Information Processing Analysis Of
Chronically Ill Children's Problem Solving Abilities

by

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Abstract

The objectives of this study were to (1) identify and describe Chronic Asthmatic and Insulin Dependent Diabetic children's strengths and weaknesses in curriculum-related problem solving across the following variables: problem specific declarative knowledge; problem specific procedural knowledge; recall of recently acquired information; problem identification; problem representation; effectiveness of problem solving strategies; automatic processing; and ability to plan, monitor and use feedback; and (2) to identify information processing patterns which contribute to these children's strengths and weaknesses in problem solving. Using an information processing theoretical framework a methodology was developed to meet these objectives.

The 48 subjects in this study included 12 grade seven and 12 grade eight Chronic Asthmatic and 12 grade seven and 12 grade eight Insulin Dependent Diabetic children. They were presented with reading and mathematics problems appropriate to their grade level and asked to think aloud from the time they were

presented with the problem until they arrived at the problem solution. An additional problem which was not domain-specific explored the subjects' ability to relate experiential knowledge to the problem solving activity and examined their use of planning, monitoring and decision making. The time from the first complete reading of the question and answer choices to the solution of the problem was recorded for each question. The reading and mathematics questions were categorized according to their skill objectives.

An analysis of the 2,832 verbal protocols of the subjects using the methodology developed in this study provided the following information: individual and group information processing profiles which identify problem solving strengths and weaknesses; the identification and description of information processing patterns of individuals and groups across reading and mathematics skill objectives and across questions common to both grade levels; the effects of school absenteeism on problem solving ability; and an indication of the time required by chronically ill children to solve reading and mathematics problems.

The implications of the results of this study for both school teachers and health educators are discussed and suggestions for further research using the methodology developed in this study are offered.

Table Of Contents

Chapter	Page
1. Review Of The Literature	1
Introduction	1
Chronic Illness And School Related Problems	3
Chronic Asthma And School Related Problems	7
Insulin Dependent Diabetes Mellitus And School Related Problems	10
Summary	16
Theoretical Framework	18
Memory Organization And Functions	19
Knowledge Structures	23
Problem Solving Characteristics	25
Information Processing Components	33
Problem Statement And Research Objectives	38
2. Research Methodology	43
Population	43
Sample	44
Test Instrument	45
Data Collection	51
Development Of Information Processing Codes	55
Reading Codes	57
Mathematics Codes	65
Data Analysis	76
3. Presentation Of Results	78
Background Information	78
Scores And Response Times	80
Reading Comprehension	85
Recognizing And Understanding Factual Information	86
Making Generalizations	89
Inferring Underlying Relationships	91
Questions 1-15	93
Mathematics	96
Single Step Problems	96
Multiple Step Problems	98
Number Systems	99
Fractions	100
Operational And Relational Symbols	102
Geometry	104
Determining Differences/Rates/Ratios	105

Table Of Contents

3. (cont'd)
 Interpreting And Relating Data From Maps And Graphs 107
 Inferring From Maps And Graphs . . . 110
 Questions 40 - 70 112
 Subject Profiles For Reading and Mathematics 116
 Effects Of Absenteeism On Problem Solving . 127
  Grade Seven Male Diabetics . . . 128
  Grade Seven Female Diabetics . . . 131
  Grade Seven Male Asthmatics . . . 133
  Grade Seven Female Asthmatics . . . 135
  Grade Eight Male Diabetics . . . 136
  Grade Eight Female Diabetics . . . 138
  Grade Eight Male Asthmatics . . . 140
  Grade Eight Female Asthmatics . . . 141
 The "Plan Your Day" Question . . . 143

4. Discussion And Implications 148
 Background Information 149
 Scores and Response Times 151
 Processing Patterns Across Reading Skill Objectives 155
 Processing Patterns Across Mathematics Skill Objectives 159
 Effects Of Absenteeism On Problem Solving . 161
 Ability To "Plan Your Day" 164
 Value Of Information Processing Profiles . 167

5. Conclusion 170
  Evaluative Summary 170
  Contributions Of The Study 179
  Suggestions For Further Study 180

 References 182

Appendices

Appendix — Page

A. Parent and Subject Consent Form 201

B. Test Instrument 202
Letter of Permission to use items from the Canadian Tests of Basic Skills . . 203
Test Format 204

C. Reading Code Definitions 221

D. Mathematics Code Definitions 222

E. Scores and Response Times of Diabetic Subjects 223

F. Scores and Response Times of Asthmatic Subjects 224

G. Table G-1: Means and Standard Deviations of Reading and Mathematics Scores and Response Times 225
Table G-2: Mann-Whitney U Statistics . 226

H. Information Processing Code Frequencies and Percentage Occurrences: Reading
Table H-1: Recognizing and Understanding Factual Information . . . 227
Table H-2: Making Generalizations . . 228
Table H-3: Inferring Underlying Relationships 229
Table H-4: Reading Questions 1 - 15 . 230

I. Information Processing Code Frequencies and Percentage Occurrences: Mathematics
Table I-1: Single Step Problems . . 231
Table I-2: Multiple Step Problems . . 232
Table I-3: Number Systems 233
Table I-4: Fractions 234
Table I-5: Operational and Relational Symbols 235
Table I-6: Geometry 236

Appendices

Appendix

I. (cont'd)

Table I-7: Determining Differences/ Rates/Ratios 237

Table I-8: Interpreting and Relating From Maps and Graphs . . 238

Table I-9: Inferring From Maps and Graphs 239

Table I-10: Mathematics Questions 40-70 240

J Information Processing Code Percentage Occurrences by Absenteeism

Table J-1: Reading Questions 1-15 . . 241

Table J-2 Mathematics Questions 40-70 242

List of Figures

Figure	Page
1. Information processing profile in reading: grade 7 female asthmatic, Subject 36 . .	121
2. Information processing profile in reading: grade 7 male diabetic, Subject 5 . .	121
3. Information processing profile in reading: grade 8 male asthmatic, Subject 42 . .	121
4. Information processing profile in reading: grade eight female asthmatic, Subject 44 .	121
5. Information processing profile in mathematics: grade 7 male diabetic, Subject 6 . .	122
6. Information processing profile in mathematics: grade 7 female diabetic, Subject 11 . .	122
7. Information processing profile in mathematics: grade 8 male diabetic, Subject 16 . .	123
8. Information processing profile in mathematics: grade 8 female asthmatic, Subject 48 . .	123

List of Tables

Table Page

1. Information Processing Patterns: Reading . . 95
2. Information Processing Patterns: Mathematics . 117

CHAPTER 1

REVIEW OF THE LITERATURE

Introduction

Children's scholastic abilities are usually assessed by comparing their product scores on time-limited tests with group norms. This method of assessment does identify the specific domains and even the specific skill objectives which give rise to difficulty for an individual child or a group of children. It does not identify why children have difficulty, and it does not allow for the identification of information processing patterns displayed by problem solvers who may possess a variety of ability levels. When dealing with particular subgroups of learners, the group norms do not reflect the individual differences inherent in the subgroups. If educators are to optimally address learning problems they need a clearer picture of how children process information from the time they are presented with the problem until they give their response. A method for identifying and describing children's processing of information during curriculum related problem solving is needed. Once such a method is developed it is anticipated that patterns of information processing will emerge across high and low ability problem solvers. As specific components of information processing that contribute to children's strengths and weaknesses in problem solving can be identified, educators will gain insight into the children's abilities and difficulties. With this added knowledge, they will be better equipped to choose teaching strategies appropriate to the needs of the students.

It is the purpose of this study to develop a methodology which identifies and describes information processing patterns used by children in solving core curriculum type problems. Because the process for the development of such a methodology is lengthy and time consuming, the number of subjects involved in the study is of necessity restricted. It is therefore advantageous to choose to analyse the problem solving abilities of a population of children expected to exhibit a wide range of problem solving abilities.

From the following review of the literature of chronically ill children and their school related problems it will be noted that these children can be expected to display a wide range of problem solving abilities. The two sub-groups of chronically ill children selected to represent the population for this study are children with Chronic Asthma, the chronic condition with the highest incidence in childhood; and children with Insulin Dependent Diabetes, the most common metabolic disease of childhood. Childhood is broadly defined to include adolescence. Not only would this population of children provide a wide range of problem solving strengths and weaknesses, but increased knowledge of their information processing patterns would be helpful to both school teachers and health educators.

Chronic Illness And School Related Problems

Chronic physical illness is a comprehensive term which encompasses a number of long term physical conditions that affect one or more body organs and represent an active disease process. The illness may be life-threatening or benign and usually requires a long period of medical supervision (Kleinberg, 1982). Chronic physical illness affects 10 to 15% of the child population (Haggerty, 1984). Although there are definite physiological differences between the various conditions, there are many common concerns (Perrin, Ireys, Shayne & Moynihan, 1984; Pless, 1983). One of the most significant of the common problems is academic performance. Even though the majority of children with a chronic illness are of normal intelligence (Olch, 1971; Rutter, Tizard, & Whitmore, 1970; Walker & Jacobs, 1984; and Weitzman, 1984), underachievement and poor scholastic performance are considered major concomitants of chronic illness (Walker & Jacobs, 1984). Following a comprehensive review of the literature on chronic illness and school achievement, Schlieper (1985), reports that 30 to 40% of children who have a chronic illness have school-related problems. This figure includes children whose chronic illness involves cerebrocortical impairment. Several studies indicate that chronically ill children without neurological impairment also experience serious academic problems (Khan, Herndon & Ahmadian, 1971; McAnarney, Pless, Satterwhile & Friedman, 1974; Olch, 1971; Rutter, Tizard & Whitmore, 1970; and Sultz, Schlesinger, Mosher & Feldman, 1972).

Factors associated with the degree of academic problems include: age at diagnosis (Holaday, 1974; Stehbens, Kisker & Wilson, 1983; Weil & Ack, 1964); sex (Pless & Roghmann, 1971; Sultz et al., 1972); social class and parents' educational level (Conovor, 1973; Pless, 1983); teacher expectations (Drotar, 1981; Sultz et al.,1972; Walker & Jacobs, 1984; Weitzman,1984); and physical condition plus side effects of treatment (Weitzman, 1984). There is conflicting evidence in the literature regarding the relationship between chronic illness and psychosocial maladjustment. Deasy-Spinetta (1983), Pless (1983) and Weitzman (1984) place children with chronic illness at higher risk for psychosocial problems. Rodgers, Hellemeier, O'Neill & Slonim (1981) consider a school age child with a chronic illness highly susceptible to depression. Brantley, Stabler & Whitt

(1981); Gath, Smith & Baum (1980), Matthews & Drotar (1981) and Tavormina, Kastner, Slater & Watt (1976) indicate few statistical differences on measures of adjustment between chronically ill and physically healthy children.

There is also conflicting evidence in the literature concerning the effect of absenteeism on academic performance. In reviewing the literature on school absence associated with children's health problems, Weitzman, Klerman, Lamb, Menary & Alpert (1982) found the evidence for a relationship between absenteeism and school achievement inconclusive. Douglas & Ross (1965) expressed the view that frequent school absences are more harmful than an occasional long absence. Walker & Jacobs (1984) concur with this view stating that children absent from school for health problems for a period of two weeks or more are eligible for hospital or home teaching, whereas children experiencing short episodic interruptions in schooling are generally left to catch up on their own. Weitzman et al (1982) contend that absence behavior is most relevant as an indicator of the child's and family's adaptation to the chronic illness. This concurs with the findings of Parcel, Gilman, Nader & Bunce (1979) which indicate that the rates of absenteeism vary directly with the mother's perception of the severity of the child's asthma. Weitzman et al (1982) state that family functioning is negatively associated with school absence and that the patterns of absenteeism can help identify families with unmet health needs.

Clearly, there is concern about the academic performance of chronically ill children and a number of factors are considered to contribute to scholastic difficulties. A review of the literature dealing specifically with the school related problems of the two subpopulations of chronically ill children of this study follows.

Chronic Asthma And School Related Problems

The chronic condition with the highest incidence in childhood is asthma. In the United States and Australia, asthma has been estimated to affect 9 to 14% of all school age children (Cropp, 1985; Pearlman, 1984). Asthma is a disorder of the tracheobronchial tree in which there is recurrent, at least partially reversible, generalized obstruction to airflow. The disorder is usually manifested by cough, respiratory distress and expiratory wheezing (Pearlman, 1984).

In the Sultz et al (1972) epidemiological study of chronic conditions in children in Erie County, United States, the ratio of male asthmatics to female asthmatics was reported as 1.7 to 1. Based on data collected from medical records, school records and parent interviews, Sultz et al (1972) report that 22.4% of the asthmatic children were below grade level for their chronological age and that 37% experienced academic problems such as failing a subject or neglecting homework assignments. Sultz et al (1972) did not compare the chronically ill population with healthy peers. Rutter et al (1970) in their epidemiological survey of children with a chronic condition on the Isle of Wight, found on the basis of a shortened version of the WISC and the Neale Analysis of Reading Ability Test, that asthmatic children had a verbal intelligence score above that in the general population. However, 13%

were reading at a level at least 24 months below that expected on the basis of their chronological age and WISC IQ and 11% had specific reading retardation of at least 28 months.

Rutter et al (1970) found a strong positive association between reading retardation and a high absence rate from school. However, their healthy peer group who did not experience the same degree of reading retardation did not have significantly less days of absenteeism. Thirty-one percent of the asthmatic children in the Sultz et al (1972) study were absent from school for more than six weeks during an academic year. Parcel, Gilman, Nader & Bunce (1979) found that children with asthma were absent 8.4% of the school days whereas non-asthmatic children were absent 5.9% of school days.

Conway and Littlewood (1985) investigated 142 hospital admissions for acute asthma during a one year period and found that of the 41% who were school attenders, only 8% were thought to be receiving adequate treatment prior to admission. Closer medical supervision and more aggressive treatment may lower school absentee rates. Alexander (1983), and

Cropp (1985), question the extent to which medications commonly used to treat asthma may be contributing to deficits in cognitive functioning. It is suggested that learning and memory deficits may be caused by therapeutic corticosteroids and concentration difficulties may be associated with beta adrenergic substances and theophylline.

<u>Insulin Dependent Diabetes Mellitus And School Problems</u>

Insulin Dependent Diabetes Mellitus (IDDM) is the most common metabolic disease of childhood. Children with IDDM require insulin injections daily, regular monitoring of blood sugar levels and adherence to a diet and exercise regime. These children need to be aware of factors that will influence their blood sugar levels and of steps to take to maintain optimum health. Glucose provides the major source of energy to the brain and central nervous system and relatively little glucose can be stored in the brain so normal neuronal functioning is dependent on blood glucose supplies (Holmes, Hayford, Gonzalez & Weydert, 1983).

Sultz et al (1972) report that 16.1% of children with Diabetes Mellitus were below grade level, 35.5% experienced school problems such as failing a subject or not completing assignments, and 19.4% missed at least 6 weeks of school, not necessarily consecutively, during an academic year. Gath, Smith & Baum (1980) compared 76 IDDM children whose mean age was 10.9 years with a control group and found twice as many diabetic children at least two years behind in reading. Fifty percent of the children with poorly controlled diabetes were retarded in reading. Data for this study was collected by means of clinical interviews and two questionnaires completed by the children's teachers. Control data was obtained by means of a questionnaire completed by teachers on non-diabetic classmates but the controls were not matched for intelligence.

Sterky (1963) found no difference between the school achievement of diabetic and non-diabetic children in spite of the increased absenteeism of the diabetic children. Weil & Ack (1964) administered the Stanford-Binet Intelligence Scale Form M and the

California Achievement Test in reading and arithmetic to 39 diabetic children and 26 non-diabetic siblings. No difference was found in achievement levels between diabetic children and their siblings as a total group or on the basis of age of onset or duration of the disease in the diabetic child. Both groups however had a high rate of academic problems. Children who had developed diabetes prior to five years of age averaged ten IQ points below their non-diabetic sibling but this did not significantly affect achievement results. Kubany, Danowski & Moses (1956) administered the Stanford-Binet IQ Test and the Minnesota Multiphasic Personality Inventory to 20 male diabetics with mean age of 17.7 and 20 female diabetics with mean age of 19.9. General intelligence scores were in the middle of the normal range and there was no evidence of predisposition to behavior abnormalities. No relationship was found between diabetic onset, age or abnormal behavior and any of the personality variables. Delameter, Bubb, Warren-Boulton & Fisher (1984) also state that levels of emotional disturbance are no higher among diabetics than for the general population.

