be in tune with the developmental phases of children and students. The achievement of this would result in an adult population more competent in manipulating spatial ideas by means of graphic language, that is, a more graphicate population. Map studies contribute to cognitive development because complex cognitive skills are practised in the pursuit of understanding of a new language which expresses spatial ideas in visual-spatial form. This would seem to be more important than placing undue emphasis on the practice of cognitive processes for their own sake. Facility with the use of graphic language is particularly critical at this time in order that the recent mass of information relating to distributions of phenomena over the earth's surface may be used in the solution of human problems.

APPENDIX 1

CONDENSED VERSION OF THE
TAXONOMY OF EDUCATIONAL OBJECTIVES

CONDENSED VERSION OF THE
TAXONOMY OF EDUCATIONAL OBJECTIVES

Cognitive Domain

KNOWLEDGE

1.00 Knowledge

Knowledge, as defined here, involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting. For measurement purposes, the recall situation involves little more than bringing to mind the appropriate material. Although some alteration of the material may be required, this is a relatively minor part of the task. The knowledge of objectives emphasize most the psychological processes of remembering. The process of relating is also involved in that a knowledge test situation requires the organization and reorganization of a problem such that it will furnish the appropriate signals and cues for the information and knowledge the individual possesses. To use an analogy, if one thinks of the mind as a file, the problem of a knowledge test situation is that of finding in the problem or task the appropriate signals, cues and clues which will most effectively bring out whatever knowledge is filed or stored.

1.10 Knowledge of Specifics

The recall of specific and isolable bits of information. The emphasis is on symbols with concrete referents. This material, which is at a very low level of abstraction, may be thought of as the elements from which more complex and abstract forms of knowledge are built.

1.11 Knowledge of Terminology

Knowledge of the referents for specific symbols (verbal and non-verbal). This may include knowledge of the most generally accepted symbol referent, knowledge of the variety of symbols which may be used for a single referent, or knowledge of the referent most appropriate to a given use of a symbol.

*To define technical terms by giving their attributes, properties or relations.

*Familiarity with a large number of words in their common range of meanings.

*Illustrative educational objectives selected from the literature.

1.12 Knowledge of Specific Facts

Knowledge of dates, events, persons, place, etc. This may include very precise and specific information such as the specific date or exact magnitude of a phenomenon. It may also include approximate or relative information such as an appropriate time period or the general order of magnitude of a phenomenon.

*The recall of major facts about particular cultures.

*The possession of a minimum knowledge about the organisms studied in the laboratory.

1.20 Knowledge of Ways and Means of Dealing with Specifics

Knowledge of the ways of organizing, studying, judging, and criticizing. This includes the methods of inquiry, the chronological sequences, and the standards of judgment within a field as well as the patterns of organization through which the areas of the fields themselves are determined and internally organized. This knowledge is at an intermediate level of abstraction between specific knowledge on the one hand and knowledge of universals on the other. It does not so much demand the activity of the student in using the materials as it does a more passive awareness of their nature.

1.21 Knowledge of Conventions

Knowledge of characteristic ways of treating and presenting ideas and phenomena. For purposes of communication and consistency, workers in a field employ usages, styles, practices, and forms which suit best the phenomena with which they deal. It should be recognized that although these forms and conventions are likely to be set up on arbitrary, accidental, or authoritative bases, they are retained because of the general agreement or concurrence of individuals concerned with the subject, phenomena, or problem.

*Familiarity with the forms and conventions of the major types of works, e.g., verse, plays, scientific papers, etc.

*To make pupils conscious of correct form and usage in speech and writing.

1.22 Knowledge of Trends and Sequences

Knowledge of the processes, directions and movements of phenomena with respect to time.

*Understanding of the continuity and development of American culture as exemplified in American life.

*Knowledge of the basic trends underlying the development of public assistance programs.

1.23 Knowledge of Classifications and Categories

Knowledge of the classes, sets, divisions, and arrangements which are regarded as fundamental for a given subject field, purpose, argument or problem.

*To recognize the area encompassed by various kinds of problems or materials.

*Becoming familiar with a range of types of literature.

1.24 Knowledge of Criteria (Standards of Judgement)

Knowledge of the criteria by which facts, principles, opinions, and conduct are tested or judged.

*Familiarity with criteria for judgment appropriate to the type of work and the purpose for which it is read.

*Knowledge of criteria for the evaluation of recreational activities.

1.25 Knowledge of Methodology

Knowledge of the methods of inquiry, techniques and procedures employed in a particular subject field as well as those employed in investigating particular problems and phenomena. The emphasis here is on the individual's knowledge of the method rather than his ability to use the method.

*Knowledge of scientific methods for evaluating health concepts.

*The student shall know the methods of attack relevant to the kinds of problems of concern to the social sciences.

1.30 Knowledge of the Universals and Abstractions in a Field

Knowledge of the major schemes and patterns by which phenomena and ideas are organized. These are the large structures, theories, and generalizations which dominate a subject field or which are quite generally used in studying phenomena or solving problems. These are at the highest levels of abstraction and complexity.

1.31 Knowledge of Principles and Generalizations

Knowledge of particular abstractions which summarize observations of phenomena. These are the abstractions which are of value in explaining, describing, predicting, or in determining the most appropriate and relevant action or direction to be taken.

*Knowledge of the important principles by which our experience with biological phenomena is summarized,

*The recall of major generalizations about particular cultures.

1.32 Knowledge of Theories and Structures

Knowledge of the body of principles and generalizations together with their interrelations which present a clear, rounded, and systematic view of a complex phenomenon, problem, or field. These are the most abstract formulations, and they can be used to show the interrelation and organization of a great range of specifics.

*The recall of major theories about particular cultures.

*Knowledge of a relatively complete formulation of the theory of evolution.

INTELLECTUAL ABILITIES AND SKILLS

Abilities and skills refer to organized modes of operation and generalized techniques for dealing with materials and problems. The materials and problems may be of such a nature that little or no specialized and technical information is required. Such information as is required can be assumed to be part of the individual's general fund of knowledge. Other problems may require specialized and technical information at a rather high level such that specific knowledge and skill in dealing with the problem and the materials are required. The abilities and skills objectives emphasize the mental processes of organizing and reorganizing material to achieve a particular purpose. The materials may be given or remembered.