Kovacs, Feinberg, Paulauskas, Finkelstein, Pollack & Crouse-Novak's (1985) report on the first phase of their longtitudinal study of the coping responses and psychosocial characteristics of newly diagnosed IDDM school age children revealed the following: mean age at diagnosis was 11; sex distribution was 60% female and 40% male; class placements consisted of 84% in regular classes, 6% in classes for the gifted, and 10% in special or remedial classes; mean verbal mental age by WISC-R Vocabulary Subtest was 11 years and 10 months; mean non-verbal mental age based on WISC-R Block Design Subtest was 11 years and 6 months; and 64% of the children weathered the diagnosis and early strain of their medical illness without notable distress. With a supportive mental health team, even those experiencing a strong emotional reaction to the diagnosis had a highly favorable prognosis for emotional adjustment to their diabetes.

Cognitive differences were noted in IDDM patients ages 10 to 19 who developed diabetes before the age of five when compared to non-diabetics and diabetics diagnosed after the age of five (Ryan, Vega & Drash, 1985). Although the mean neuropsychological test scores for all three groups were well within the normal range, the early onset diabetics performed more poorly on verbal tests assessing general knowledge and practical reasoning ability, visuoconstructional and problem-solving skills, the Boston Embedded Figures Test, the Standardized Road Map Test, the Visual Reproductions Subtest of the Wechsler Memory Scale and on the Wrat Reading Test. The duration of the subject's diabetes best predicted performance on tests requiring highly overlearned, primarily verbal skills and age of onset best predicted scores on tests requiring the ability to process relatively unfamiliar, generally nonverbal information in novel ways.

Holmes, Hayford, Gonzalez & Weydert (1983) studied the effect of different blood glucose levels on cognitive functioning in 12 juvenile-onset IDDM university students. Using an artificial insulin/glucose infusion system, each subject was tested during low glucose, normal glucose and high glucose blood levels using three equivalent but different tasks assessing memory, attention, visual-spatial ability, reading (Nelson Denny) and mathematical computation. Reading comprehension was assessed through the number of questions answered correctly in the eight minutes allotted for the test. Arithmetic ability was assessed by counting the number of correctly completed problems and the number attempted in the one minute allotted for the test. Attention and fine motor skills, assessed by visual reaction time were slowed during both the low and high glucose states but more so for the low glucose state. Subjects correctly completed an equivalent number of arithmetic calculations when they had high and normal blood glucose levels but completed fewer arithmetic problems when their blood glucose level was low. The percentage of correct answers to the problems attempted showed no glucose-related effect. The speed of recalling rote arithmetic functions was slowed suggesting that the rate of remembering information may have been impaired at low glucose levels when performance was timed.

<u>Summary</u>

The literature suggests that chronically ill children are at higher risk for academic problems than the healthy child population. A number of factors (absenteeism, treatment effects etc.) have been suggested as reasons for increased vulnerability to academic problems. Reading and mathematics are two curriculum areas with which these children appear to have particular difficulty. However, Drotar (1981) cautions that chronic illness research has concentrated on identifying differences between chronically ill children and their healthy peers, to the exclusion of examining within-group differences. For the most part, measures used to assess chronically ill children have been standardized on physically healthy children. Statements about performance have been based on product scores and the problem solving process has rarely been considered. In some situations, differences may be more related to the time needed to complete tests than to cognitive skills (Holmes et al, 1983). Knowledge of chronically ill children's information processing strengths and weaknesses is lacking.

Chronic Asthmatic and Insulin Dependent Diabetic children have been chosen as the population for this study for the following reasons: (1) Chronic Asthma is the chronic condition with the highest incidence rate in childhood; (2) Insulin Dependent Diabetes is the most common metabolic disease of childhood; and (3) children with either of these conditions are at risk for academic problems, particularly in the core curriculum areas of reading and mathematics, and therefore can be expected to display a wide range of information processing strengths and weaknesses.

The following section reviews the literature which provides the conceptual framework for the analysis of problem solving abilities.

Theoretical Framework

The most appropriate conceptual framework within which to examine cognitive processing abilities during problem solving appears to be the information processing theoretical framework. Within this framework a method has been provided for the collection of data (Ericsson & Simon, 1984) and for task analysis (Glaser & Pellegrino, 1982; Greeno, 1980; Larkin, 1980; Newell & Simon, 1972; Sternberg, 1984c; 1985). The implications for (1) the development of instructional programs based on the results of task analysis and (2) a better understanding of cognitive development in general, are also well documented (Brown, Campione, Cole, Griffin, Mehan, & Reil, 1982; Frederiksen, 1984; Gardner, 1985; Kail & Bisanz, 1982; Rigney, 1980; Wagner & Sternberg, 1984).

The review of the literature will be presented under the following headings: memory organization and function; knowledge structures; problem solving characteristics; and information processing components.

Memory Organization and Functions

An understanding of human memory as an information processing system is essential in order to understand problem solving ability. The model of human memory most widely accepted by researchers in cognitive science, integrates the following memory structures: sensory registers; working memory (WM); short term memory (STM); and long term memory (LTM). Stimuli received through the sense organs are briefly held in a sensory register. These stimuli are most commonly visual, auditory, tactile or olfactory. The role of the sensory register is to briefly maintain a stimulus event to give it time to be recognized, classified, temporarily stored in short term memory, or ignored (Frederiksen, 1984). Some forms of stimuli appeared to be retained longer than others, for example, the duration of echoic storage appears greater than the duration of iconic storage (Klatzky, 1975).

It is proposed that the process of perception or recognition involves a search for a match between the patterns of information held briefly in the sensory register and patterns previously stored in long term memory (Gilmartin & Newell, 1976). Encoding was defined by Klatzky (1984) as the subprocesses that perceive sources of new information, operate on this information using stored information, and enter the new data into memory. Some encoding, such as reading by a skilled reader is automatic, but most encoding requires attention.

Short term memory span is generally limited to approximately four or five chunks of information (Chi, 1976). The concept of chunking originated with Miller (1956) and refers to the recoding of information by combining single units of information into larger units or chunks of information. The size of each chunk varies according to the familiarity of the content, the number and nature of items involved and the strategies available to prevent decay or displacement. For example, one may chunk five colours, only three nonsense syllables, but several stanzas of familiar poetry (Simon, 1974). The amount of information that can be held in short term memory is a direct function of the amount of information an individual can encode in a single chunk (Ericsson & Simon, 1984). Chi (1976) sees the basic parameters of capacity and rate of information loss as similar between children and adults. However, Chi (1977) states that young children are limited in their ability to control strategies such as rehearsal, naming, grouping and recoding which help code and maintain information in short term memory. Rehearsal has been defined as the cycling of information through the memory store to renew information in short term memory or transfer rehearsed items to long term memory (Klatzky, 1975). Short term memory and working memory are often used synonymously, but for those who make a distinction between the two (Chase, 1984; Greeno, 1973; Mayer, 1983; Simon, 1979), working memory deals only with information in focal attention and controls the sequence of processing.

In contrast to short term memory, long term memory has an apparent unlimited capacity and has been described as a richly indexed and cross-indexed data base. Simon (1979) describes long term memory in terms of a recognition memory and a semantic memory. Recognition memory has been compared to an index and semantic memory to the textbook content. Recognition memory identifies familiar stimulus patterns and retrieves, for short term memory, the chunks that point to information about patterns stored in long term memory. Each time new information is stored in semantic memory, elaboration of the recognition memory must take place in order for the new information to be readily accessible. Fixation, or storage in semantic memory is often speeded up with the use of mnemonic devices. Therefore, Simon (1979) suggests that the ability to store new information is limited more by the time required to modify and elaborate recognition memory than to add the information to semantic memory. Factors which are purported to affect recall include compatibility between encoding and retrieval contexts, and the presentation of appropriate retrieval environments to access previously forgotten material (Brown & Campione, 1981; Norman, 1980).

Although there are several models of long term memory, most describe long term memory as an orderly associative system. Descriptors that have been used to represent long term memory organization are: network systems comprised of nodes and links, properties and lists, or associated concepts (Anderson, 1983; Cohen & Murphy, 1984; Klatzky, 1975; Millward 1980; Simon, 1979); and set and feature models which group information according to categories or features (Bruner, Goodnow & Austin, 1956; Millward, 1980).

Knowledge Structures

Information coming from different sensory sources has different features and will therefore be represented by different knowledge structures. These knowledge structures may contain sensory-perceptual information such as smells or tastes; declarative knowledge such as facts and meanings; or procedural knowledge relating to motor and cognitive skills (Frederiksen, 1984). Chi (1981) also adds strategic knowledge, defined as knowledge of heuristic rules. Klatzky (1984) describes two types of activation of the knowledge structures, "bottom-up" or stimulus driven activation, or "top-down" or conceptually driven activation. The concept of a hierarchy of knowledge structures led Eylon & Reif (1984) to examine the effects of knowledge organization on task performance. Subjects who acquired knowledge content organized in a hierarchical format performed recall and problem solving tasks better than the subjects who acquired the same information organized at a single level.

An alternative to the hierarchical construct is one which discusses depth of processing in terms of size and elaborateness of networks. Information which accesses and activates larger networks can be processed more deeply because of the greater number of cognitive associations to which it is linked (Ingram, 1984). Kail & Bisanz (1982) describe the following general properties of the human knowledge system: (1) theoretically, there are no limits on the quantity of knowledge that can be stored in long term memory; (2) forgetting reflects an inability to access stored knowledge; (3) most knowledge can be accessed by multiple routes and multiple cues indicating its richness in interconnecting links; (4)

knowledge has a weak cognitive economy in that everything known about a concept may not be directly accessed via the concept but rather through inference; and (5) a process can operate on itself as well as on other representations and processes.

Problem Solving Characteristics

The computer simulation approach to problem solving has contributed the concepts of task environment, problem representation, and problem space to aid in the discussion of problem solving. The task environment is the structure and inter-relationships of facts or concepts that make up the problem. Problem representation is influenced by the way the problem is stated and involves first a language interpretation process and then a solution planning process. It is basically the individual's perception of the problem and Greeno (1980) states that the problem solver apprehends relationships that permit the selection of goals and sub-goals as well as problem solving methods by relatively direct retrieval from long term memory rather than through an elaborate search for relationships.

Hinsley, Hayes & Simon (1977) examined problem representation and processing strategies in relation to algebra word problems and concluded that if subjects recognize the category of the problem early in their formulation of the problem representation, they will likely employ heuristics specific to formulating and solving problems of the category in question. If they do not recognize the category for the problem they will employ a general solution strategy.

The problem space refers to the problem solver's internal representation of the givens of the problem, the goal state, the intermediate problem states, and the operators or necessary moves to reach the goal state (Simon, 1978). The solving process begins as soon as there is enough information about the problem space to enable action. The understanding process continually generates more specifications for the problem space. The understanding process is in part determined by previous experience and therefore may be different for different people. If the problem is familiar, recall of information from long term memory is facilitated and elements of the problem space, constructed in previous problem solving exercises, can be used. Since the process of problem space construction can require considerable effort, familiarity with similar problem types should decrease the time required to arrive at the solution (Hayes & Simon, 1974). When a problem is not clearly understood by the problem solver, only a small part of the potentially relevant information stored in long term memory becomes involved in the solution process. The problem space changes as additional features of the problem are recognized.

The success of the problem solver is related to the ability to represent critical features of the task environment in the problem space (Amarel, 1983; Frederiksen, 1984). Problem solvers use a number of strategies to search through a problem space (Greeno, 1975; Hayes, 1981; Larkin, 1980; Newell, 1980). Common among these strategies are the trial and error method, hill climbing, means-ends analysis, and heuristic search. Trial and error is a random search through the problem space and results in many wasted moves. Hill climbing takes place if a graded evaluation function exists and beginning with a local search there is a gradual movement toward the goal state. Hill climbing is more systematic than trial and error but it does not work well in problems that require movement away from the goal in order to ultimately reach the goal. Means-ends analysis is more powerful than hill climbing because it can consider many dimensions of difference between the current state and the goal state. The problem solver works on only one goal at a time with the objective of bringing the present goal closer to the end goal but this is done by comparing the difference between the two goals and setting a new goal that will decrease the difference and bring the problem solver closer to the end goal. Movement toward the end goal need not be along one gradient and may at some point include movement away from a goal in order to ultimately make progress toward the end goal. The success of heuristic search depends on the amount of heuristic knowledge an individual possesses (rules of thumb and strategies that have worked in the past). These will help evaluate how well the current representation is performing and suggest new representations (Lenat, 1983). Heuristic search requires memory to keep prior positions in the problem space so that the search can backtrack and continue in different directions.

Simon (1978) demonstrated that different information processing strategies may produce functionally equivalent results but processing time may vary considerably. The effective implementation of strategies is dependent on the problem solver's domain specific declarative and procedural knowledge (Greeno, 1980; Larkin, 1980). For example, an arithmetic question which requires finding an average is given to a class along with three possible answers, only one of which is correct. Children who understand the concept of averaging and know that they must add and then divide the sum of their addition by the number of figures added (declarative knowledge) and who can add and divide efficiently and accurately (procedural knowledge) will have implemented efficient and effective strategies to arrive at the correct answer. Children who do not have the declarative knowledge base may use trial and error or other inefficient strategies to arrive at an answer that approximates one of the three given answers. Children who have weak procedural knowledge may have difficulty with accurate addition and division and may or may not arrive at the correct answer. Cognitive development is largely the increment of declarative and procedural knowledge (Chi, 1981). Research which examines differences in problem solving between high and low ability problem solvers (experts and novices) across a number of domains has established that the richness of the declarative and procedural knowledge base is central to performance differences.

As a person's knowledge base becomes more richly structured, the criteria for problem perception shift. Novices perceive problems on the basis of the words or objects described in the problem, whereas experts relate problems to principles or methods relevant for problem solution (Schoenfeld & Herrmann, 1982). With the development of expertise, individuals become more exhaustive in the processing of information, and tend to consider all information presented, rather than only a subset of information

(Reif, 1980; Sternberg, 1984a). In contrast to novices, experts spend more time on problem encoding and global planning (Lesgold, 1984; Sternberg, 1984a). There is evidence that experts can encode information into larger perceptual chunks, and that these chunks are more readily recalled even though the number of chunks retained in short term memory remains limited to a five to seven chunk capacity (Simon & Chase, 1973). Experts have a richer store of appropriate knowledge in long term memory which is better organized for retrieval and therefore results in greater speed and fluency of performance (Rigney, 1980). They are at an advantage in their area of expertise because their efficient handling of familiar tasks frees processing resources to deal with the complexities of the problem, or, to learn new tasks. Novices become overwhelmed with new information and must engage global resources so frequently that new information is quickly lost (Sternberg, 1984a).

A major factor in skill acquisition and the development of expertise in both the cognitive and motor domains is automaticity which is sometimes referred to as overlearned or scripted behavior. According to Shiffrin & Schneider (1977), information processing can be controlled or automatic. Controlled processing requires attention and therefore uses up the capacity of working memory, whereas automatic processing uses up little of the working memory capacity, and speeds up the processing involved. The characteristics of automatic processing have been outlined by Shiffrin & Dumais (1981). The intermediate products of automatic processes are unavailable to metacognition and therefore to verbal report because they require minimal attentional resources and are therefore primarily unheeded (Ericsson & Simon, 1984). The advantages of controlled processing are described by Lefebvre-Pinard (1983) who stresses the importance of self-awareness of cognitive functioning. Attentional processes are positively correlated with the ability to accurately encode, to elaborate recognition memory, and to choose and monitor the search and retrieval strategies used in problem solving.

Information Processing Components

In order to understand how information is processed, Newell and Simon (1972) decomposed tasks into components and defined a component as an elementary information process that operates on internal representations of objects or symbols. The component may translate a sensory input into a conceptual representation, transform one representation into another, or translate a conceptual representation into a motor output (Sternberg, 1985). Each component has the properties of duration, difficulty and probability of execution. Sternberg (1985; 1984b; 1984c; 1980) developed a triarchic theory of human intelligence based on the information processing component construct.