2.00 Comprehension

This represents the lowest level of understanding. It refers to a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other material or seeing its fullest implications.

2.10 Translation

Comprehension as evidenced by the care and accuracy with which the communication is paraphrased or rendered from one language or form of communication to another. Translation is judged on the basis of faithfulness and accuracy, that is, on the extent to which the material in the original communication is preserved although the form of the communication has been altered.

*The ability to understand non-literal statements (metaphor, symbolism, irony, exaggeration).

*Skill in translating mathematical verbal material into symbolic statements and vice versa.

2.20 Interpretation

The explanation or summarization of a communication. Whereas translation involves an objective part-for-part rendering of a communication, interpretation involves a re-ordering, re-arrangement, or a new view of the material.

*The ability to grasp the thought of the work as a whole at any desired level of generality.

*The ability to interpret various types of social data.

2.30 Extrapolation

The extension of trends or tendencies beyond the given data to determine implications, consequences, corollaries, effects, etc. which are in accordance with the conditions described in the original communication.

*The ability to deal with the conclusions of a work in terms of the immediate inference made from the explicit statements.

*Skill in predicting continuation of trends.

3.00 Application

The use of abstractions in particular and concrete situations. The abstractions may be in the form of general ideas, rules of procedures, or generalized methods. The abstractions may also be technical principles, ideas, and theories which must be remembered and applied.

*Application to phenomena discussed in one paper of the scientific terms or concepts used in other papers.

*The ability to predict the probable effect of a change in a factor on a biological situation previously in equilibrium.

4.00 Analysis

The breakdown of a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations between the ideas expressed are made explicit. Such analyses are intended to clarify the communication, to indicate how the communication is organized, and the way in which it manages to convey its effects, as well as its basis and arrangement.

4.10 Analysis of Elements

Identification of the elements included in a communication.

*The ability to recognize unstated assumptions.

*Skill in distinguishing facts from hypotheses.

4.20 Analyses of Relationships

The connections and interactions between elements and parts of a communication.

- *Ability to check the consistency of hypotheses with given information and assumptions.
- *Skill in comprehending the interrelationships among the ideas in a passage.

4.30 Analysis of Organizational Principles

The organization, systematic arrangement, and structure which hold the communication together. This includes the "explicit" as well as "implicit" structure. It includes the bases, necessary arrangement, and the mechanics which make the communication a unit.

- *The ability to recognize form and pattern in literary or artistic works as a means of understanding their meaning.
- *Ability to recognize the general techniques used in persuasive materials, such as advertising, propaganda, etc.

5.00 Synthesis

The putting together of elements and parts so as to form a whole. This involves the process of working with pieces, parts, elements, etc., and arranging and combining them in such a way as to constitute a pattern or structure not clearly there before.

5.10 Production of a Unique Communication

The development of a communication in which the writer or speaker attempts to convey ideas, feelings, and/or experiences to others.

- *Skill in writing, using an excellent organization of ideas and statements.
- *Ability to tell a personal experience effectively.

5.20 Production of a Plan, or Proposed Set of Operations

The development of a plan of work or the proposal of a plan of operations. The plan should satisfy requirements of the task which may be given to the student or which he may develop for himself.

- *Ability to propose ways of testing hypotheses.
- *Ability to plan a unit of instruction for a particular teaching situation.

5.30 Derivation of a Set of Abstract Relations

The development of a set of abstract relations either to classify or explain particular data or phenomena, or the deduction of propositions and relations from a set of basic propositions or symbolic representations.

- *Ability to formulate appropriate hypotheses based upon an analysis of factors involved, and to modify such hypotheses in the light of new factors and considerations.
- *Ability to make mathematical discoveries and generalizations.

6.00 Evaluation

Judgments about the value of material and methods for given purposes. Quantitative and qualitative judgments about the extent to which material and methods satisfy criteria. Use of a standard of appraisal. The criteria may be those determined by the student or those which are given to him.

6.10 Judgments in Terms of Internal Evidence

Evaluation of the accuracy of a communication from such evidence as logical accuracy, consistency, and other internal criteria.

- *Judging by internal standards, the ability to assess general probability of accuracy in reporting facts from the care given to exactness of statement, documentation, proof, etc.
- *The ability to indicate logical fallacies in arguments.

6.20 Judgements in Terms of External Criteria

Evaluation of material with reference to selected or remembered criteria.

- *The comparison of major theories, generalizations, and facts about particular cultures.
- *Judging by external standards, the ability to compare a work with the highest known standards in its field--especially with other works of recognized excellence.

APPENDIX 2

SOUTH CARLETON FAMILY OF SCHOOLS

GEOGRAPHY CURRICULUM

1974

GEOGRAPHY CURRICULUM

Living and Learning

2

SOUTH CARLETON FAMILY OF SCHOOLS

GEOGRAPHY CURRICULUM

1974

Committee Members:

Goulbourn Public School - Alf Mangan
Kars Public School - Al Cameron
Manotick Public School - Bob Samways*
North Gower Public School - Terry Holmes
Richmond Public School - Jim Casselman
South Carleton High School - Stu Rogers*
Stittsville Public School - Gord Hall

*Co-chairmen

PROPOSED CONTINUUM FOR GEOGRAPHY DEVELOPMENT, S.C.H.S. FAMILY

K-1	2	3, 4	5	6	7	8	9	10	11, 12	13
Child Family Neighbourhood	Other Communities	Eastern Hemisphere	Western Hemisphere	North America	Southern Lands	Europe + Asia	Canada	Specific Specialized Area	Canada	Specific Specialized Area
Development at One Tier of Comprehension					Repeat of Regions with refinement			Repeat with sophistication		
1st phase					2nd phase			3rd phase		

Educational Psychology

- Known $\longleftrightarrow$ Unknown
- Concrete $\longleftrightarrow$ Abstract
- Specific $\longleftrightarrow$ General $\longleftrightarrow$ Specific
- Transfer of responsibility from teacher to student
- To develop principle of spatial analysis at various scales and using a variety of environmental selections

- This scheme is proposed as the continuum of Geographic Areas K-13 for S.C.H.S. Family.
- Rationale is as per Ministry of Education, P2.J2., Man and Earth, S7 and existing programme at S.C.H.S.
- Within these regions or geographical topics, the various skills and concepts are "plugged in" and taught.
- Within this scheme there is ample opportunity for Environmental Studies, Regional Approach, Thematic Approach, and Utilizing of Relevant Issues and Current Events.