The triarchic theory of intelligence proposed by Sternberg (1984b, 1984c, 1985) is comprised of a componential subtheory, an experiential subtheory, and a contextual subtheory. The experiential subtheory examines intelligence in relation to the ability to deal with novel tasks or situational demands, and the ability to automatize the processing of information. The contextual subtheory emphasizes the roles of adaptation to, selection of, and shaping of environmental contexts in order for the individual to fit the environment. The componential subtheory offers a framework for examining the mental mechanisms underlying intelligent performance and consists of metacomponents, performance components and knowledge-acquisition components.

Metacomponents are executive processes used in planning, monitoring and decision making. Among the metacomponents identified by Sternberg (1985) are: problem identification (identification of the end goal); selection of problem representation (diagrams and/or linguistic descriptors); process selection (choice of performance components relevant for solving the problem); strategy selection (how and when to use the performance components); resource allocation (decision regarding allocation of attentional resources); solution monitoring (keeping track of what is done and what needs to be done); and sensitivity to feedback (ability to understand feedback, recognize its implications and act upon it). Planning which attends to all of the above metacomponents is defined by Hayes-Roth & Hayes-Roth (1979) as the predetermination of a course of action aimed at achieving some goal. They perceive problem solving as a two stage process which includes planning as stage one and monitoring and guiding of the plan as stage two. The planning activity according to the Hayes-Roth & Hayes-Roth (1979) model is largely opportunistic since several observations or decisions made during the planning process can contribute to plan development and result in many different decision sequences.

Performance components are always under the direction of the metacomponents and are used in the execution of various strategies. There are a large number of possible performance components. Some examples are encoding, inferring, mapping, comparing, justifying, and responding.

The knowledge-acquisition components are the processes used in gaining new declarative and procedural knowledge and consist of selective encoding (sifting out relevant from irrelevant information); selective combination (putting the relevant information together); and selective comparison (relating newly acquired information or retrieved information to stored information). Knowledge-acquisition components are also activated by and feedback to the metacomponents.

Using a componential analysis of inductive reasoning tasks, Glaser & Pellegrino (1982) concluded that there are three major, interrelated factors that differentiate high and low skill problem solvers. These are the management of memory load, the procedural knowledge of task constraints, and the organization of an appropriate knowledge base. Through the analysis of verbal protocols collected during task performance, mathematical and analogical error patterns could be noted for the high and low ability groups. Also using verbal protocols and a componential analysis approach, Greeno (1980) analysed the problem solving abilities of grade nine geometry students and subsequently developed a computer simulation model that represents the knowledge required to solve geometry problems. Knowledge of propositions used in making inferences, of perceptual concepts used in recognizing patterns, and of strategic principles used in setting goals and plans was considered necessary for problem solution.

Sternberg (1984a; 1985) analysed the performance of children considered intellectually gifted and those considered intellectually retarded, and found that the gifted had superior metacomponential, performance and knowledge-acquisition skills. They were better able to selectively encode, combine and compare, thus giving them greater insight into the solution of novel problems. According to Sternberg (1984a; 1985) the following list indicates contributing factors to impaired componential functioning: impaired activation by metacomponents; poorly stocked or poorly organized declarative and/or procedural knowledge base; reduced working memory capacity; inadequate motivation resulting in non-utilization of componential system; impaired functioning of components such as slow performance execution or inability to infer; impaired coordination between controlled and automated componential subsystems; and impaired ability to use feedback.

Ability to use feedback has been identified as particularly important to successful academic task performance by Rigney (1980) who supplies the following list of self monitoring skills: keeping one's place in a long sequence of operations; learning the sequence of operations, identifying likely error areas, choosing a strategy that will reduce error probability and provide recovery, identifying the kinds of feedback available at various points and evaluating its usefulness; detecting errors previously made, keeping a mental log of what has been done so as to determine what comes next, and justifying the response.

In summary, using a componential framework, problem solving abilities can be identified and described across the various metacomponents and performance components involved in the problem solving tasks.

PROBLEM STATEMENT AND RESEARCH OBJECTIVES

Factors which relate to effective problem solving and intellectual functioning include a) the richness and the organization of domain specific declarative and procedural knowledge in long term memory; b) the time required to modify and elaborate long term memory knowledge structures in order to add new knowledge; c) memory span as related to the amount an individual can encode in a single chunk; d) the ability to extract the critical features of the problem statement and to form an appropriate problem representation; e) the selection of efficient and appropriate problem solving strategies, and f) the amount of processing which is automatic. Problem solving tasks can be decomposed into components so that an individual's ability to plan, monitor, make decisions, execute strategies and acquire new knowledge can be examined. The identification and description of information processing patterns associated with high and low ability problem solvers can be ascertained through the identification of cognitive components arrived at through the analysis of verbal protocols collected during task performance.

In order to develop a methodology which will identify and describe information processing strengths and weaknesses of children across problems addressing various skill objectives, the following variables will need to be considered:

(1) The child's long term store of domain specific knowledge, both declarative and procedural, and the child's ability to access this knowledge (i.e. the knowledge the child brings to the task).

(2) The child's ability to store and then recall newly acquired information (i.e. the knowledge the student acquired or organized during the execution of the task).

(3) The child's ability to extract the critical features from the problem statement.

(4) The child's ability to form an appropriate problem representation.

(5) The efficiency and effectiveness of the processing strategies used by the child to work through the problem space.

(6) The amount of automatic processing used by the child, the depth of processing and the time taken to process the information.

(7) The child's ability to plan, monitor, and use feedback during problem solving.

Therefore, the objectives of this study can be stated as:

Objective 1:

To identify and describe Chronic Asthmatic and Insulin Dependent Diabetic children's strengths and weaknesses in curriculum related problem solving across the following variables:

a) problem specific declarative knowledge

b) problem specific procedural knowledge

c) storage and recall of recently acquired information

d) problem identification

e) problem representation

f) effectiveness of problem solving strategies

g) automatic processing

h) ability to plan, monitor and use feedback.

Objective 2:

To identify information processing patterns which contribute to these children's strengths and weaknesses in problem solving.

Since the literature differs as to whether the sex of the chronically ill child is related to the degree of academic problems experienced, (Holmes et al., 1983; Sultz et al., 1972), the information processing abilities of the two groups will be examined across the sexes.

The study is exploratory in nature. The literature has provided a theoretical framework and suggested concepts to be addressed in the development of a methodology which will enable the identification and description of children's problem solving strengths and weaknesses across the above listed variables. A method for analyzing children's curriculum related problem solving abilities across these variables could not be found in the literature, but the value of this type of knowledge about children's problem solving abilities and its implications for educators is well documented (Frederiksen, 1984; Gardner, 1985; Glaser & Pellegrino, 1982; Wagner & Sternberg, 1984). It is therefore necessary to develop a methodology which will enable the above objectives to be met.

The following chapter presents the design of the study and the development of the methodology used to analyze the children's problem solving abilities.

CHAPTER 2

RESEARCH METHODOLOGY

In addition to describing the population, sample, and test instrument, this chapter gives a rationale for using verbal protocols as data and describes the data collection procedure as well as data analysis methods. However, the quintessence of this chapter is the description of the development of a methodology for identifying and describing the problem solving strengths and weaknesses of the subjects through the analysis of their verbal protocols. Information processing codes have been assigned to the solution patterns which evolved from the protocol analysis. These processing codes are defined and verbal protocol examples of each are provided.

<u>Population:</u> Grade seven and eight, male and female, Insulin Dependent Diabetic or Chronic Asthmatic children who understand the English

language, and do not have a communication disorder or diagnosed learning disability. Communication disorder for the purpose of this study has been defined as any serious impediment to verbal communication which would inhibit the collection of verbal protocols, e.g. severe stuttering or the use of non-verbal language. Diabetic children are insulin dependent, have been diagnosed as having Diabetes Mellitus for six months or longer and their physician considers their diabetes to be under control. Chronic Asthmatic children are those receiving at least one medication for asthma on a regular basis but who are not on continuous steroid therapy.

<u>Sample:</u> Forty-eight children, of whom 24 have Insulin Dependent Diabetes Mellitus and 24 have Chronic Asthma. Each group consists of 12 males and 12 females with 6 grade seven and 6 grade eight subjects of each sex.

All patients in the Diabetic and Asthma clinics of the Children's Hospital of Eastern Ontario who met the inclusion criteria were referred by the clinic nurse. Physicians in Ottawa-Carleton also referred Chronic Asthmatic children meeting the criteria because an insufficient number of subjects were available through the clinic.

The researcher fully explained to the parent and to the potential subject, the purpose and nature of the study, stressing that participation was voluntary, that the time commitment was a maximum of two hours, that information would be confidential, and that they could withdraw from the study at any time without affecting the care received at the Children's Hospital of Eastern Ontario or from their physician. It was indicated that individual appointments for testing would be made at the parent's and subject's convenience. Following the parent's and subject's stated willingness to participate, their signed consent was obtained (Appendix A).

Test Instrument:

The test instrument (Appendix B) contains reading comprehension and mathematics problem solving items plus an item relating to a real-life situation. The reading comprehension and mathematics items have been taken from the Canadian Tests of Basic Skills Form Six (King, 1981) with the written permission of Nelson Canada (letter of permission included in Appendix B). Each of the items from the Canadian Tests of Basic Skills is nationally normed thus giving an indication of the degree of difficulty of each question for Canadian students at the same grade level. It is not claimed that the internal consistency reliability coefficients for the major skill objectives (which are .87 to .96) nor the composite reliability (.97 to .98 for all grades) of the Canadian Tests of Basic Skills will be inherited because the test items for this study have been extracted from the Canadian Tests of Basic Skills. However, there is some assurance that the items appropriately reflect the skill categories and that their level of difficulty is appropriate to the grade levels. Criteria used to establish the content validity of the reading and mathematics items include: placement and emphasis in current Canadian instructional materials; recommendations of specialists; research studies with various populations; and feedback from users over the past 40 years. (King, 1982).

Of the 23 reading comprehension items for grade seven and 24 items for grade eight, 15 items overlap. All items have been taken from Test R (Reading Comprehension) Level 13 and Level 14. The mathematics section of the test consists of 35 items for grade seven and 34 items for grade eight with 31 items overlapping. The items on the mathematics section have been taken from Level 13 and Level 14 of Test M-1 (Mathematics Concepts), Test M-2 (Mathematics Problem Solving) and Test W-1 (Maps, Graphs, and Tables). Drawing students from two grade levels allowed for a wider range of abilities to be observed on overlapping items. The selection of items in both reading and mathematics range from easy to difficult as determined by the national norms for the items. Skill objectives for each test item are provided by the Canadian Test of Basic Skills' Teacher's Guide (King, 1982).

Questions on the reading comprehension section of the test focus on the students' ability to recognize and understand stated factual details and relationships (literal meaning); to infer underlying relationships (interpretive meaning); and to develop generalizations from a selection (evaluative meaning). Questions on the mathematics section require the following skills: an understanding of numeration, number systems, and sets; an understanding of operational and relational symbols; a knowledge of fundamental operations, ratios, and proportions using fractions; an understanding of the basic concepts of probability and statistics, and of basic geometry and measurement; a knowledge of how to solve single step and multiple step problems using addition, subtraction, multiplication and division; an ability to use graphs and tables to determine differences, ratios, relative rates and trends and draw conclusions; and an ability to use maps to determine direction and distance, and to interpret and relate data.

The question item format of the test instrument as related to the specific skill objectives is as follows:

(1) recognizing and understanding factual information

questions 2, 3, 4, 6, 12, 21, 24, 25, 31;

(2) making generalizations

questions 5, 7, 9, 10, 13, 15, 17, 22, 23, 27, 28, 29, 30, 32;

(3) inferring underlying relationships

questions 1, 8, 11, 14, 16, 18, 19, 20, 26;

(4) single step mathematics

questions 33, 34, 35, 48, 49, 51, 52;

(5) multiple step mathematics

questions 38, 50, 53;

(6) number systems

questions 36, 37, 40;

(7) fractions

questions 43, 44;

(8) operational and relational symbols

question 46;

(9) geometry

questions 39, 42, 45, 47;

(10) determining differences, rates and ratios

questions 54, 56, 57, 58, 59, 69;

(11) interpreting and relating data from maps and graphs

questions 55, 60, 61, 62, 63, 65, 67, 68; and

(12) inferring from maps and graphs

questions 64, 66, 70.

Under the skill objective called operational and relational symbols, only one item was available from Levels 13 and 14, Form 6.

The additional question which is not domain-specific explores the subjects' ability to relate real world knowledge to the problem solving activity and examines their use of planning, monitoring, and decision making (metacomponents). The question is based on a problem presented by Hayes-Roth and Hayes-Roth (1979) and later used by Sternberg (1984d). Subjects are given a map with streets and businesses clearly marked and a number of tasks to be completed within a specific time frame. The final task is to get to the airport and on a plane to a prescribed destination by 4:30 p.m. Bus routes and schedules are provided. The instruction "Plan your day" leaves the opportunity for subjects to include personal activities such as packing and eating breakfast or lunch. This problem solving activity requires subjects to identify from the problem statement all the tasks that must be completed, to use the map and prior knowledge to set priorities and determine the route, and to adhere to time constraints imposed by bus schedules. Subjects need to rely on prior knowledge to determine which shops will sell certain required items, and how long it should take to complete tasks (e.g. buying a bathing suit).

A practice run was conducted with a grade 7 and a grade 8 subject to give the researcher experience collecting verbal protocols on the test items and to identify any difficulties with the presentation of the test instrument.

Data Collection: Background information collected for each subject included the subject's birthdate, the longest absence from school and the grade level at the time, the number of days absent from school in the last two school years, the subject's latest marks in language arts and mathematics, the parents' school leaving level, and the subject's response to the following questions: 1) What is your favorite subject in school? 2) What subject do you like the least? 3)

What subject do you do best in? 4) What is your poorest subject? and 5) What job or career would you like to have when you finish school? Collecting the background information at the beginning of the testing session helped the researcher establish rapport with the subject.

At the beginning of the testing session the researcher reiterated (previous explanation given at time consent was signed) the importance of thinking aloud and the purpose of the two tape recorders. Paper, pencils and a ruler were provided and the subject was invited to use them whenever he/she wished. Data was collected in the form of verbal protocols and accompanying scribbles. Subjects were individually tested and each session was tape recorded from the reading of the first question to the completion of the last question. Subjects were asked to read the question out loud and then to think through the answer out loud. If there were silences approaching 20 seconds, the researcher would prompt with "What are you thinking?". Concurrent verbal reports or "think aloud" reports reflect the activity in working memory and successive states of heeded information in a cognitive process, thus providing a source of data about the structure of that process (Ericsson & Simon, 1984). If the researcher felt that the concurrent report lacked completeness, the subject was asked immediately following the completion of the problem, "How did you think that through?" or "Can you tell me what you were thinking when you were doing that problem?". Within the framework of information processing theory it is assumed that information recently attended to can be readily accessed from short term memory or at least in part retrieved from long term memory and verbalized. A review of empirical studies by Ericsson & Simon (1984) found no evidence that concurrent verbalization changes the course, structure or speed of the thought processes. Hafner (1957), Dansereau & Gregg (1966) and Tell (1971) suggest that verbalization may facilitate the solution process. Individual differences in the richness of think aloud protocols can be related to the subject's comfort with verbalizing his/her thinking and with the type of problem presented (Hoc, 1984). Individuals who have automatized processes involved in a problem solution provide a limited verbal report since automatic processing is unheeded and therefore not available for concurrent verbal reporting. Ericsson & Simon (1984) list three criteria which must be satisfied if verbal data is to be used to infer underlying cognitive processes. First, the verbalizations should be relevant to the task given. In domain-specific reading and mathematics questions, relevance to the task is easily discerned. Second, the verbalizations should be logically consistent with preceeding verbalizations; and third, a subset of information heeded during the task will be remembered and can be retrieved through retrospective reporting.

Verbal protocol collection and analysis followed the guidelines of Ericsson and Simon (1984). The taped verbalizations were transcribed verbatim and the response time recorded. The response time is the time from the end of the first complete reading of the question plus the answer choices to the time the final response is given. Repeated readings of the question have been included in response time but discussions of aspects of the problem following the response are not included. The complete test provided 59 protocols per subject.