SOUTH CARLETON FAMILY OF SCHOOLS - GEOGRAPHY CURRICULUM K-13

K	1	2	3	4	5	6	7	8	9	10	11	12	13
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LEARNING MATERIALS *designates point of introduction within curriculum K-13

- *Globe
- *Globe
- *Globe
- *Models
- *Pictures-observing -recording - analysing -hypothesis
- (Movies, slides, prints)
- * Excursions/Field trips
- *Bulletin Board
- *Flannelgraph
- *Pictographs
- *Pictorial Maps
- *Guest speakers
- *Newspapers
- *Relief maps (oriented on floor)
- *The Interview
- *Field Sketching
- *Blackboard sketches
- *Blackboard sketchmaps
- *Maps-hung-on-Flath Wall
- *Raised Relief Maps
- *Different types of maps
- *Design of simple instruments
- *Outline maps-with routes etc. marked
- *Outline maps -Blank-
- *Graphs & tables
- *Statistical Charts
- *Satellite Photos
- *Topographic map (local)
- *Topographic maps (Cdn.&Foreign)
- *Air Photo
- *Cross Section Diagrams
- *Weather maps
- *Arc Pyramids
- *Spider diagram
- *Stream table
- *Letraset

PRINTED RESEARCH MATERIALS

- *Books
- *Primary Atlas
- *Table of Contents
- *Library
- *Newspapers
- *Junior Atlas
- *Encyclopedia
- *Cdn (Oxford Atlas (3rd)
- *Magazine Periodic Index
- *Economic Atlas

as a model of earth
shows land & water
shape of earth
earth turns
symbol for land & water (the water planet)
surrounding atmosphere
sun's shadow
Globe measurement of Earth
North Pole - South Pole
Names & shapes of Continents
of Major Oceans
Hemisphere lines
Equator
General World Climates
Natural & Man-Made Boundaries
Sun & Moon
Eclipses

GLOBE SKILLS

Notes:

- Primarily a skill area of communication in which the student learns a facility with a symbolic language all of its own.
- Objective: to develop the concept of a 3 dimensional view of earth and the representation of reality in an abstract form; with increasing skills of reading, interpretation, composing and thinking in graphic terms.
- Constant exposure and use of the globe within the classroom, K-13 is essential.

The environmental studies programme provides a unique source of graphic content material

Resource Texts.

- P. Thornhill. EARTH IN ORBIT. Methuen.
- A.R. Crane. The EARTH GRID. Bellhaven.
- G.H. Copsell. THE TEACHING OF GEOGRAPHY. Macmillan
- M. Taubler. MAP SKILLS. Continental Press
- R. Harris. MAP AND GLOBE USAGE. Rand McNally
- C. Odell. Successful Teaching With Globes. Denoyer-Geppert
- J. Maynard. MAP SKILLS FOR TODAY'S GEOGRAPHY. American Education Publications

Legend

- * Grade at which skill is introduced
- Grades at which skill is developed systematically
- — — Grades at which skill is maintained, reinforced and extended

- * Calculation of Longitude
- * Standard Time Zones
- * Mean - Sun - Tides
- * Great Circle Routes
- * Polar Projections
- * Distortion from Round Earth to Flat Map
- * Circle measurement - Degree, Minute
- * Shadow stick & the Altitude
- * Angle of the Sun & Zenith
- * Nautical Mile
- * Drifting Continental Theory
- * Time March & Magnetic North
- * Earth's spheres & Composition
- * Graticles position & B.M. Station
- * Solar Time - Universal Time
- * Oblique Spherical
- * Coriolis Effect
- * Thermohaline/Huguen
- * Various Projections & Theory
- * Circle measurement - minute

K	1	2	3	4	5	6	7	8	9	10	11	12	13
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- Interpret pictorial symbols
- Describe relative positions (near-far, left-right)
- Locates self in relation to environment
- Street addresses
- Maps show location
- Maps ON FLOOR (HORIZONTAL)
- Sample 3D maps using blocks

- Painting pictures of local environment
- Symbols stand for real things
- Simple maps of classroom, bedroom etc.
- Lettering on all maps
- Place name labels
- Interpret colour key
- Interpret non pictorial symbols
- Trace routes of others
- Bird's eye view
- Shadow stick
- Legend
- Statement of scale
- Compare Maps with Oblique Pictures
- Transfer of Globe to flat paper
- Conventions of Maps
- Use of compass
- Rivers, rain, Dunes, hills
- International colour scheme
- Linear Scale
- Orient Map, North-South
- Map, Albert, Bonn
- Maps for different purposes
- Maps show distribution
- Maps hung on North Wall (VERTICAL)
- Road Map
- Giving Direction to Quarry, Continent, World
- Location of self to Nation, Continent, World
- Routes of Explorers & why
- Use of outline maps
- Wind & Ocean Currents
- Latitude

MAP SKILLS

Notes:

Primarily skills but a number of key concepts exist in this continuum which if not correctly handled will plague the student as a misconception throughout his lifetime.

Therefore the initial approach to the various skills and concepts of map reading and interpretation must be carried out with great care.

A map, on a single sheet of paper can contain more information than can be expressed in a chapter of a book. The great need is to teach the child to read the language, symbols and spatial relationships that exist on the map page. Therefore, Geography provides a special READING PROGRAMME. The skills and facility learned are used daily by the child for the rest of his life!

- Different symbols for same thing
- Intermediate points of the compass
- Satellite photos of Earth
- Use variety of symbols with skill
- Longitude
- Interrelationships: climate, altitude, currents etc.
- Map index - grid & grid system
- Sketch map - constant scale, direct area & shape
- Interpretation of variety of maps
- Open & closed scale
- Compare map with vertical Satellite Photos
- Location map
- Compass rose
- Representative fraction
- Large & Small Scale Maps
- Orographic Rainfall & Rain Shadow
- Local Topographic Map
- Contour Lines
- Compass bearings
- Cross Section Profile
- N.S. U.S. V.E.
- Adjusting to various scales
- Adjusting to Aerial Photographs
- Various Projections & Theory
- Units of - Degrees
- Military Town Plan
- Simple Map
- Dot Map
- 50 Maps

Preface and Explanatory Note

Purpose:

Based upon an observed need, the Geography Curriculum Committee and its work was initiated by the Principals of the South Carleton Family of Schools, November 1975.

It is the sincere hope of the committee that all teachers will develop a sense of commitment to implement this continuum of concepts and skills.

Geography as a discipline is built around NINE CONCEPTUAL FRAMEWORKS. To give our studies a sense of direction and clear cut BEHAVIOURAL OBJECTIVES, each of us must remind ourselves of these Frameworks and the concepts and skills contained in each. Only then will we be adding to the continuing growth of the child and the integrity of the subject.

Each Conceptual Framework contains a number of MUST KNOWS which constitute a core curriculum. It should be noted, however, that this core of Must Knows constitutes only 50% of the curriculum for each grade. While this portion must be co-ordinated and "plunged in" it does leave the teacher free to innovate and "add to" for the remaining 50% of the curriculum. This remaining work in the geography portion of your programme should reflect the resources available to you, topical matters, innovation and inspiration as well as the particular needs and interests of the youngsters.

We expect that each teacher will introduce and develop these Must Knows beginning at the very latest where they appear in the sequence on the charts. They should be reviewed and refined with each subsequent year. This should be done at a level of sophistication appropriate to the level of the child's ability.

Whatever your various units of work, they should have these skills and concepts woven into them.

If these Must Knows are considered as building blocks, and if each one of us adheres to the sequence as outlined, then it should follow that each learning experience for the child will reinforce the preceding ones. This, then, would reduce to a minimum many of the misunderstandings, omissions, frustrations and faulty concepts which tend to develop.

We will have achieved co-ordination and an improved learning/teaching experience for all !

Explanation of the Sequence Charts K-13:

The following flow charts indicate the overall sequence of skills and concepts which form the nucleus of Geographical Understanding.

Preface and Explanatory Note (continued)

These charts should be studied in order that each teacher may clearly see where their course material fits into the whole continuum.

With each concept, the latest point at which it must be introduced is indicated by an asterisk, the grade levels through which it is to be developed systematically, by a solid line; the grade levels where it is to be maintained, reinforced and extended, by a broken line.

The initial conceptual framework regarding MAPS AND CLOES skills and concepts is an example of this idea. It will be hopefully supplemented by a similar presentation of the remaining conceptual frameworks.

Each conceptual framework contains what we as a family of schools, consider to be the essential core curriculum. Through the committee members we agree.

SEQUENCE CHART OF MAP AND GLOBE SKILLS AND UNDERSTANDING

INTRODUCTION

The Sequence Chart of Map and Globe Skills and Understanding is an instructional aid for use in the study of geography and its inter-relationship with the other areas of the social studies from kindergarten through the sixth grade.

Development of an understanding of physical geography (the nature of the surface features of the earth) and of cultural geography (man's relationship to his environment) is an important outcome of instruction in the social studies. Maps and globes are tools of instruction essential to the understanding of geography and of the other areas in the social studies program.

Purposes:

Among the purposes of the sequence chart are to:

- .Provide a framework for teachers from which pupils may be guided to learn the language necessary for reading and interpreting maps and globes. This is achieved through participation in appropriate learning activities.
- .Provide teachers with a developmental sequence of skills and understandings through defining broad skill areas. These increase in complexity from grade level to grade level.

Organization:

The first column on the chart contains these headings:

- .The Earth - Size, Shape and Motion
- .Direction - Orientation
- .Location
- .Scale - Distance
- .Symbols
- .Use - Interpretation

Skills and understandings are grouped in the categories most consistently recognized by authorities in the teaching of maps and globes. They are arranged in a sequence which generally parallels the content of the social studies program. They are also organized by grade levels, which are designated at the top of the chart.

Guiding Principles:

- Backgrounds, abilities, and achievements of children vary.
- .Therefore, the order of presentation of the skills and understandings within each grade level which appears on the

Sequence Chart of Map and Globe Skills and Understanding (continued)

chart does not necessarily indicate the sequence of their presentation.

The list of skills and understandings for the different grade levels has been developed as a guide for suggested learnings and achievement. In the initial use of this chart, pupils may not have been introduced to the skills and understandings preceding their grade level. The depth of understanding and the proficiency demonstrated by the pupils will indicate the point at which they will begin.

In the primary grades, the reading of simple globes and maps, along with informal interpretive experiences, comprises the major emphasis. Many experiences with floor maps and other activities may be needed before pupils in the primary grades are able to relate their understandings to wall maps.

In the middle and upper grades, direct instruction is provided in the skill areas. More complex map reading and interpretive skills are introduced as pupils mature and their background of knowledge grows.

In all grades, the use of map and globe skills and understandings is an integral part of social studies instruction. It is not anticipated that these skills and understandings will be taught totally apart from the areas of the social studies.

Effective use of the Sequence Chart of Map and Globe Skills and Understandings will be further achieved as the teacher:

- .Builds a background of basic information from which accurate concepts about natural and cultural features of geography may emerge.
- .Provides opportunities for pupils to understand and use geographic terms, symbols, and tools.
- .Clarifies meaning through the use of the immediate environment whenever possible and supplements instruction by the use of pictures, films, filmstrips and other aids when necessary.
- .Provides an organized, gradual, and systematic program of instruction in the use of maps and globes, including review and reteaching as needed, to assure the continuous development of knowledge, understanding and skill.
- .Provides opportunities for pupils to use the globe frequently, emphasizing the value of maps and globes as sources of information rather than as tools for only memorization of places and names.
- .Develops these skills and concepts in the Sequence Chart while seeing them within the continuum of curriculum K-13 as illustrated in the Overview Chart.