Development of Information Processing Codes For Diagnostic Purposes

Once each subject's taped protocols had been transcribed, the response time for each question was noted, the answers were scored right or wrong, and the verbal protocol for each answer was segmented so that the researcher could trace the steps taken in the thinking process to arrive at the answer. Segments were identified as dealing with (1) domain specific declarative knowledge; (2) domain specific procedural knowledge; (3) the recall of newly-acquired information, i.e. material given in the associated text or in the question itself; (4) problem identification; (5) problem representation; (6) problem solving strategies; and (7) responses reflecting automatic processing. The researcher looked for information processing similarities and contrasts by comparing the protocols of incorrect responses on the same question across subjects and then by comparing the protocols of correct responses on the same question across subjects. A large sample of protocols (n = 1740) out of the total 2,832 protocols were used to identify and define distinct information processing codes for analysis of verbal protocols obtained during reading and mathematics problem solving. The first 1,740 protocols (58 problems x 30 subjects) which were transcribed were used. These were protocols recorded during both reading and mathematics problem solving from both diabetic and asthmatic subjects. Fourteen codes evolved for each domain (reading and mathematics) but 10 of the 14 codes identify similar information processing approaches for both domains. Full definitions for the reading codes are presented in Appendix C and for the mathematics codes in Appendix D. In order to more clearly understand the processing codes, examples of verbal protocols matching the code definitions are presented. These examples are followed by a description of the relationship of the codes to the cognitive variables identified in the research objectives.

Reading Codes

CO Correct answer only
Appears to understand the problem right away

Example: Question 8
Which of these is true of the movement of glaciers?
1) It cannot be measured
2) It occurs only in summer
3) It is fast in the winter and slow in the summer
4) The rate varies greatly

Response of Subject 31:
OK ahm
The rate varies greatly.

Variables:
Automatic processing-immediate problem identification, appropriate problem representation, good declarative and procedural knowledge base, immediate recall of previously read text.

CB Correct answer with basis for answer
Appears to understand the problem right away
Uses logical reasoning to arrive at right answer or accurately recalls content and fully explains basis for answer.

Example: Question 10
Which of these is most like the "writing of glaciers in the history of the earth"?
1) The minerals taken from mines deep under the earth
2) The remains of ancient plants and animals in rock formations
3) The hieroglyphic writings of the Egyptians
4) The writings of historians of ancient Greece

Response of Subject 30:
OK I'd say its number 2
The remains of ancient plants and animals in rock formations
Its like the glacier could form over an animal in a rock
Its sort of like it pushes in
I learned in science class, pressure forms in pushing down

The animal dies and the bones leave a mark
Like what the animal was like
Like a fossil.

Variables:
Appropriate problem identification and problem representation, good declarative and procedural knowledge, effective problem solving strategies.

CNB Correct answer not based on text
Appears to understand the problem
May respond by eliminating answers
or by reasoning not based on information
in the text

Example: Question 2
Which of these is not a name for a type of glacier?
1) Alps 3) Piedmont
2) Continental 4) Valley

Response of Subject 42:
I think it would be number 1
The Alps
Because the Alps is a place and I don't really see
how you could
Well they may do it
But I don't see why they would name just a special
type of glacier for a special area.

Variables:
Appropriate problem identification and problem representation, relevant information from previously presented text not retrieved, response based on previously stored related declarative and procedural knowledge.

INB Incorrect answer not based on text
Appears to understand the problem
Does not remember or retrieve content from the text
accurately or at all
May choose the "best" answer

Example: Question 1
Why are scientists especially interested in glaciers?
1) Glaciers are very rare
2) Glaciers are disappearing from the earth

3) An understanding of glaciers may reveal important facts about the history of the earth
4) The reasons for the movement of glaciers has long been a complete puzzle to scientists

<u>Response of Subject 27:</u>
OK I don't think they said anything about glaciers being rare
Disappearing from the earth like dinosaurs
An understanding of glaciers may reveal important facts about the history of the earth
The reasons for the movement of glaciers has long been a complete puzzle to scientists
They said quite a bit about that
Probably number 4 I think.

<u>Variables:</u>
Appropriate problem identification and problem representation, does not accurately retrieve information from previously presented text, response is not based on previously stored declarative or procedural knowledge, problem solving strategy appears to be guessing, does not return to the text to check the response.

CWK Correct answer but demonstrates weak domain specific knowledge
Appears to understand the problem
May not use all the information given in the question or may reason illogically or superficially

<u>Example:</u> <u>Question 11</u>
Which of these is important in the movement of all glaciers?
1) changing weather
2) width of valleys
3) nearness to water
4) location of snow line

<u>Response of Subject 36:</u>
OK ah I think it would be number 1
The changing weather because when the sun
When it's sunny in the night and cold in the evening
it heatens and ah refreezes and
It makes it go faster

Variables:
Appropriate problem identification and problem representation, weak problem specific declarative and procedural knowledge, does not base response on recall of information from previously presented text, problem solving strategy illogical, does not return to the text to check response.

IWK Incorrect answer - demonstrates weak domain specific knowledge
Appears to understand the problem
May not use all the information given in the question or may reason illogically or superficially

Example: Question 8
Which of these is true of the movement of glaciers
1) It cannot be measured
2) It occurs only in summer
3) It is fast in the summer and slow in the summer
4) The rate varies greatly

Response of Subject 1:
Ahm it cannot be measured
Well that's false 'cause it can be measured
It occurs only in the summer
Ah, I think if it can move it can move anytime
Ah it is fast in the winter and slow in the summer
Ah I think it would be number 3
Ah it could probably move faster in its own climate
Its own natural climate then a different one to it

Variables:
Appropriate problem identification and problem representation, weak problem specific declarative and procedural knowledge, does not base response on recall of information from previously presented text, problem solving strategy illogical, does not return to the text to check response.

CDR Correct answer but difficulty with problem representation
May not understand the problem fully
Domain specific knowledge weak

Example: Question 10
Which of these is most like the "writing of glaciers in the history of the earth"?

1) The minerals taken from mines deep under the earth
2) The remains of ancient plants and animals in rock formations
3) The hieroglyphic writings of the Egyptians
4) The writings of historians of ancient Greece

Response of Subject 17:
I don't understand that question
Which of these is most like the writings of glaciers in the history of the earth
Researcher: What do you think it means?
Subject: Uhm...information...facts...about scientists...moving bodies of ice that begin as heavy snowfall in areas of perpetual snow and intense cold...well I think 'cause it says here it says a huge boulder unlike others tells the scientist that a glacier has carried it there I'd have to say its number 2...the remains of ancient plants and animals in rock formations. Because it says others are the earth, pebbles, the broken stone and the rocks left behind as the glacier melted.
The debris is left in patterns that show the direction of the glacier's movement..

Variables:
Difficulty with problem identification and problem representation, problem specific declarative and procedural knowledge weak, does return to the text to check recently acquired information, problem solving strategies weak.

IDR Incorrect answer - has difficulty with problem representation
May not understand the problem fully
Domain specific knowledge weak

Example: Question 27
What does the closing phrase "put your best foot forward" mean?
1) Make a good appearance
2) Favour your strongest foot
3) Show off your new shoes
4) Wear the best shoes money can buy

Response of subject 22
Favour your strongest foot
'Cause the other one doesn't like
I mean if they're going to be outshone
And maybe indicate too much weight.

Variables:
Difficulty with problem identification and problem representation, problem specific declarative and procedural knowledge weak, problem solving strategy weak.

UPR Unable to form a problem representation
Abandons the problem or seeks help

Example: Question 10
Which of these is most like the "writing of glaciers in the history of the earth"?
1) The minerals taken from mines deep under the earth
2) The remains of ancient plants and animals in rock formations
3) The hieroglyphic writings of ancient Greece

Response of Subject 14:
Um..I don't quite get that question..
Well its obvious that..
I'm trying to figure out uhm..what it means
I don't know...I (goes on to the next question)

Variables:
Unable to identify the problem, unable to form a problem representation, problem specific declarative and procedural knowledge not available, relevant information from previously presented text not identified for recall, non-use of problem solving strategies.

CE Correct answer but elaborates the story content, the question or the answer

Example: Question 1
Why are scientists interested in glaciers?
1) Glaciers are very rare
2) Glaciers are disappearing from the earth
3) An understanding of glaciers may reveal important facts about the history of the earth
4) The reasons for the movement of glaciers has long been a complete puzzle to scientists

Response of Subject 9:
It might be number 3 because
They don't really know...how...the...earth began...Like
there are really two different stories
So I'd probably say number 3.

Variables:
Appropriate problem identification, problem representation not entirely appropriate, associated declarative and procedural knowledge employed, effective problem solving.

IE Incorrect answer - elaborates the story content the question or the answer

Example: Question 16
Why had Sonia offered to push Brian's wheelchair?
1) Brian couldn't handle a wheelchair at all
2) Sonia wanted to tell Brian all about the birds
3) Sonia wanted to do a good deed
4) Sonia wanted to get some fresh air and exercise

Response of Subject 6:
The answer I found is a little bit different than
these ones because the answer in there is that she
felt sorry for him 'cause Brian couldn't handle a
wheelchair at all..is the one I'm going to pick
'Cause Brian had cerebral palsy and when you have
that disease you shake a lot of the time..your hands
and whatever parts of your body.

Variables:
Appropriate problem identification and problem representation, associated declarative and procedural knowledge employed, effective problem solving, aware that response is incorrect.

CW Correct answer but had to work at understanding or solving the problem

Example: Question 1
Why are scientists especially interested in glaciers?
1) Glaciers are very rare
2) Glaciers are disappearing from the earth
3) An understanding of glaciers may reveal important facts about the history of the earth
4) The reasons for the movement of glaciers has long been a puzzle to scientists

Response of Subject 31:
If I read the first paragraph
Ah ahm
Well ahm
I can't scrape anything from paragraph 1 that could be an answer..but maybe paragraph 2...
Uhm hm
If I reread the story
I think
I reread the story and I think one of the answers to why are scientists especially interested in glaciers would be number 3
An understanding of glaciers may reveal important facts about the history of the earth
Because ah a part in paragraph 4
It is because ah
By such marks scientists know that in the last Ice Age 10,000 years ago
Just because of some of the glaciers they found out when the last Ice Age was..
By the marks of the glaciers
Maybe that was the answer.
(186 seconds for response.)

Variables:
Appropriate problem identification and problem representation, recall of recently presented information poor, problem solving strategy inefficient but effective, problem specific declarative and procedural knowledge weak.

IW Incorrect answer but worked diligently at understanding or solving the problem

Example: Question 6
Which of these phrases tells best how continental glaciers differ from piedmont or valley glaciers?
1) Faster melting 3) Faster in motion
2) More extensive 4) More common

Response of Subject 14:
Um (40 seconds of silence)
I'm not sure..I have to read it again
Oh the shape of the glaciers
Because it mentioned how big they were.
(94 seconds for response)

Variables:
Appears to understand problem (problem identification) and to form appropriate representation, does not recall recently presented information, problem specific declarative and procedural knowledge weak, problem solving strategy ineffective.

SP Skipped the problem without attempting it

Variables:
Not addressed.

Mathematics Codes

CO Correct answer only
Appears to understand the problem right away

Example: Question 51
The watermelon Sam selected had a mass of 8 kg. How much did the watermelon cost? (20 1/2 cents/kg.)

1) 82 cents	3) \$1:64
2) \$1.60	4) (Not Given)

Response of Subject 10:
\$1.64

Variables:
Immediate problem identification, appropriate problem representation, good declarative and procedural knowledge, automatic processing.

CB Correct answer with basis for answer
Appears to understand the problem right away
Demonstrates domain specific knowledge
Procedural strategy efficient

Example: Question 41
The average of 3 numbers is 8. Two of the numbers are 11 and 9. What is the other number?
1) 3 2) 4 3) 8 4) 10

Response of Subject 12:
Oh OK 11 and 9.....20
I have 20
Something divided by 3 is 8
24
Is 4 there?
Yes number 2'

Variables:
Appropriate problem identification and problem representation, good declarative and procedural knowledge, effective and efficient problem solving strategy, checks to see if answer is one of the given responses.

CWK Correct answer but demonstrates weak domain specific knowledge
Appears to understand the problem
May not use all the information given in the question or may reason illogically or superficially

Example: Question 47
In the diagram below which angle has a measure of about 60 degrees?
1) AOD 3) DOC
2) AOC 4) BOC

Response of Subject 2:
DOC
Because AOD is 90 degrees angle...
AOC is a ...
AOC could be the answer 'cause it seems right..and DOC would be higher than 90 degrees..and BOC is a 90 degrees angle
Oh no it isn't
Its ah
Um AOC could have possibly be 60 because its higher than 90 and BOC is the right answer.

Variables:
Appropriate problem identification, problem specific declarative and procedural knowledge weak, poor problem representation, problem solving strategy weak because domain specific knowledge is poor.

IWK Incorrect answer - demonstrates weak domain specific knowledge
Appears to understand the problem
May not use all the information given in the question or may reason illogically or superficially

Example: Question 44
The scale on a map of Canada is 1 cm = 300 km. Bill's hometown is approximately 2.67 cm from Sudbury. About how far does Bill live from Sudbury?

1) 900 km   3) 600 km
2) 800 km.   4) 200 km

<u>Response of Subject 6:</u>
600 km 'cause it says right here 1 cm is 300 km and it says approximately he lives 2.67 cm
2 cm = 600 so

<u>Variables:</u>
Appropriate problem identification, problem representation and problem specific declarative knowledge but weak procedural knowledge, does not check response by doing multiplication on paper.

CEA Correct answer by eliminating answers
Appears to understand the problem but arrives at answer through elimination of incorrect responses.

<u>Example:</u> <u>Question 36</u>
Below is the picture of a time clock at a factory. The clock has only one hand which takes 8 h to go around once. If the hand starts at 0 where would it be after 15 h?
1) 0   3) 5
2) 3   4) 7

<u>Response of Subject 11:</u>
It wouldn't be 0
And it wouldn't be 3 or 5
So it would be 7.

<u>Variables:</u>
Appropriate problem identification and problem representation, problem solving strategy inefficient but effective because problem specific declarative and procedural knowledge appropriate.

IEA Incorrect answer by eliminating answers
Appears to understand the problem
Eliminates the answers to arrive at the response which is incorrect

<u>Example:</u> <u>Question 43</u>
Which number sentence below is false?
1) 3/6 > 2/3   3) 1/5 > 1/6
2) 1/2 < 3/4   4) 3/6 = 6/12

Response of Subject 2:
3/6 is higher than 2/3..it's true
1/2 is lower than 3/4 hm...
yea it's lower
1/5 is lower than 1/6 so..
is higher than 1/6
No it isn't
And 3/6 is equal to 6/12
So 3 is false.

Variables:
Appropriate problem identification and problem representation, problem solving strategy ineffective because problem specific declarative and procedural knowledge weak.

CCE Correct answer but makes calculation error
Appears to understand the problem

Example: Question 57
About what part of all material shipped in 1965 was oil?

1) one-fifth 3) one-third
2) one-fourth 4) one-half

Response of Subject 4:
Ah I'm thinking....
I'm just looking at the oil diagram and how much oil there is and then bring it down to one of these
Ah I think it is one-half because the oil in 1965
There are 12 lines here and 12 lines up here so that is one-half (The correct count is 11 million tonnes of oil and 12 of other products).

Variables:
Appropriate problem identification and problem representation, good declarative and procedural knowledge, problem solving strategy efficient but answer incorrect because of error in counting which was not found because the answer was not checked.

ICE Incorrect answer because of calculation error
Appears to understand the problem

Example: Question 49
The class printed 360 copies of the first issue, 400 copies of the second issue and 425 copies of the third issue. What was the increase in the number of copies from the first to the third issue?

1) 65 3) 40
2) 60 4) (Not Given)

Response of Subject 43:
Not Given
400 take away 360 or I mean
Like I went...it's hard to explain
Like there's 30, 30 more made 400
And that's 25
So I got for my answer 45

Variables:
Appropriate problem identification, inadequate problem representaiton, declarative and procedural knowledge weak, problem solving strategy inadequate, does not check response.

CDR Correct answer but difficulty with problem representation
May not understand the problem fully
Domain specific knowledge weak

Example: Question 45
In drawing below, line segments AB and CD are parallel. What is the length of line segment CD?

1) 1.5 cm 3) 3 cm
2) 2 cm 4) 4 cm

Response of Subject 3:
2 cm
This line (points to DO) is a little bit bigger than that one (CD).

Variables:
Inappropriate problem identification and problem representation, declarative and procedural knowledge weak, problem solving strategy leads to correct response by chance.