KINDERGARTEN

THE EARTH - SIZE, SHAPE AND MOTION

LOCATION

- 1 - Begins to understand that a globe is a small model of the earth, which is very large. 1.31
- 2 - Begins to understand that the globe is round because the earth is nearly round 1.12
- 3 - Begins to understand that the earth turns 1.12
- 4 - Begins to describe relative location of places. Begins to understand that the earth is round, flat, up, down, front, back, over, under, back, front, here, there) 1.11
- 5 - Locates specific areas within the school 1.12
- 6 - Begins to locate features of the earth on a picture and on the flat map of the community 2.10
- 7 - Uses a globe to understand that the earth is round, flat, up, down, front, back, over, under, back, front, here, there) 2.11
- 8 - Uses the globe to discover that the earth is round, flat, up, down, front, back, over, under, back, front, here, there) 2.20
- 9 - Begins to use a simple globe to point out approximate locations of places, discussed 1.12

KINDERGARTEN

DIRECTION - ORIENTATION

- 10- Begins to orient self as to location in relation to things in the environment 1.12
- 11- Begins to place objects in relationship to one another 1.12
- 12- Uses the terms up and down with understanding 1.11
- 13- Becomes aware of left and right 1.11
- 14- Becomes acquainted with areas of the school and makes simple floor maps of the school with blocks 2.20
- 15- Becomes familiar with street addresses and the names of cardinal directions; north, south, east, and west 1.12
- 16- Begins to make simple maps of the immediate school community on the classroom floor and orients them as to direction (floor blocks) 2.20

SCALE - DISTANCE

- 17- Begins to express distance in terms of in relative terms (near, far, etc.) 1.11
- 18- Begins to understand that places on earth which are far apart appear to be close together on maps 1.31
- 19- Generalizes that some toys are small-scale models of real things 1.31

KINDERGARTEN

SYMBOLS

- 20 - Begins to understand that the globe is a symbol for the earth 1.31
- 21 - Begins to learn that pictorial symbols on a map stand for real things on earth 1.21
- 22 - Begins to identify color symbols for land and water on simple maps and globes 2.1
- 23 - Paints pictures of things in the environment according to his maturity and interest 2.10
- 24 - Describes features of the environment verbally; understands that they can be described through pictures and other materials 1.31

USE - INTERPRETATION

- 25 - Interprets pictures 2.10
- 26 - Reads simple picture maps 2.10
- 27 - Uses simple globes showing land and water areas 2.10
- 28 - Begins to understand the purposes of maps and globes 2.4

THE EARTH - SIZE, SHAPE, AND MOTION

GRADE ONE

GRADE TWO

GRADE THREE

1- Understands that a globe is the most accurate map because it is a model of the earth 1.31

2- Understands that the earth is made up of land and water and is surrounded by air 1.12

3- Understands that globes and wall maps are symbols for all or parts of the earth 1.31

4- Begins to understand that on earth the sun appears to rise in the east and set in the west because of the rotation of the earth 1.12

1- Understands that the earth is a sphere and that it can be divided into hemispheres on globes and maps 1.21

2- Begins to understand that the earth is a planet 1.12

3- Understands that the earth rotates from west to east, and demonstrates this with a globe 1.12

4- Understands the relationship between the earth's rotation and day and night 1.12

1- Learns that any part of the surface of the earth can be shown and located on a map 1.12

2- Learns that the earth is not a perfect sphere 1.12

3- Uses the globe frequently to determine correct map concepts of shape, size, distance, and location 2.10

4- Begins to understand that the rotation of the earth with relationship to the sun causes, causing the day and night change 1.12

5- Comparisons of maps

- Distance
- Location
- Shape
- Legend

LOCATION

GRADE ONE

GRADE TWO

GRADE THREE

5 Understands that things are located in definite relation to, or direction from, one another 1.31

6 Observes landmarks in the community 1.12

7 Generalizes about his environment, such as, "We live in a hilly place," or "We live in a valley" 1.11

8 Recognizes that friends and relatives live in various places in the community, nation, and other parts of the world 1.12

9 Learns the names of his city, and country and locates them on a globe 1.12

10 Uses streets and avenues as a simple grid system; makes avenues go north and south, and streets go east and west on floor maps made in the classroom 2.10

11 Locates places he has visited in and out of the community on a map and describes them using geographical terms correctly 2.25

5 Recognizes his city, and country on a map or globe and understands that they are in a large land mass or continent called North America 1.12

6 Locates major natural features of the community on maps and globes 1.21

7 Observes locations, sizes, and shapes of land and water areas on a globe 1.12

8 Understands that a globe contains all the countries in the world but may not show all of their boundaries 1.31

9 Locates North America in relation to other continents on a globe, as they are brought up in discussion 1.12

10 Finds the equator on a globe; recognizes that it is a great circle halfway between the poles, dividing the earth into a Northern Hemisphere and a Southern Hemisphere 1.21

11 Locates places of interest as situated north or south of the equator 1.21

6 Understands the concept of continents as large masses of land and oceans as large bodies of water, locates the continents on maps and globes 1.11

7 Locates places in relation to continents and oceans on maps and globes 1.12

8 Recognizes specific land areas by their shape and location (peninsula, island, etc.) 1.12

9 Locates his country on a globe; compares its size and shape with other countries 1.12

10 Recognizes similarities between areas on a globe and the areas on a map 1.12

11 Understands the need for latitude and longitude on a globe or map; locates South Pole, equator, and other locations exactly 1.12

12 Locates the community on a globe or on a map of continents; compares the size and shape of the community with other countries 1.12

12- Locates places of vital current interest in the community, nation, and world on maps or globes

12- Uses the globe and wall maps to locate areas in the news and to relate them to his community

13- Locates about 20 places of interest in the community and in the world in locating places in the world

14- Locates about 20 places of interest in the community and in the world in locating places in the world

15- Relates current events to the community, nation, and world

USE - INTERPRETATION

GRADE ONE

GRADE TWO

GRADE THREE

13 - Makes and interprets diagrams of the classroom correctly 2.10

14 - Makes and uses large-scale picture maps of familiar areas of the school and community 2.10

15 - Makes maps showing the distribution of houses and people in a given block 2.10

16 - Makes maps showing the distribution of schools in a given part of the neighborhood 2.10

17 - Learns to use maps as a source of information 2.10

18 - Finds familiar points of interest on a large map of the community; compares them with the actual places 2.10

19 - Compares photographs of community features with pictorial maps of the same area 2.10

20 - Becomes aware of the unity of the earth's surface features 1.12

13 - Reads simple maps and globes with understanding; relates information to his geographic environment 2.20

14 - Understands that maps are made for different purposes, to give different kinds of information about the earth 1.24

15 - Makes pictorial maps showing kinds of businesses or occupations within a given area of the community 2.10

16 - Understands that Canada is of vast size, and compares its size on various maps and globes 1.31

17 - Uses wall maps with globes to compare the same areas (shape and size) 1.31

18 - Understands and uses simple map terms correctly, such as equator, North Pole, South Pole, continents, oceans, lakes 1.11