IDR Incorrect answer - has difficulty with problem representation
May not understand the question fully
Domain specific knowledge weak

<u>Example:</u> <u>Question</u> <u>36</u>
Below is the picture of a time clock at a factory. The clock has only one hand which takes 8 h to go around once. If the hand starts at 0 where would it be after 15 h?
1) 0 3) 5
2) 3 4) 7

<u>Response</u> <u>of</u> <u>Subject</u> <u>34:</u>
12
OK 13 14 15
It would be 3 o'clock in the morning or afternoon
It would be number 3 .

<u>Variables:</u>
Appropriate problem identification, inappropriate problem representation, declarative and procedural knowledge weak.

UPR Unable to form a problem representation
Abandons the problem or seeks help

<u>Example:</u> <u>Question</u> <u>64</u>
In Aztec what use is made of the land with the least annual precipitation?
1) Mining 3) Raising hogs
2) Grazing 4) Growing lumber
(requires the use of 3 maps)

<u>Response</u> <u>of</u> <u>Subject</u> <u>4:</u>
I'm looking at the question and at precipitation to see which has the least numbers...I think it is ah... I think its
Researcher: Where are you looking?
(Subject points to right area on precipitation map but uncertain about where to go from there and decides to leave the problem after 267 seconds.)

<u>Variables:</u>
Incomplete problem identification, unable to form problem representation, declarative and procedural knowledge weak.

CW Correct answer but had to work at understanding or solving the problem

Example: Question 38

Mr. and Mrs. King bought a 2-year fire insurance policy on the house with $40,000 of coverage. The 2-year rate was 1.75 times the annual rate of $4.00 per $1,000. What did the insurance cost for 2 years?

1) $160 3) $320
2) $280 4) (Not Given)

Response of Subject 37:

Well, the total insurance is..$40,000
And 2 year rate is...1.75
One year...2 year rate times
Two year rate...1.75 times annual rate of $4.00 per $1,000
1.75 times...$4.00 per $1,000
So, 40,000, so that'd be 40,000 times 4
16,000
Wait a minute (quiet computations and rereads problem slowly)
I'm trying to figure out how much they have to pay on the
Trying to figure out the total cost
What took uh..the total coverage times the $4.00 per $1,000
For every $1,000...and then I'm trying to
Don't know if this is going to work
Times it by 1.75...see what I come up with (quiet computations)
Won't work
I'm trying to figure out...to work it out
Hm Um try 40,000 divided by $4.00 per $1,000
That'd still be 40,000 so that'd be 40,000 divided by 4..hm and that should be divided by 1.75
Think that will work (more computations)
(sighs)
I can't take the next...40,000 year..rate was 1.75..Is that..that's the interest rates?
Trying 40,000 times 1.75
Oh I think I have it..
OK its 40,000....$40,000...
So 40 times 4 equals 160
So 160 times 1.75 (computations)
That's..OK it's number 2...280
(heaves a sigh of relief - has stayed with the problem for 914 seconds)

Variables:
Appropriate problem identification, some difficulty with representation, declarative and procedural knowledge. Adequate, problem solving strategy trial and error. Therefore inefficient but is persistent and monitors response.

IW Incorrect answer but worked diligently at understanding or solving the question

Example: Question 38
Mr. and Mrs. King bought a 2 year fire insurance policy on the house with $40,000 of coverage. The 2 year rate was 1.75 times the annual rate of $4.00 per 1,000. What did the insurance cost for 2 years?
1) $160 3) $320
2) $280 4) (Not Given)

Response of Subject 38:
Two year fire insurance policy
The two year rate was...times the annual rate for $1,000
4 times 40,000...no
4 times 40
$4.00...be 40
4 times 4....$80....$1.60...160.....360
That'd be for
And that'd be for 2 years so that would make 2 times 2...3...OK now what do I do next?
$40,000 of coverage
Two year rate was 1.75 times the annual rate
1.75 was the annual rate
Multiply it by 1.75...I think
Hm
Oh so it'd be more than that
Something like
It's 1.75 times this
Then it would be number 4...Not Given.
OK

Variables:
Appropriate problem identification, faulty problem representation, declarative and procedural knowledge weak, problem solving strategy inefficient and ineffective.

SP Skipped the problem without attempting to do it

Variables:
Not addressed.

The correct answer only, or CO codes, for both reading and mathematics, indicate automatic processing which occurs if there is immediate problem identification, appropriate problem representation, and a good declarative and procedural knowledge base. The CB codes for both reading and mathematics indicate that the subject displayed good declarative and procedural knowledge, had no difficulty with problem identification or representation, accurately recalled new information, and used efficient and effective problem solving strategies. The reading codes CNB and INB indicate that the subject either did not retain or could not retrieve information from the previously presented text. Those who answered the question correctly relied on previously stored related knowledge or were lucky guessers.

CWK and IWK codes for both reading and mathematics signify weak declarative and procedural knowledge. There is no evidence of depth of processing and problem solving strategies are inefficient. The mathematics' CEA and IEA codes represent responses arrived at by working through the given answers and eliminating all but one of the given answers. This problem solving strategy was infrequently found in the reading responses. The other set of codes specific to mathematics, CCE and ICE, reflect mainly on the individual's performance and ability to monitor and use feedback, since responses reflect an adequate knowledge base and appropriate problem solving strategies. The CE and IE reading codes represent responses which indicate that the problem stimulated several associated knowledge structures in long term memory and this sometimes defocused the end goal, therefore interfering with problem representation.

The codes which relate to problem representation are the same for reading and mathematics. CDR and IDR codes represent responses which indicate that the subject did not have a rich store of domain specific knowledge which would help with problem identification and the formation of an appropriate problem representation. Correct responses seem accidental rather than rational. UPR codes represent a struggle to understand the problem, an inability to form a problem representation and finally abandonment of the problem. Such responses indicate the subject has not been able to extract critical features from the problem statement, or does not have or cannot access related knowledge stores in order to form a problem representation. The CW and IW codes for both reading and mathematics demonstrate motivation and determination. These codes are indicative of lengthy response times during which subjects experiment with different problem representations and different strategies. Finally, the SP codes represent unattempted problems.

When the 2,784 reading and mathematics protocols (58 problems x 48 subjects) had been coded, the researcher put the coded protocols aside for two weeks and then with only the definitions at hand, recoded 50% (1,392) of the protocols. Twenty-one protocols were recoded differently, therefore 98.49% of the codes were in agreement with the previous coding. Intercoder agreement was then sought by presenting a total of 50 randomly selected protocols to four school teachers along with the written information processing code definitions. Each teacher received a brief orientation to the coding system. Intercoder agreement between the researcher and each teacher ranged from .77 to .92.

Data Analysis:

The Statistical Analysis System was used for the preliminary analysis of data. The following information was entered into the data file for each subject: the sex and group to which the subject belongs; the grade level; whether the subject had been absent 10 days or less, or 11 days or more over the past six school semesters; and the processing code and response time for each question. The numerical symbol for each processing code also identified correct and incorrect answers.

The number of correct responses and the response times in reading and mathematics were determined for each individual and subsequently for each group. The means and standard deviations of the reading scores, mathematics scores, reading response times and mathematics response times for all eight groups were computed. The frequencies of codes for each set of skill objectives were determined according to the sex/group and the grade level. The frequencies of codes for responses to questions answered by both grades were determined according to sex/group, grade, and absenteeism. For each set of skill objectives and questions responded to by both grades, the percentage of occurrences of code frequencies was determined by dividing the code frequencies by the number of observations, for example, the 31 common mathematics questions would provide 31 times 6 (individuals per sex/group) or 186 observations. Finding the percentage of occurrences of code frequencies facilitated the identification of processing patterns and processing problems..

The Mann-Whitney U Test was used to decide whether there was a significant difference between the means of the groups on reading scores, mathematics scores and response times. Significance of the U Statistic was determined by reference to the Table of Critical Values for the Mann- Whitney U Statistic (Owen, 1962).

The verbal protocols for the "plan your day" question were examined in terms of each subject's problem identification; problem representation; procedural strategies; use of the subject's experiential knowledge base with regard to time allocation, time-event relationships, and the meeting of personal needs.

CHAPTER 3

PRESENTATION OF RESULTS

Background Information

The children who participated in this study were between the ages of 12 and 14. This age range corresponds to the average chronological ages of Canadian children in grades seven and eight for whom test levels 13 and 14 of the Canadian Tests Of Basic Skills, Form 6 were designed. The age range of the grade seven and grade eight Chronic Asthmatic and Insulin Dependent Diabetic children in this study is therefore in keeping with the average chronological age of Canadian children in grades seven and eight.

Although the parents' school leaving level ranged from non-completion of elementary school to university graduation, 39.58% of the children had at least one parent with a university education. Across the eight groups, five out of eight of the highest scores in reading and five out of eight of the highest scores in mathematics were obtained by subjects who had at least one university educated parent. However, taking tie scores into consideration, seven individuals who had at least one parent with a university education received the highest scores in reading as did five individuals whose parents did not have a university education. Six individuals with university educated parents and four individuals whose parents did not have a university education received the highest scores in mathematics. In contrast, six out of eight of the lowest scores in reading and seven out of eight of the lowest scores in mathematics were held by subjects whose parents did not have a university education. Again taking tie scores into consideration, eight individuals whose parents did not have a university education and three individuals whose parents did have a university education received the lowest scores in reading. Pless (1983) stated that chronically ill children's academic success is positively correlated with their parent's educational achievement level. The fact that more children whose parents have a higher education do well than do poorly would tend to support this statement.

In order to help establish rapport between the researcher and the subject before the verbal protocols were recorded, each subject answered academic interest and achievement questions. The academic subject most frequently identified as best liked was science and least liked was mathematics. The subject in which the best marks were most frequently obtained was language arts, and the one in which the lowest marks were most frequently obtained was mathematics. In response to the question " What job or career would you like to have when you finish school?", 64.58% of the subjects responded with definite career goals, indicating that chronically ill children do make future career plans and consider themselves to be capable individuals.

Scores And Response Times

Individual scores and response times for the reading and mathematics questions are presented in Appendix E for Insulin Dependent Diabetic subjects and in Appendix F for Chronic Asthmatic subjects. The means and standard deviations of the scores and response times are given in Appendix G, Table G-1, and the Mann-Whitney U statistics for the between group differences for each grade level are available in Appendix G, Table G-2.

Significant differences at the $\alpha = 0.05$ level were found 1) between mean reading scores of grade seven male and female diabetic subjects; 2) between mean mathematics response times of grade seven female diabetic and female asthmatic subjects; 3) between mean mathematics scores of grade eight male diabetic and female diabetic subjects; 4) between mean mathematics scores of grade eight male and female asthmatic subjects and 5) between mean mathematics response times of grade eight male diabetic and male asthmatic subjects.

There were major group differences in variances for scores and response times, with the grade seven and grade eight male diabetics consistently having the larger variance for response time measurements. Although the grade seven female diabetics had significantly higher reading scores than the grade seven male diabetics, both groups had four out of six individuals who scored below their respective group mean. Their mean reading response times were almost the same (789.00 and 789.50 seconds). One-half of the females had reading scores below 17.16 and took longer than 789.0 seconds to respond, whereas one-half of the males had reading scores below 13.16 but took less than 789.50 seconds to respond. The males appear to have taken a less reflective approach to problem solving.

The grade seven female asthmatics took significantly longer to answer the mathematics problems than did the female diabetics. Four female diabetics had scores above the group mean of 23.33 and response times above the group mean of 1659.00 seconds whereas only two female asthmatics had scores above their group mean of 20.00 and above their group mean response time of 2537.17 seconds. The mean mathematics response time for the female diabetics was 65.38% less than the mean mathematics response time for the female asthmatics.

The grade eight male diabetics had significantly better mathematics scores than the female diabetics.

The mean mathematics score was 18.66 for the females and 24.66 for the males and the mean response time for the females was 2027.16 and for the males 1555.00. Four out of six of the females obtained mathematics scores which were below the mean score for their group. Grade eight male asthmatics also had significantly better mathematics scores than did their female counterparts. The mean score for the females was 16.33 and for the males 25.83. Their respective mean response times were 1878.16 and 2212.83 seconds. One-half of the females, but only one of the males, had scores below their respective mean mathematics scores. Four out of six of the males obtained above mean scores but took longer than the group mean time to respond. One-half of the females took less than the group mean time to respond. The score means for grade eight male diabetics and grade eight male asthmatics were similar but there was a significant difference in mathematics response times. The male asthmatics had a mean response time of 2212.83 seconds whereas the male diabetics had a mean response time of only 1555.00 seconds.

Because each group consists of only six

subjects, the major value in identifying significant group differences lies in the comparison of information processing patterns between the groups. In order to identify and thus understand the differences in the subjects' problem solving abilities, an information processing analysis of the subjects' verbal protocols in response to the reading and mathematics questions is presented according to the skill objectives addressed by the questions.

The percentage of correct responses by the children in this study across the various skill objectives can be roughly compared to the percentage of correct answers to the same items by children nationally. All of the test items of the Canadian Tests of Basic Skills have item norms. These norms are adjusted estimates of the per cent of students nationally who answered each item correctly. Item norms are available for the fall, midyear, and spring school terms. Because the children in this study responded to the test items under different conditions (e.g. verbal protocols were recorded and there were no time restrictions), and because the testing of subjects took several months to complete, the norms are used only as indicators of item difficulty. It is useful to compare the subjects' declarative and procedural knowledge base to that of Canadian children at the same grade level even though the subjects have an advantage because they are not time limited and because they are thinking aloud (Dansereau & Gregg, 1966; Hafner,1957; Tell, 1971). Both the fall and midyear norms are referred to because the testing of the subjects extended over this period of time.

READING COMPREHENSION

Three skill objectives are addressed in the reading comprehension section of the test. Information processing code frequencies and percentage occurrences of the codes for each skill objective are presented in Appendix H, Table H - 1 to Table H - 3. Grade seven and grade eight subjects both answered the first 15 questions of the reading test and Table H - 4 presents the information processing code frequencies and percentage occurrences across the eight groups. The results will be presented by skill objectives and the discussion plus a summary table will follow the presentation of all results.

Recognizing And Understanding Factual Information

As indicated in Appendix H, Table H-1, the grade seven female asthmatics had the most difficulty recognizing and understanding factual information. Even though they answered only 47% of the questions correctly, they exceeded the midyear norm (44.66) for grade seven Canadian children on these items. The only group to fall below the norms for both the fall (51.50) and midyear (56.50) terms was the grade eight female asthmatic group whose responses were only 50% correct. The high scorers were the grade eight male asthmatics who correctly answered 71% of the questions. The most frequent reason for incorrect responses across all eight groups was an inability to remember or retrieve content from the text accurately, or at all. This was evident in 35% of the responses of the grade eight female asthmatics. The second most common reason for error for the grade seven male and female diabetics was difficulty understanding the question. For all other groups the second most common reason for error was not using all the information in the question or reasoning illogically or superficially.

Differences in information processing patterns which contributed to the significant difference in reading scores between the male and female grade seven diabetics can be identified from Table H-1. By adding the percentage of responses that were coded correct answer only and the answers coded correct with an accurate and comprehensive explanation (CO + CB), the percentage of responses reflecting good declarative and procedural knowledge can be obtained. Thirty-one percent of the grade seven male diabetics' and 47% of the female diabetics' responses demonstrated good declarative and procedural knowledge. Twenty-eight percent of the responses of the grade seven male diabetics and 19% of the responses of the grade seven female diabetics were incorrect because the subjects could not remember or retrieve the content from the text accurately. Grade seven male diabetics also had slightly more difficulty with problem representation (17% as compared to 11% for the female diabetics).

Information processing patterns contributing to a high percentage of correct answers can be examined by looking at the processing patterns of the grade eight male asthmatics who answered 71% of the questions correctly. The grade eight male asthmatics were the only group whose best score across the reading skill objectives was in recognizing and understanding factual information. Fifty-six percent of the responses demonstrate good declarative and procedural knowledge. However, 13% of the correct responses were arrived at by eliminating answers or by reasoning not based on the text and therefore drawing on a previously stored knowledge base. The remaining 2% of the correct responses were correct in spite of illogical or superficial reasoning or disregarding information given in the question.

The grade seven female asthmatics who scored most poorly on these questions had an equal amount of difficulty with problem representation (14%), not using all the given information in the question or reasoning illogically or superficially (14%), and failing to remember or retrieve information from the text (14%). Forty-seven percent of their responses were correct and 42% of these responses demonstrated good declarative and procedural knowledge.