19 - Becomes aware of some resources of his country through the use of maps and globes 2.10

16 - Uses various kinds of maps to find places of interest in the community, city, and nation 1.12

17 - Uses the globe freely as a source of information 1.10

18 - Compares aerial photographs of specific localities with large-scale maps of the same area 2.20

19 - Uses inset maps 2.10

20 - Learns to compare maps and makes inferences from them 2.20

21 - Increases geography vocabulary to meet requirements of a widening view of the world 1.11

USE - INTERPRETATION

GRADE FOUR

- 25- Uses a variety of maps and globes (political, physical, economic, special features) for different purposes 3.00
- 26 Uses both physical and political maps of the same areas for clarifying concepts 3.00
- 27 Consults more than one map for information about an area 2.30
- 28 Uses a variety of maps to discover the relationship between physical features, man's use of the land, and population distributions; generalizes from the information 3.00
- 29 Habitually consults maps and globes as resources for a variety of information 3.00
- 30 - Makes inferences from maps, noting relationships, such as those between livestock production, corn and grain production, and proximity to transportation systems 2.30
- 31 - Determines from a relief map, the direction in which rivers flow, and traces the course of a river from its source to its mouth 2.30
- 32 - Translates specific information from maps and globes into bar graphs, and reads information from bar graphs 2.10
- 33 - Becomes aware of the effect of ocean currents on the history and geography of the United States and Canada 1.22
- 34 - Uses outline maps to record specific information discovered by study 1.12

Grade 5 (continued)

- 37 Traces routes of explorers significant in history 1.12
- 38 Relates the effect of ocean currents 1.22

GRADE FIVE

- 27- Compares maps and text descriptions of an area to draw inferences from them 2.30
- 28 - Uses maps to increase understanding of current and past history 3.00
- 29 - Refers to dates of maps and globes before interpreting information from them 3.00
- 30 - Compares old and new maps to learn about changes man has effected on the earth 2.00
- 31 - Grows increasingly skillful in interpreting many kinds of maps 2.20

- 32 - Makes inferences from maps, noting relationships, such as those between livestock production, corn and grain production, and proximity to transportation systems 2.30
- 33 - Determines from a relief map, the direction in which rivers flow, and traces the course of a river from its source to its mouth 2.30
- 34 - Translates specific information from maps and globes into bar graphs, and reads information from bar graphs 2.10
- 35 - Becomes aware of the effect of ocean currents on the history and geography of the United States and Canada 1.22
- 36 - Uses outline maps to record specific information discovered by study 1.12

GRADE SIX

- 33- Identifies natural and man-made features of his state on a map 2.10
- 34- Identifies areas of low, middle, and high elevations on various kinds of maps 2.10
- 35- Begins to understand the relationship between climate and topography, such as elevation, and how they affect location, 1.22
- 36- Interprets resource maps in terms of possible occupation of a region 2.30
- 37- Compares physical and political maps of the United States and Canada 2.10
- 38- Reads and makes inferences from maps given in maps, graphs, and tables 2.20
- 39- Uses various kinds of maps for different purposes (topography, weather) 3.00
- 40- Translates information gathered from maps and globes and into line and circle graphs 2.20
- 41- Learns about the effect of the prevailing westerlies on vegetation, forests, and agriculture 1.22

DIRECTION - ORIENTATION

GRADE ONE

GRADE TWO

GRADE THREE

- 26 Understands that up is away from the center of the earth and that down is toward the center of the earth 1.11
- 27 Uses left and right correctly 1.11
- 28 Understands that there is a North Pole and a South Pole 1.11
- 29 Understands that the North Pole is the point farthest north on the earth and on globes, and that the South Pole is the point farthest south on the earth and on globes 1.21
- 30 Begins to use the cardinal directions 1.25
- 31 Makes floor maps of the community (floor blocks and other materials) and orients them, with teacher help 2.20
- 32 Understands that a map can be used to determine the direction and distance of one place from another 1.21
- 33
- 34

- 26 Finds north by facing his shadow during a sunny noon; understands that south is behind him, east is on his right, west is on his left 1.25
- 27 Understands that the equator divides the earth into two hemispheres, Northern Hemisphere and Southern Hemisphere 1.21
- 28 Begins to understand that north is toward the North Pole and south is toward the South Pole; finds north and south on a globe 1.21
- 29 Learns that cardinal directions are determined by the poles of the earth; establishes directions with understanding 1.21
- 30 Uses the sun and a shadow stick to establish east-west directions 1.21
- 31 Learns to read directions on large maps correctly oriented by being placed on the classroom floor 1.21
- 32 Begins to understand the use of a magnetic compass 1.25
- 33 Learns to follow a simple diagram of the route to be taken on a class trip 2.10
- 34 Locates a place on a simple map by following given directions 2.10

- 28 Knows that cardinal directions are determined by the poles and that north is the direction of the North Pole 1.21
- 29 Learns that the North Star or Polar Star can be used to find north; direction of north 1.21
- 30 Begins to understand the difference between true north and magnetic north as shown by a magnetic compass 1.21
- 31 Understands the four cardinal directions; magnetic compass; map and globe; a map compass or compass rose; direction finders 1.21
- 32 Understands that about half the earth on a map at places other than the top of the map 1.21
- 33 Uses the intermediate directions (northeast, northwest, southeast, southwest) 1.25
- 34 Learns that the earth is divided into four major hemispheres (Northern, Southern, Eastern, Western) 1.21

THE EARTH - SIZE, SHAPE, AND MOTION

GRADE FOUR

GRADE FIVE

GRADE SIX

- 1- Learns about the vast size of the earth, its circumference, and diameter 1.12
- 2- Understands that portraying the earth's surface on a flat map involves distortion of land and water areas 1.31
- 3- Begins to learn about the inclination of the earth's axis and its effect upon light, dark, and seasonal change 1.31
- 1- Compares photographs of the earth's surface, taken at great distances above the earth, with a globe; generalizes about the curvature of the earth from this evidence; and first-hand observation (horizon, eclipse) 1.31
- 2- Begins to understand the concepts of the earth's rotation on its axis and the earth's revolution around the sun 1.12
- 3- Understands the relationship between the rotation of the earth and time 1.22
- 1- Traces and understands the orbits of the earth around the sun and the orbits of the moon around the earth 1.12
- 2- Traces and understands the orbits of man-made satellites around the earth 1.12
- 3- Learns about some ways that the earth's shape, size, and set of motions influence plant and animal life on earth 1.22
- 4- Learns about some ways in which the shape of the earth affects the distribution of sunlight, vegetation, circulation of air, and climatic conditions 1.22
- 5- Compares and contrasts the size of the earth to other planets, the sun, and the moon 1.12

SYMBOLS

GRADE FOUR

GRADE FIVE

GRADE SIX

4 - Consults map legends before interpreting various maps 2.10

5 - Understands the use of color to show elevation or altitude 1.21

6 - Begins to understand the use of the International Color Scheme on relief maps 1.21

7 - Learns about colors other than the International Color Scheme used to designate elevations 1.21

8 - Learns abbreviations commonly used on maps 1.21

9 - Uses color symbols which provide specialized information, such as those used for rainfall or vegetation 1.21

10 - Recognizes boundary lines, such as county, national, and international 1.21

4 - Consults the map legend and finds several illustrations of the symbols given on the map 1.21

5 - Uses a variety of symbols with understanding 2.10

6 - Compares map legends on several different maps and generalizes about standardized symbols 1.21

7 - Understands that there may not be symbols given for all the information on a map or globe 1.21

6 - Devises map symbols and legends for outline maps used for special purposes 3.00

7 - Compares the various uses on different maps for the same kinds of symbols, such as lines and dots 2.20

8 - Understands that the surface of the earth is irregular (above and below sea level, and in the oceans) 1.12

9 - Understands relief on a map or globe as it is shown by merged colors, shading, contours, and hachures 2.10

10 - Compares aerial photographs with maps of the same area 2.20

11 - Uses the map legend to interpret the special use of color to present various kinds of information, such as food production, languages, and population concentrations in different parts of the world 2.10

DIRECTION - ORIENTATION

GRADE FOUR

- 8 - Reads maps to find the principal man-made features of his community 2.10
- 9 - Begins to learn that the Northern and Southern Hemispheres are divided by the equator and that the Eastern and Western Hemispheres are divided by the prime meridian and the 180th meridian 1.21
- 10 - Understands that the earth can be divided into various hemispheres 1.21

GRADE FIVE

- 8 - Locates natural barriers which influenced exploration, the movement of people, and settlements 1.22
- 9 - Compares natural and man-made boundaries 2.10
- 10 - Maintains understanding of the purpose and uses of a grid system in locating places on a map 1.21
- 11 - Learns that imaginary east-west and north-south lines form a grid on globes and maps 1.21
- 12 - Begins to understand the meaning of parallels and meridians on globes and maps 1.21
- 13 - Begins to learn that north-south lines are called meridians of longitude 1.21
- 14 - Begins to understand that latitude means the distance north or south of the equator 1.21

Grade 5 (continued)

- 17 - Uses the intermediate directions accurately, in establishing or describing location 1.25
- 18 - Orient's maps of different projections 1.25
- 19 - Understands the meaning of northern latitudes and southern latitudes 1.11
- 20 - Understands the meaning of and uses the terms low, middle, or high latitudes correctly and torrid, temperate, and frigid zones 1.11
- 21 - Reviews parallels and meridians on globes and on flat maps 1.21

GRADE SIX

- 12 - Extends understanding of latitude and longitude 1.21
- 13 - Understands the relationship between meridians and time, and compares time in various parts of the world 1.22
- 14 - Understands the meaning of the low, middle, and high latitudes:
 - low latitudes - the area between the Tropic of Cancer and the Tropic of Capricorn 1.11
 - middle latitudes - the area between the Tropic of Cancer and the Arctic Circle; and also the area between the Tropic of Capricorn and the Antarctic Circle
 - high latitudes - the area between the Arctic Circle and the North Pole and the area between the Antarctic Circle and the South Pole
- 15 - Understands that most places on the earth's surface can be reached within a few hours by using great circle routes 1.21
- 16 - Locates ocean currents, such as the California current and others currents affecting the Pacific 1.12
- 17 - Develops the concept of the great circles as any circle that divides the earth into hemispheres; compares distances of great circles (air routes) with other routes 2.20

SCALE - DISTANCE

GRADE FOUR

GRADE FIVE

GRADE SIX

- 14 Compares the mileage scale on the legends of various maps 2.10
- 15 Begins to learn that mileage scales are expressed in different ways on different maps 1.21
- 16 Understands that large-scale maps show more detail than small-scale maps 1.31
- 17 Estimates distances on a map and checks them by using the mileage scale 2.10

- 17 - Understands that latitude is the distance north or south of the equator and is measured in degrees 1.21
- 18 - Understands that distance from the equator may be measured in miles or degrees 1.21
- 19 - Extends understanding of linear mileage scales 2.10
- 20 - Estimates linear distances which cannot be directly observed or measured 2.10
- 21 - Uses with understanding maps of identical areas drawn to different scales 1.31
- 22 - Understands that longitude is the distance east or west of prime meridian and is measured in degrees 1.21

- 18- Understands that distances on a map can be measured by using fractional parts of the scale unit of measurement 1.25
- 19- Measures and compares different travel routes. (air, land, and water) 2.20
- 20- Uses various mileage scales with understanding (scales expressed graphically, in words) 1.25

LOCATION

GRADE FOUR

- 18 Locates places in relation to the equator or Northern and Southern Hemispheres. 1.12
- Finds and understands the meaning of North Pole, South Pole, equator, Arctic Circle, Antarctic Circle, Tropic of Cancer, and Tropic of Capricorn 1.11
- Locates the three major oceans 20 (Atlantic, Pacific, Indian) and notes the lands which they touch 1.12
- Locates continents (commonly identified as North America, South America, Europe, Asia, Africa, Antarctica, and Australia) and notes their relationship to one another 1.12
- Distinguishes continents by their sizes, shapes, and positions 1.12
- Locates his state in relation to the rest of the nation and the world 1.12
- Reads maps to find the principal natural features of his community and state 2.10

GRADE FIVE

- 23 Locates areas in the news on a world map or globe 1.12
- Locates places on a map or globe with reference to distance from the equator 1.12
- 24 Locates places of historical significance. 1.12
- 25 Traces routes of explorers and settlers of the Americas 1.12