Making Generalizations

From Table H - 2 it can be seen that the grade seven female asthmatics did considerably better at making generalizations than they did at recognizing and understanding factual information (74% correct as compared to 47%). Female diabetics were much better at making generalizations than the grade seven male diabetics which also contributed to the significant difference in reading scores between these two groups. The females answered 80% of the questions correctly whereas the males answered only 54% correctly. Good declarative and procedural knowledge was evident in 72% of the responses by the grade seven diabetic females but in only 44% of the responses of the males in this group. Thirty-seven percent of the responses of the grade seven male diabetics were incorrect because the subjects did not remember or retrieve the content from the text accurately but only 11% of the answers of the females were incorrect for this reason. All four grade eight groups reasoned illogically or superficially or did not use all the information given in the question in 17 to 18% of their answers.

Although no significant differences in overall reading scores were found between groups other than the grade seven male and female diabetics the different information processing patterns across the eight groups are clearly evident in Table H - 2. The groups who had the most difficulty making generalizations were the grade eight female asthmatics, the grade seven male diabetics and the grade eight female diabetics. The percentage of occurrences vary but the information processing patterns contributing to incorrect responses are similar. The majority of incorrect responses were made because of an inability to remember or retrieve information from the text accurately, because of illogical or superficial reasoning, or because of difficulty with problem representation.

One-half of the groups, the grade seven female diabetics, male asthmatics and female asthmatics and the grade eight male diabetics, received their highest reading scores on this skill objective. All grade seven groups scored above the fall norm of 53.22 and the midyear norm of 58.44 on these items. All grade eight groups scored above the fall norm of 50.63, but only the male diabetics scored above the midyear norms.

Inferring Underlying Relationships

The three groups who had difficulty making generalizations (the grade seven male diabetics, the grade eight female diabetics, and the grade eight female asthmatics) received their highest reading scores on this skill objective. The grade seven female diabetics had the highest percentage of correct responses (79%) and 75% of their responses reflected good declarative and procedural knowledge. The grade seven male diabetics had 65% of their responses correct and 50% reflected good declarative and procedural knowledge.

The grade eight subjects had between 23 and 27% of their responses incorrect because they reasoned illogically or superficially, whereas the grade seven subjects had between 8 and 13% of their answers incorrect for the same reason. Out of the 5 inference questions for grade eight and the 8 inference questions for grade seven, the two groups answered 4 questions in common. The major reason for incorrect responses (8 to 17%) in the grade seven groups was an inability to remember or retrieve information from the text accurately. The grade eight subjects also experienced this difficulty in 7 to 13% of their responses. Subjects who cannot remember or retrieve information from the text accurately do not have an accurate base of knowledge from which to make inferences.

Table H - 3 demonstrates the variety of information patterns used by the eight groups, for example, eleven different information processing codes were identified for grade seven male diabetics' responses but only five for the grade eight male diabetics. The answers of the grade eight males were incorrect either because they could not remember or retrieve information from the text, or because they did not use all the information in the question or reasoned illogically or superficially. The percentage of correct responses for all eight groups was well above the midyear norms of 57.38 for grade seven and 52.60 for grade eight for these test items.

Questions 1 - 15 Answered By All Groups

Questions common to all groups provided an opportunity to compare information processing strengths and weaknesses across the two grade levels. The expectation was that the grade eight subjects would find the questions easier and therefore respond differently than the grade seven subjects. Table H - 4 indicates that this was not the case. The highest percentage of correct responses (68%) was made by the grade seven female diabetics. The grade eight female diabetics had only 57% of the answers correct. The major reason for difficulty in all groups was an inability to remember or retrieve information from the text accurately or at all. The extent to which groups experienced this difficulty ranged from 17% to 31% of the responses. Differences in the percentage of responses demonstrating good declarative and procedural knowledge (CO + CB) also varied across the groups rather than being consistently higher for the grade eight subjects. All grade seven and grade eight groups scored above the midyear norms for their grade level with the exception of the grade eight female diabetics who scored below the midyear norm but above the fall norm for grade eight students nationally.

Appendix H, Tables 1 - 4 provide a detailed analysis of each group's problem solving approaches to the questions within each set of skill objectives and for the common reading questions. Both the information processing patterns which resulted in correct answers and those which resulted in incorrect answers are given. In order to make comparisons across the skill objectives, Table 1 summarizes the percentage of correct answers, the percentage of answers ~~demonstrating~~ integrated declarative and procedural knowledge, and the major reasons for difficulty across all skill objectives and across the questions answered by all groups.

Table 1

Information Processing Patterns: Reading

Group	Grade	% Correct	% CO & CS	Major Reasons For Difficulty		
Skill Objective: Recognizing And Understanding Factual Information						
MD	7	53	31	INB (28)	IDR (17)	IWK (3)
FD	7	61	47	INB (19)	IDR (11)	IWK (6)
MA	7	50	44	INB (19)	IWK (19)	IDR (8)
FA	7	47	42	INB (14)	IWK (14)	IDR (14)
MD	8	54	52	INB (38)	IWK (4)	
FD	8	56	40	INB (29)	IWK (6)	IW (4)
MA	8	71	56	INB (19)	IWK (8)	
FA	8	50	33	INB (35)	IWK (8)	IDR (6)
Skill Objective: Making Generalizations						
MD	7	54	44	INB (37)	IDR (6)	IWK (4)
FD	7	80	72	INB (11)	IWK (6)	IDR (4)
MA	7	76	61	INB (11)	IDR (7)	IWK (4)
FA	7	74	52	INB (15)	IWK (6)	
MD	8	68	67	IWK (20)	INB (11)	
FD	8	55	50	IWK (20)	INB (15)	IDR (6)
MA	8	58	53	INB (20)	IWK (19)	IDR (5)
FA	8	52	45	INB (21)	IWK (21)	IDR (5)
Skill Objective: Inferring Underlying Relationships						
MD	7	65	50	INB (13)	IWK (13)	IDR (4)
FD	7	79	75	INB (8)	IWK (8)	
MA	7	71	52	INB (17)	IWK (10)	
FA	7	69	52	INB (17)	IWK (10)	
MD	8	60	57	IWK (27)	INB (13)	
FD	8	63	57	IWK (23)	INB (7)	
MA	8	60	47	IWK (23)	INB (10)	IDR (7)
FA	8	60	47	IWK (27)	INB (13)	
Questions 1 - 15						
MD	7	51	33	INB (31)	IDR (9)	IWK (9)
FD	7	68	58	INB (17)	IWK (9)	IDR (6)
MA	7	58	50	INB (18)	IWK (13)	IDR (8)
FA	7	59	47	INB (18)	IWK (11)	IDR (9)
MD	8	57	64	INB (21)	IWK (9)	
FD	8	57	48	INB (23)	IWK (11)	IDR (6)
MA	8	64	53	INB (17)	IWK (13)	IDR (6)
FA	8	62	39	INB (31)	IWK (13)	IDR (3)

Note: For code definitions see Appendix C
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

MATHEMATICS

The mathematics questions addressed nine skill objectives. Thirty-one of the questions were answered by both the grade seven and eight subjects. Appendix I, Tables 1 - 9 present the information processing code frequencies and percentage occurrences for the skill objectives. Table I - 10 presents the analysis of the responses to the 31 questions answered by all groups.

Single Step Problems

Single step problems require the use of one of the following: addition, subtraction, multiplication, or division. The percentage of answers correct in this skill category ranged from 33% for the grade eight female asthmatics to 79% for the grade eight male diabetics. Table I - 1 identifies the strengths and weaknesses in information processing across the groups. The grade eight female asthmatics had incorrect responses because of difficulty with problem representation for 25% of the questions and were totally unable to form a problem representation for 13% of the questions. In 21% of their answers they either did not use all the information given in the question or they reasoned illogically or superficially. Difficulty with problem representation was also the most common reason for error in the grade seven female diabetic group. Incorrect answers due to calculation errors occurred in all but two groups and correct answers in spite of calculation errors occurred in four groups.

There were significant differences between the grade eight male and female diabetics and between the grade eight male and female asthmatics in the overall mathematics scores, and differences in information processing patterns for the single step problems help identify why these differences exist. The grade eight males had similar patterns in that their major reasons for difficulty were illogical or superficial reasoning and calculation error. The females also demonstrated illogical or superficial reasoning but to a much greater extent than their male peers (29%

compared to 17%, and 21% compared to 13%). A major difference between grade eight male and female asthmatics lies in the ability to appropriately represent the problem. The female asthmatics incorrectly responded to 38% of the problems because of difficulty with problem representation whereas the males had this difficulty with only 4% of the problems. All groups with the exception of the grade eight asthmatic group scored above the midyear norms for these items. The grade eight asthmatics were far below even the fall norms of 56.25.

Multiple Step Problems

Multiple step problems involved the combined use of the basic operations of addition, subtraction, multiplication and division. Analysis of the subjects' management of these problems is available in Table I - 2. There is evidence of much difficulty with problem representation. The percentage of responses which were incorrect plus the percentage of problems which were abandoned because of difficulty with problem representation across the groups are as follows: 25% for grade seven male diabetics; 42% for grade seven female diabetics; 25% for grade seven female asthmatics; 12% for grade eight male diabetics; 44% for grade eight female diabetics; 11% for grade eight male asthmatics; and 44% for grade eight female asthmatics. The grade seven male asthmatics did not have difficulty with problem representation. They responded correctly to 75% of the problems. Both the grade seven and the grade eight female groups scored below the fall norms on these items. The grade eight female diabetics correctly responded to only 39% of the problems within this skill objective and the grade eight female asthmatics to only 44% of the problems.

Number Systems

Test question 40 is an example of a problem in this category. The objective is to find the missing numeral in a number series. Table I - 3 shows that the subjects had much less difficulty with this skill objective than with the previous two. Both the grade seven female diabetics and the male asthmatics were 100% correct in their responses. Eighty-three per cent of the responses of the grade eight female asthmatics were correct, a marked difference in performance when compared to the 33% correct for single step problems and 44% correct for multiple step problems. Difficulty with problem representation led to error in 25% of the responses of grade eight female diabetics, and in 17% of the responses of both the grade seven and grade eight female asthmatics. The item norms for grade seven were 81.5 for the fall and 85.0 for midyear, and for grade eight 65.5 for the fall and 71.0 for midyear. All groups scored above the fall norms and only the grade seven male diabetics, the grade seven female asthmatics and the grade eight female diabetics scored below their respective midyear norms.

Fractions

Table I - 4 indicates that all groups to varying degrees, either did not use all the information given in the question or reasoned illogically or superficially. The declarative and procedural knowledge base necessary to accurately answer questions dealing with fractions is weak. This was the cause of error in 58% of the responses of the grade eight female asthmatics, in 50% of the responses of grade eight female diabetics , in 33% of the responses of grade seven male diabetics, grade seven female asthmatics and grade eight male diabetics, in 25% of the responses of grade seven female diabetics and grade eight male asthmatics, and in 17% of the responses of grade seven male asthmatics. An example of this type of thinking can be demonstrated in the response of subject 48, a grade eight female asthmatic, to question 43:

Which number sentence below is false?

1) 3/6 > 2/3	3) 1/5 > 1/6
2) 1/2 < 3/4	4) 3/6 = 6/12

Response: Uhm I'd say number 3... Uhm...'cause 1/5 is less than 1/6, 'cause 6 you have more pieces and 5 you have less pieces.

Also common to several of the responses which were coded within this information processing pattern was the tendency to round off numbers rather than multiply the entire number given in the question. For example, in Question 44, many subjects multiplied 2 x

300, rather than 2.67 x 300.

Three groups scored below the fall norms, the grade seven female asthmatics, the grade eight female diabetics and the grade eight female asthmatics. All other groups scored above the midyear norms. Female asthmatics in grade seven correctly answered 25% of the questions and the grade eight female asthmatics only 17% of the questions. In contrast, their male counterparts answered 75% of the questions correctly.

Operational And Relational Symbols

The one question which addressed this skill objective for both grade levels was Question 46:

> Which sign if placed in the O will make
>
> z O 1/z = 1 a true number sentence?
>
> 1) + 2) − 3) x 4) ÷

Fifty percent of the responses of the grade eight female asthmatics indicated the question was abandoned because subjects were unable to form a problem representation. This was also the case for 33% of the responses of the grade eight female diabetics, and 17% of the responses in all remaining groups. Thirty-three percent of the grade eight male diabetics and of the grade seven male asthmatics used a faulty problem representation. Thirty-three per cent of the responses of the grade seven male diabetics indicated that the subjects had worked diligently at understanding or solving the question but still did not obtain the right answer. An equal percentage of grade seven female diabetics worked diligently at understanding or solving the problem and answered the question correctly. Since problem representation is determined by the way the problem is stated and involves first a language interpretation process and then a solution construction process, the source of the problem may lie primarily in the language interpretation process. Had the Canadian Tests Of Basic Skills' asked "Which sign if placed in the circle..." subjects would not have confused the O with a numerical zero. Also, another letter for the z would have eliminated confusion with a 2, even though the question might have been easier had the subjects' perceived the z's as 2's. Table I - 5 gives a complete description of information processing patterns used in response to this question. The item norms for grade seven are 37.0 for fall and 43.0 for midyear; and for grade eight, 54.0 for fall and 60.0 for midyear. Three groups scored above the midyear norms, the grade seven female diabetics, male asthmatics and female asthmatics. Only 33% of the grade seven and eight male diabetics, grade eight female diabetics and female asthmatics responded correctly to the question.

Geometry

As indicated in Appendix I, Table I - 6, correct responses ranged from 50% of the answers to 78% of the answers. Only one group, the grade seven female asthmatics scored below the midyear norms. The grade seven female diabetics had the highest percentage of correct answers and they demonstrated good declarative and procedural knowledge in 67% of their responses. The other 11% of their correct responses revealed initial difficulty with problem representation. Incorrect answers (22%) were also a result of difficulty with problem representation which resulted in subjects' working with a faulty representation. The major reason for difficulty in all groups except the grade eight female asthmatics was difficulty with problem representation but 13% of the responses of the grade eight female asthmatics were also in this category. The grade eight female asthmatics did not even try to answer 17% of the geometry questions.

The grade seven female asthmatics, as well as having difficulty with problem representation, did not use all the information given in the problem or reasoned illogically or superficially thus reflecting weak declarative and procedural knowledge in 22% of the responses. For example, in Question 47, the question clearly indicates that line segments AB and CD are parallel. This was a frequently ignored given. Many responses, if correct, were based on statements such as "well it looks a little less than OD" , or if incorrect, " its about the same as AO and OD ".

Determining Differences / Rates / Ratios

In order to answer these questions the subjects had to extract information from a graph or map.

Appendix I, Table I - 7, shows that the grade seven female asthmatic subjects had the most difficulty with these problems. In all groups, the males answered more questions correctly than their female peers. Faulty problem representation or inability to form a problem representation was the major cause for error in the grade seven female diabetics, the grade eight male asthmatics and the grade eight female asthmatics. Question 54 was a frequent source of difficulty because some subjects compared the black part of the graph for 1975 and 1970 and gave the right answer , i.e. one million more tonnes were shipped in 1975. Other subjects looked at the coal legend and accurately identified coal on the graph but assumed that 16 million tonnes of coal were shipped in 1975 and 14 tonnes were shipped in 1970. This was arrived at by counting from the bottom of the graph or referring to the values along the left vertical axis. To arrive at the correct answer the subjects must count the crossed sections representing coal and subtract the one from the other. Similarly, in response to question 56, the answer "other products" rather than "coal" was given because as

Subject 8 said "....each time its more high than these ones" (pointed to the height of each column). Illogical or superficial reasoning was the other main reason for error. An example is Subject 33's response to Question 57:

About what part of all material shipped in 1965 is oil?

1) One-fifth 3) One-third

2) One-fourth 4) One-half

Response: (repeats question) ..2 3 4 5 6 7 8 9 10 11 . . . one-fourth....11, 11 tonnes was oil, and there's 12, then I just took one away from five and got one-fourth.

None of the grade eight subjects skipped questions in this skill category, but in grade seven the percentage of responses skipped were as follows: 14% by male asthmatics, 6% by both male diabetics and female asthmatics, and 3% by female diabetics. All groups scored above the midyear norms for these items.