GRADE SIX

- 21 Compares time in the community with that of time in other localities 1.12
- Locates air and ocean currents which affected historical exploration and understands their role in the development of countries 1.22
- 22 Locates major cities in the Western Hemisphere and the world. 1.12
- Uses the grid system to find exact locations 1.25
- 23 Traces and compares trade and travel routes (air, land, and water) 2.20
- 24 Understands the division of the globe into 360° 1.21
- 25 Locates and uses the International Date Line to interpret time zones 1.25
- 26 Finds and understands the meaning of standard time zones 1.21
- 27 Relates the parts of the world 1.12 to other parts of the world 1.12 157
- 28 Locates the chief physical features of the United States and Canada 1.12

USE - INTERPRETATION

GRADE FOUR

- 25- Uses a variety of maps and globes (political, physical, economic, special features) for different purposes 3.00
- 26 Uses both physical and political maps of the same areas for clarifying concepts 3.00
- 27 Consults more than one map for information about an area 2.30
- 28 Uses a variety of maps to discover the relationship between physical features, man's use of the land, and population distributions; generalizes from the information 3.00
- 29 Habitually consults maps and globes as resources for a variety of information 3.00

GRADE FIVE

- 27- Compares maps and text descriptions of an area to draw inferences from them 2.30
- 28 - Uses maps to increase understanding of current and past history 3.00
- 29 - Refers to dates of maps and globes before interpreting information from them 3.00
- 30 - Compares old and new maps to learn about changes man has effected on the earth 3.00
- 31 - Grows increasingly skillful in interpreting many kinds of maps 2.20
- 32 - Makes inferences from maps, noting relationships, such as those between livestock production, corn and grain production, and proximity to transportation systems 2.30
- 33 - Determines from a relief map, the direction in which rivers flow, and traces the course of a river from its source to its mouth 2.30
- 34 - Translates specific information from maps and globes into bar graphs, and reads information from bar graphs 2.10
- 35 - Becomes aware of the effect of ocean currents on the history and geography of the United States and Canada 1.22
- 36 - Uses outline maps to record specific information discovered by study 1.12

Grade 5 (continued)

- 37 traces routes of explorers significant in history 1.12
- 38 relates the effect of ocean currents 1.22

GRADE SIX

- 33- Identifies natural and man-made features of his state on a map 2.10
- 34- Identifies areas of low, middle, and high elevations on various kinds of maps 2.10
- 35- Begins to understand the relationships between climate and other factors, such as elevation, ocean currents, location, 1.22 reference to the earth 2.10
- 36- Interprets resource maps in terms of possible occupation of a region 2.30
- 37- Compares physical and political maps of the United States and Canada 2.10
- 38 Reads and makes inferences from maps given in maps, graphs, and tables 2.20
- 39 Uses various kinds of maps for different purposes (topography, weather) 3.00
- 40 Translates information gathered from maps and globes and into line and circle graphs 2.20
- 41 Learns about the effect of the prevailing westerlies on vegetation, forests, and agriculture 1.22

MAPS & GLOBES

MATHEMATICAL

Globes

1. Shape of the earth
2. Continents, oceans, etc.
3. Meridians and antemeridians
Parallels, N. & S Poles
Equator, Tropics
4. Latitude & Longitude (degrees)
5. Earth rotation, earth orbit
6. (a) Time - Day & night - Year
(b) Time Zones
7. Symbols
8. Scale
9. Direction
10. Distance
11. Projections, N & S Polar
12. Great Circle Routes - Polar

Maps

Scale

1. Statement and scale legend

Direction

1. Latitude & Longitude - local topographical maps
2. True North

Distance

1. Use scale legend

Symbols

1. Basic map reading
physical and cultural

Interpretation

1. Use maps in Atlases for:
(a) Product maps
(b) Rainfall, etc.

Geometry

Use of the compass and the protractor

- (a) the circle
- (b) the sphere

Percent

Use of graph (bar circle, line, etc.) to represent statistics and compare data.

Scale

- (a) constructing own scales
- (b) conversion of linear units
- (c) measurement of linear distance on maps and globes using compass, string, etc.
- (d) calculation of areas represented by different maps
- (e) comparing areas of maps of different scales
- (f) estimation

SKILLS - GRADE NINEMAPS AND GLOBESGlobes

1. Reinforce use - different types of globes
2. Political pattern
3. Drifting Continental Plate theory

MapsProjections

1. Introduce properties desirable in a map
 - (a) Constant scale
 - (b) Conformality
 - (c) Correct shape
 - (d) Correct area
 - (e) Great circles and rhumb lines as straight lines
2. A more advanced look at the Lambert Conformal (Conic) and Polar stereographic (Plane surface)

Scale

1. Representative fraction
2. Large scale and small scale maps
3. Vertical and horizontal scale (cross-section)

Direction

1. TM, MN, CN.
2. True North, Magnetic North
Compass North

Distance

1. Nautical mile (latitude)
Statute mile
2. Circle Measurement (degrees, minutes)

Symbols

1. Reinforce map reading
2. Reinforce profiles

MATHEMATICAL

Build on from Grades Seven and Eight

Conversion of statute miles to nautical miles

Comparison of scales in topographic maps and aerial photographs.

Isopleth mapping

Reinforcement of graphs and tables, useage and interpretation

Skills Grade Nine. (continued)MAPS AND GLOBESMATHEMATICALInterpretation

1. Topographical maps
2. Atlases, i.e. Product maps
3. Air photos

MAPS AND GLOBES

Globes

1. Reinforce use

Maps

Projections

1. History of maps and map making
2. Examine closely the Mercator, Lambert, Conformal and Modified (Ney's) Lambert Conformal and the Transverse Mercator through a study of the desirable properties. This will involve all the major skills of Scale, Direction, Distance.

Scale

1. $\frac{VS}{ES} = VE \left(\frac{\text{vertical scale}}{\text{horizontal scale}} = \text{vertical exaggeration} \right)$

Symbols

1. Map problems in interpreting topographical maps of different scales
2. Section profiles
3. Aerial photographs and maps

Interpretation

1. Interpretation and use of a wide variety of maps (possibly introduce geologic maps)
2. Reinforce use of Atlases

MATHEMATICAL

Sets

- (a) Classification
- (b) Ordering

Quantative Analysis

- (a) classes
- (b) frequency
- (c) histograms

Reinforcement of graphs and tables, useage and interpretation

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