Interpreting And Relating Data From Maps And Graphs

These problems are multiple step problems which require the subject first to interpret what the question asks, then to find the map or graph which will supply the required information, extract the information from the map or graph using the appropriate legend, and finally to make the required interpretation or calculation. An example is Question 58:

"What is the total annual corn production in Clermont?"

In order to answer the question the subject must choose the Crops map (out of the six maps presented), find Clermont province, find the legend for corn, count the number of symbols for corn within the province of Clermont, refer to the legend to note that each symbol represents 250,000 tonnes, multiply 250,000 times 8 and select the correct answer, 2,000,000 tonnes.

Appendix I, Table I - 8, gives a full description of the subjects' responses to these questions. The grade eight males had much less difficulty with these problems than the grade eight females. The males demonstrated good declarative and procedural knowledge. The male asthmatics answered

85% of the questions correctly and 81% of their responses were either a prompt correct answer or a comprehensive description of an efficient procedural strategy and the correct answer. Similarly, the grade eight male diabetics answered 83% of the questions correctly with 75% of the responses demonstrating good declarative and procedural knowledge. In contrast, the grade eight female asthmatics demonstrated good declarative and procedural knowledge in only 35% of their responses. Twenty-three percent of their responses demonstrated weak procedural knowledge or non-use of all available information. Fifteen percent of the answers reflected an inability to form a problem representation and 6% of the responses indicated that the subject was working with a faulty problem representation. The most common reason for error in five of the eight groups was poor procedural knowledge and non-use of all the given information.

The most common reason for error in the grade seven female diabetics was difficulty with problem representation (13%) and an inability to form a problem representation (6%). The grade seven male asthmatics skipped 15% of the problems whereas the grade eight male asthmatics had few problems with these questions. The grade eight male asthmatics' most common reason for error was the inability to form a problem representation (6%). Eight percent of the responses of the grade seven and grade eight female diabetics were incorrect because of calculation errors. An example of a calculation error is the answer 200,000 instead of 2,000,000 for Question 68.

Only the grade eight females scored below the fall norms, their male counterparts scored well above the midyear norms of 67.75.

Inferring From Maps And Graphs

These questions are also multiple step problems. Once the problem has been identified, the subjects must know how to extract the information from the map, maps, or from the graph in order to make inferences which will result in the solution to the question. For example, Question 64 asks:

"In Aztec, what use is made of the land with the

least annual precipitation?"
The subjects must go to the precipitation map, read the legend, find the area in Aztec with the least annual precipitation, go to both the resources map and the crops map and identify from the legends associated with these maps the use which is made of the land with the least annual precipitation. Since the resources map does not show coal, iron or copper in this area, it is inferred that answer number one, mining, is not the correct answer. The resources map also indicates there are no forests in this area so the fourth answer, growing lumber, is incorrect. The crops map shows sheep and cattle in the identified area, but in order to arrive at the correct answer, the subjects will need to know the meaning of the word "grazing".

As shown in Appendix I, Table I - 9, the percentage of correct responses were 28% for the grade eight female asthmatics, 33% for both the grade seven male diabetics and the grade eight female diabetics, 39% for the grade seven female asthmatics, 50% for the grade seven female diabetics, 61% for both the grade seven male asthmatics and the grade eight male diabetics and 83% for the grade eight male asthmatics. The fall norms are 30.00 for grade seven and 46.33 for grade eight, and the midyear norms are 35.33 for grade seven and 51.33 for grade eight.

The major reason for difficulty with these problems across all eight groups was weak procedural knowledge. The second most common reason for incorrect responses was difficulty with problem representation. These were also the questions most commonly skipped by the grade seven subjects in all four groups.

Questions 40 - 70 Answered By All Groups

Appendix I, Table I - 10, allows for an examination of the strengths and weaknesses in problem solving across the groups in response to the 31 mathematics problems answered by all groups. The grade eight males had the highest number of correct responses and the highest percentage of responses demonstrating integrated declarative and procedural knowledge. As shown in Appendix G, Table G - 2, a significant difference in mathematics scores was found between the grade eight male and female diabetics and between the grade eight male and female asthmatics. The male diabetics had 75% of their responses correct with 67% demonstrating good declarative and procedural knowledge; but the female diabetics had only 57% correct and only 44% of their responses demonstrated good declarative and procedural knowledge. The grade eight male asthmatics had 79% of their responses correct with 68% demonstrating good declarative and procedural knowledge; but the grade eight female asthmatics had 51% of their responses correct and only 38% demonstrated good declarative and procedural knowledge.

The most common reason for incorrect responses was inadequate procedural knowledge. The subjects appeared to understand what was required but either did not use all the information given in the problem, or reasoned illogically or superficially. This difficulty was reflected in only 9% of the responses of the grade eight male asthmatics but in 19% of the responses of the grade eight female asthmatics. Sixteen percent of the responses of the female asthmatics indicated they could not form a problem representation and abandoned the problem but only 5% of the responses of the male asthmatics indicated this type of problem. Nine percent of the responses of the female asthmatics and 4% of the grade eight male asthmatics indicated difficulty forming a problem representation.

The grade eight male and female diabetics had similar variations. Twenty-two percent of the responses of the females and 15% of the responses of the males demonstrated weak domain-specific knowledge; 10% of the responses of the females and 5% of the responses of the males indicated difficulty in forming a problem representation and 6% of the responses of the females but only 2% of the responses of the males demonstrated an inability to form a problem representation.

There were no significant differences in mathematics scores between the grade seven groups but patterns of strengths and weaknesses did vary. The grade seven female diabetics had less difficulty with procedural knowledge than the male diabetics and the female asthmatics. Only 8% of the responses of the female diabetics, but 22% of the responses of the male diabetics, and 21% of the responses of the female asthmatics were incorrect because they did not use all the information given in the question, or they reasoned illogically or superficially. Working with a faulty problem representation or inability to form a problem representation were the second most common sources of difficulty. Incorrect answers due to calculation errors as percentage occurrences are as follows: none for the grade seven male diabetics; 6% for the grade seven female diabetics; 2% for the grade seven and the grade eight male asthmatics; 3% for the grade seven female asthmatics, the grade eight male diabetics, the grade eight female diabetics and the grade eight male asthmatics and 2% for the grade eight female asthmatics. Calculation errors were not a major cause of incorrect responses. Once students clearly established the problem goals and knew the procedure, mathematical calculations were, with the above noted minor exceptions, correct. Six groups scored above the midyear norms for these items, but the grade eight female diabetics and female asthmatics both scored below the fall norms.

Table 2 summarizes the information processing patterns for the mathematics questions by skill objectives. The percentage of correct responses, the total percentage of responses that reflect good declarative and procedural knowledge (CO + CB), and the major reasons for difficulty are presented for the nine skill objectives and for the questions answered by all groups.

Subject Profiles For Reading And Mathematics

Each subject's information processing patterns across all the reading questions and all the mathematics questions were graphed to give a reading profile and a mathematics profile for each subject. The 96 individual information processing profiles (48 reading profiles and 48 mathematics profiles) are too numerous to include as an Appendix. In order to demonstrate the differences in information processing patterns across individuals, samples of information processing profiles in reading are presented in Figures 1 to 4 and samples of information processing

Table 2

Information Processing Patterns: Mathematics

Group	Grade	% Correct	% CO & CB	Major Reasons For Difficulty		
Skill Objective: Single Step Problems						
MD	7	69	57	IWK (17)	IDR (10)	
FD	7	64	57	IDR (14)	IWK (10)	ICE (10)
MA	7	76	67	IWK (12)	IDR (7)	UPR (5)
FA	7	62	48	IWK (19)	ICE (9)	
MD	8	79	63	IWK (17)	ICE (4)	
FD	8	67	62	IWK (29)	IDR (4)	
MA	8	71	62	IWK (13)	ICE (8)	
FA	8	33	29	IDR (25)	IWK (21)	UPR (13)
Skill Objective: Multiple Step Problems						
MD	7	58	50	IDR (25)	IWK (17)	
FD	7	50	50	IDR (25)	UPR (17)	IW (8)
MA	7	75	67	IWK (25)		
FA	7	50	42	IWK (17)	UPR (17)	
MD	8	56	50	IWK (28)		
FD	8	39	33	IDR (33)	UPR (11)	
MA	8	72	56	IWK (11)	UPR (11)	
FA	8	44	28	UPR (39)		
Skill Objective: Number Systems						
MD	7	83	67	IWK (8)	UPR (8)	
FD	7	100	75			
MA	7	100	92			
FA	7	83	75	IDR (17)		
MD	8	92	83	IDR (8)		
FD	8	67	58	IDR (25)	ICE (8)	
MA	8	92	75	ICE (8)		
FA	8	83	67	IDR (17)		
Skill Objective: Fractions						
MD	7	42	25	IWK (33)	IEA (17)	IW (8)
FD	7	50	25	IWK (25)	ICE (17)	UPR (8)
MA	7	75	58	IWK (17)	ICE (8)	
FA	7	25	25	IWK (33)	ICE (17)	UPR (8)
MD	8	67	67	IWK (33)		
FD	8	42	33	IWK (50)	IW (8)	
MA	8	75	58	IWK (25)		
FA	8	17	17	IWK (58)	UPR (8)	ICE (8)

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Table 2 (cont'd)

Information Processing Patterns: Mathematics

Group	Grade	% Correct	% CO & CB	Major Reasons For Difficulty		
Skill Objective: Operational And Relational Symbols						
MD	7	33	17	IW (33)	IWK (17)	IDR (17)
FD	7	83	17	UPR (17)		
MA	7	50	17	IDR (33)	UPR (17)	
FA	7	67	33	IWK (17)	UPR (17)	
MD	8	33		IWK (33)	IDR (33)	
FD	8	33	17	IWK (33)	UPR (33)	
MA	8	50	50	IWK (33)	UPR (17)	
FA	8	33	17	UPR (50)	IEA (17)	
Skill Objective: Geometry						
MD	7	56	39	IDR (33)	IWK (11)	
FD	7	78	67	IDR (22)		
MA	7	61	44	IDR (17)	UPR (11)	IWK (11)
FA	7	50	39	IDR (28)	IWK (22)	
MD	8	71	54	IDR (17)	UPR (8)	
FD	8	58	33	IDR (17)	IWK (8)	
MA	8	67	50	IDR (13)	UPR (8)	
FA	8	58	38	SP (17)	IDR (13)	
Skill Objective: Determining Differences/Rates/Ratios						
MD	7	77	58	IWK (14)	IDR (3)	
FD	7	67	67	IDR (14)	IWK (8)	
MA	7	64	44	IWK (17)	SP (14)	
FA	7	50	39	IWK (25)	IDR (8)	UPR (8)
MD	8	72	64	IWK (14)	ICE (11)	
FD	8	58	44	IWK (22)	IDR (8)	UPR (8)
MA	8	67	56	IDR (14)	IWK (11)	
FA	8	61	53	UPR (17)	IWK (11)	IDR (11)
Skill Objective: Interpreting And Relating Data From Maps And Graphs						
MD	7	63	38	IWK (27)	IDR (6)	
FD	7	65	54	IDR (13)	UPR (6)	
MA	7	69	58	SP (15)	IWK (8)	UPR (6)
FA	7	71	56	IWK (10)	SP (8)	UPR (6)
MD	8	83	75	IWK (10)		
FD	8	56	48	IWK (14)	ICE (8)	IDR (8)
MA	8	85	81	UPR (6)		
FA	8	54	35	IWK (23)	UPR (15)	IDR (6)

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Table 2 (cont'd)

Information Processing Patterns: Mathematics

Group	Grade	% Correct	% CO & CB	Major Reasons For Difficulty		
Skill Objective: Inferring From Maps And Graphs						
MD	7	33	28	IWK (33)	IDR (17)	SP (11)
FD	7	50	44	IWK (22)	UPR (11)	SP (11)
MA	7	61	39	IWK (17)	SP (11)	
FA	7	39	22	IWK (33)	SP (17)	
MD	8	61	56	IWK (28)		
FD	8	33	22	IWK (39)	UPR (17)	
MA	8	83	72	IWK (6)	UPR (6)	IDR (6)
FA	8	28	17	IWK (39)	IDR (11)	
Questions 40-70						
MD	7	59	42	IWK (22)	IDR (11)	UPR (3)
FD	7	65	55	IDR (12)	IWK (8)	UPR (6)
MA	7	66	51	IWK (12)	SP (8)	UPR (7)
FA	7	54	40	IWK (21)	UPR (8)	IDR (7)
MD	8	75	67	IWK (15)	IDR (5)	
FD	8	57	44	IWK (22)	IDR (10)	UPR (6)
MA	8	79	68	IWK (9)	UPR (5)	IDR (4)
FA	8	51	38	IWK (19)	UPR (16)	IDR (10)

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

profiles in mathematics, in Figures 5 to 8.

The grade seven students were presented with 23 reading questions and the grade eight students with 24 questions. As demonstrated in Figure 1, Subject 36 who received a reading score of 20, had very little difficulty with the reading questions and demonstrated good declarative and procedural knowledge in 17 responses. Three questions were answered incorrectly even though she worked diligently at solving two of the questions. Subject 5 obtained a reading score of 9. Figure 2 demonstrates that his major problem was an inability to accurately remember or retrieve recently acquired information from the text. The verbal protocols of this subject indicate that he did not return to the text to seek answers or to check his answers. For example, his response to question 1, "Why are scientists especially interested in glaciers?", is "Well it said they are disappearing in the paragraph so I'd say glaciers are disappearing from the earth." The first paragraph of the text states that glaciers are found on every continent except Australia. Subject 42 received a reading score of 13. Figure 3 illustrates

Figure 1. Information processing profile in reading: grade 7 female asthmatic, subject 36.

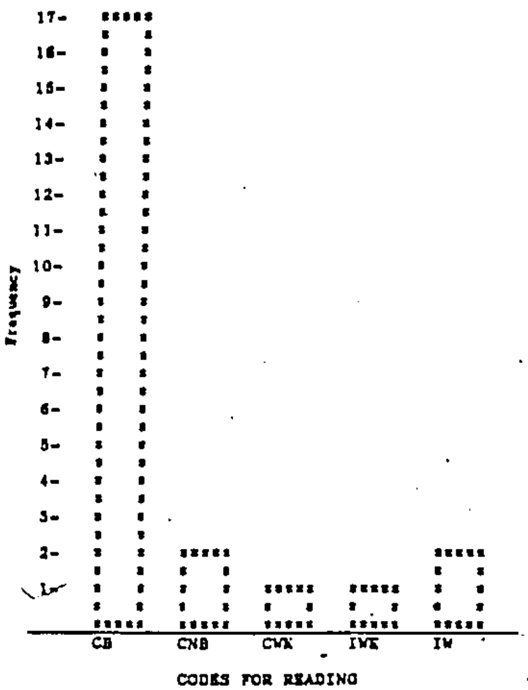


Figure 2. Information processing profile in reading: grade 7 male diabetic, subject 5.

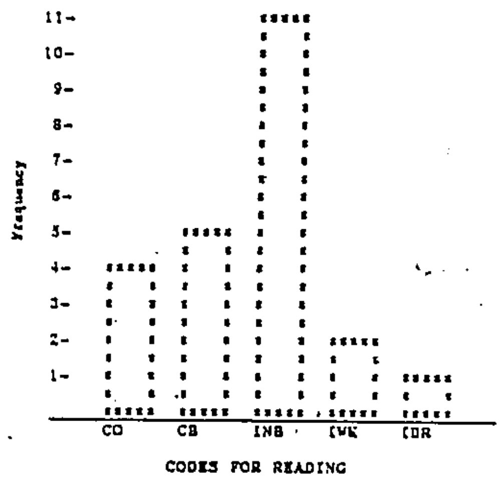


Figure 3. Information processing profile in reading: grade 8 male asthmatic, subject 42.

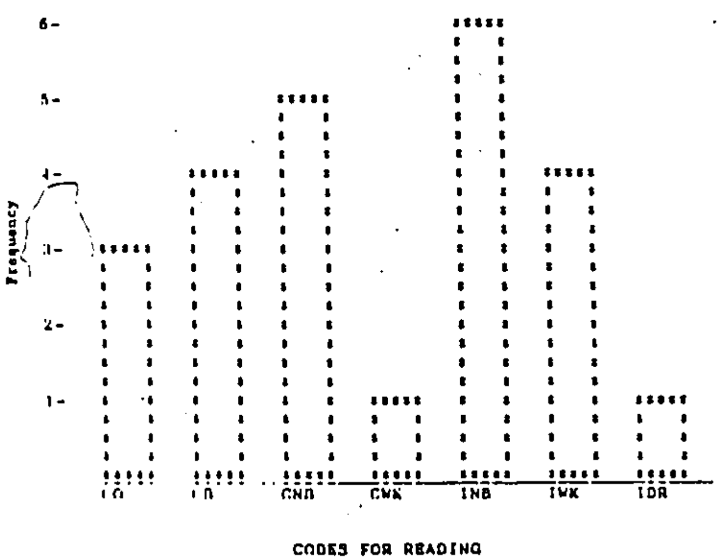


Figure 4. Information processing profile in reading: grade 8 female asthmatic, subject 44.

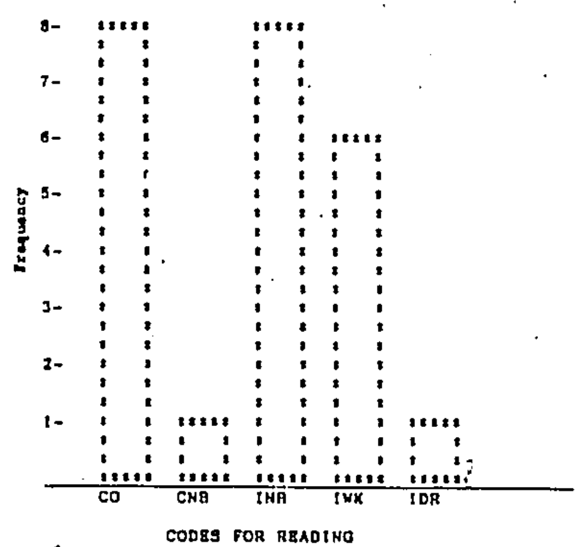


Figure 5. Information processing profile in mathematics: grade 7 male diabetic, subject 6.

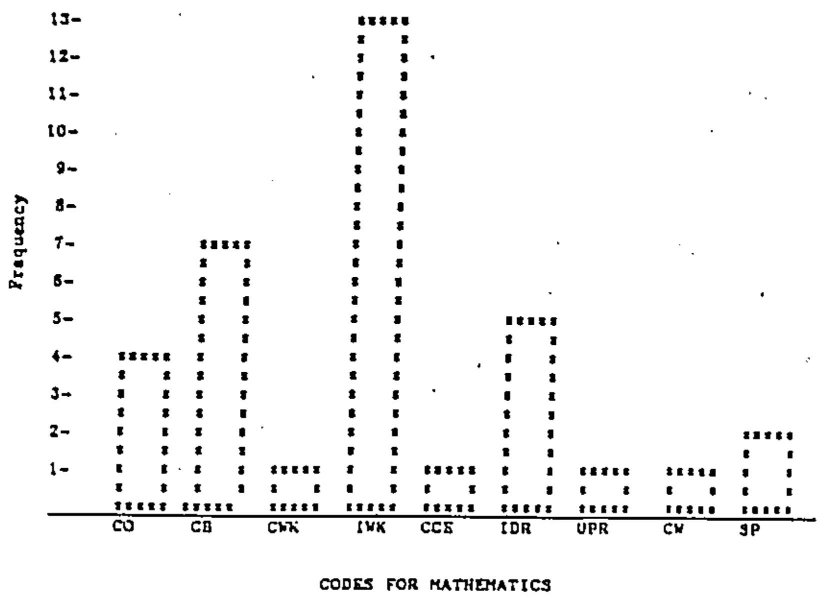


Figure 6. Information processing profile for mathematics: grade 7 female diabetic, subject 11.

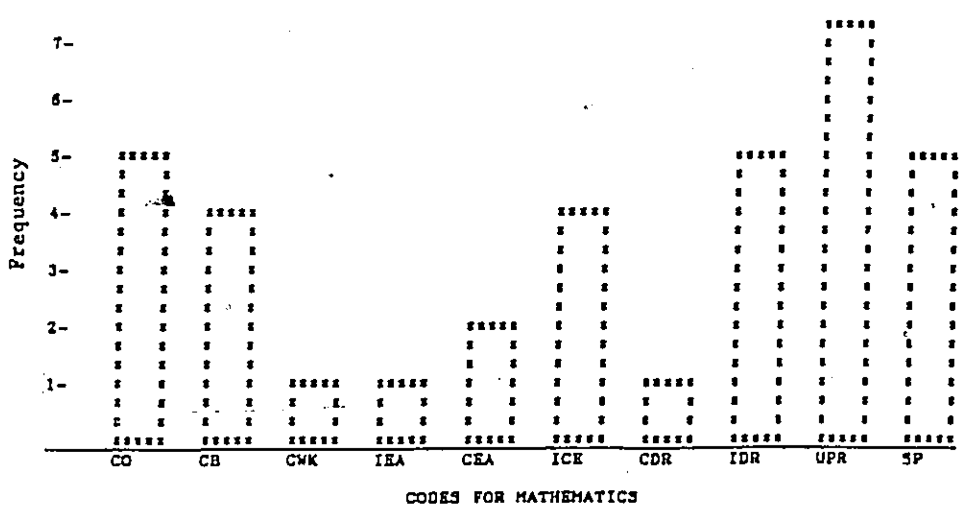


Figure 7. Information processing profile in mathematics: grade 8 male diabetic, subject 16.

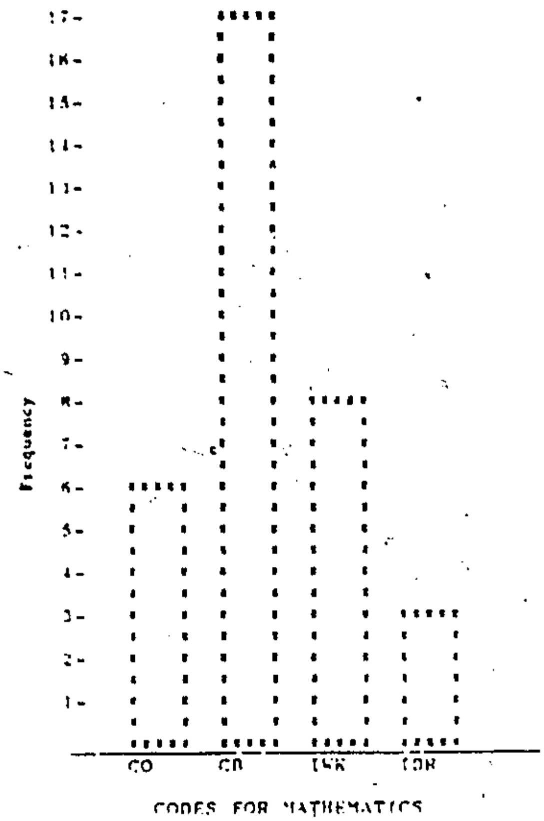
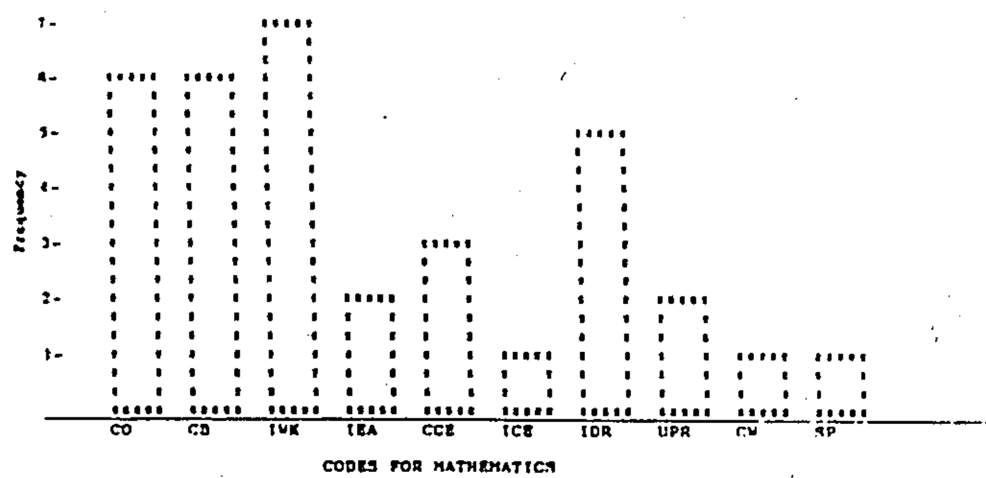


Figure 8. Information processing profile in mathematics: grade 8 female asthmatic, subject 48.



that he had a variety of response patterns. He demonstrated good knowledge of the information in the text in 7 responses but 11 ~~of~~ his responses were not based on information in the text (CNB + INB). Examples of correct responses not based on the text are his responses to questions 1 and 2: (question 1) "I'd say logically it'd be number 3, an understanding of glaciers may reveal important facts about the history of the earth" and (question 2) "I think it would be number 1, the Alps, because the Alps is a place and I didn't really see how you could, well they may do it, but I don't see why they would name just a special type of glacier for a special area." Five of his responses reflect weak domain specific knowledge (CWK + IWK). For example, he states that the width of valleys is important in the movement of all glaciers because " if it was all scrunched up in a little hole the glacier would have trouble, sort of moving about, I'd say if the valley was wide and large it could sort of flow out and yah, I think it is number 2." Subject 44 (Figure 4) received a reading score of 9 and 8 of the correct responses were correct answers only with no additional explanations offered. Nine responses (CNB + INB) were not based on information given in the text and she demonstrated weak domain specific knowledge and superficial thinking in 6 responses. An example of the latter is her response to question 26 which asks "Why is it usually best to buy the larger shoe if one foot is smaller than the other? Her response was "So your feet will have room to grow" rather than "So both shoes will be large enough."

Grade seven students were presented with 35 mathematics questions and grade eight students with 34 mathematics questions. Subject 6 (Figure 5) obtained a mathematics score of 14. He worked with a faulty problem representation (IDR) or abandoned the problem (UPR) because he could not form a problem representation in 6 questions. His major reason for difficulty however was weak procedural knowledge. For example, in response to question 44 he correctly represented the problem and then dropped the .67 and multiplied 2 times 300 to arrive at 600 as his answer; in response to question 51 he dropped the 1/2 cent or .5 and gave $1.60 for his answer; and in response to question 53 he multiplied 1.89 times 2 and obtained 2.78. Subject 11 (Figure 6) obtained a mathematics score of 13. Her major difficulty was problem representation (CDR, IDR, UPR). She also did not attempt to do 5 questions which is further indication of her difficulty with problem representation. Figure 7 demonstrates that Subject 16 correctly answered 23 questions and displayed good declarative and procedural knowledge in his responses. Three responses were incorrect because he was working with a faulty problem representation and 8 were incorrect due to weak procedural knowledge. Subject 48 (Figure 8) whose mathematics score was 16 displayed a variety of response patterns. Errors were made because of weak procedural knowledge, difficulty with problem representation, calculation errors, and because responses were selected from given answers through an elimination process rather than calculating the answer and then identifying the correct choice.

The individual profiles allow the educator to identify the subject's strengths and weaknesses in reading and in mathematics. Similarly, group or class profiles would offer insight into difficulties experienced in problem solving as well as point out strengths, especially if the profiles were compiled across skill objectives.

Effects Of Absenteeism On Problem Solving

For purposes of facilitating computer entry of data, the absentee rate was categorized into absent 0 for subjects who had been absent from school for a total of 10 days or less in the previous six semesters, and into absent 1 for subjects who had been absent from school for 11 days of more over the previous six semesters. Since the term "semester" is not well understood, subjects and their parents were asked the number of days the subject was absent from school in the last two years, whether they were scattered days or a block of time, and their longest absence from school and the grade level at the time. The responses of the high absentee and low absentee subjects in each group are analysed on the common reading questions and the common mathematics questions. The information processing patterns by absenteeism across reading questions 1 - 15 are presented in Appendix J, Table J - 1; and across mathematics questions 40 - 70 are presented in Appendix J, Table J -2.

In order to determine if the identified differences in information processing between the high and low absentee groups were common to all subjects in the high absentee groups, reference is made to the individual information processing profiles for reading and mathematics for all subjects.

Grade Seven Male Diabetics

Two individuals in the grade seven male diabetic group were absent from school 11 days or more over the previous six semesters. One subject was absent for 20 days for reasons not associated with his diabetes, and the other subject was absent for 15 days. The subject who was absent for 20 days had a reading score of 13 and a mathematics score of 20. The individual who was absent for 15 days had a reading score of 16 and a mathematics score of 14. The group mean for reading was 13.16 and for mathematics was 21.66. The individual with the reading score of 16 had the longest reading response time and the second longest mathematics response time in his group. The subjects had similar individual information processing profiles for reading but the subject who was absent for 15 days had more difficulty with mathematics.

The high absentee individuals correctly answered 53% of the questions, demonstrated good declarative and procedural knowledge in 20% of their answers, demonstrated that they accurately recalled the text in 7% of their answers and had to work hard at understanding or solving the problem in 3% of the responses. In contrast, the low absentee group correctly answered 50% of the questions, demonstrated good declarative and procedural knowledge in 40% of their answers, accurately recalled the text and fully explained their answer in 27% of their responses and and had to work diligently to produce the answer in 2% of the problems. The high absentee group gave a correct answer not based on the text but arrived at by eliminating the answers or by reasoning not based on the text twice as often as the low absentee members (16.66% compared to 8.33%). Only the high absentee subjects obtained correct answers even though they did not use all the information given in the problem or they reasoned illogically or superficially, and only these subjects struggled with problem representation but finally got the answer right. Both groups had the same major reasons for incorrect responses: inability to remember or retrieve information from the text; illogical or superficial reasoning or not using all the given information; and difficulty with problem representation.

The high absentee members did much more poorly in mathematics than in reading. They correctly answered only 44% of the questions whereas the low absentee members of their group correctly answered 67% of the questions. Twenty-six percent of the responses of the high absentee group and 51% of the responses of the low absentee group demonstrated good declarative and procedural knowledge. Illogical or superficial thinking were evident in 29% of the responses of the high absentee members and in 18% of the low absentee members. Difficulty with problem representation was evident in 17% of the responses of the high absentee group but in only 7% of the responses of the low absentee members. The percentage occurrences for the high absentee group were twice as high for each of the following: correct answer but had to work at understanding or solving the problem; incorrect answer in spite of working diligently at understanding or solving the problem; and with regard to questions skipped.

Grade Seven Female Diabetics

Three subjects were absent from school for more than 11 days over the past two years. The absenteeisms were as follows: 20 days for reasons not associated with her diabetes; 63 days with the most extended period being 17 days; and 15 days. Their reading scores were 17, 14 and 21 respectively and their mathematics scores were 26, 13, and 28. The group mean for reading was 17.16 and for mathematics was 23.33. Reading profiles for these three individuals were not markedly different but the subject who was absent for 63 days was the only one to skip mathematics questions. She had more calculation errors, and more difficulty with problem representation than the other two members of the high absentee group.

The high absentee members responded correctly to 69% of the questions and the low absentee group to 67% of the questions. Both groups reflected good declarative and procedural knowledge in 58% of their responses. The high absentee members had more incorrect answers because they could not remember or retrieve information from the text, but they had fewer incorrect answers because of difficulty with problem representation.

Although the difference is not great, the high absentee individuals had fewer mathematics questions correct (62% as compared to 67%). They had more incorrect answers because of calculation error, and inability to form a problem representation, and one individual skipped 5% of the questions. The low absentee members had twice as many incorrect responses because they were working with a faulty representation.

Grade Seven Male Asthmatics

The grade seven male asthmatics had four individuals in the high absentee category. Absences were as follows: 40 intermittent days; 20 days with two periods of 5 days each; 40 days in one school year and 6 in the other; and 50 school days. The reading scores were 21, 8, 16, and 13 respectively. Their mathematics scores were 31, 24, 30 and 7. The group mean for reading was 15.50 and for mathematics was 24.00. The individual with the reading score of 8 had the most difficulty remembering or retrieving information from the text, otherwise the major difference in profiles was that the individuals who were absent for 40 days and 46 days had more responses demonstrating good declarative and procedural knowledge. The subject with the mathematics score of 7 had 50 days of absenteeism and was the only individual in the high absentee group to skip mathematics questions. He was also the individual who most frequently could not form a problem representation.

The high absentee members correctly answered 53% of the reading questions whereas the low absentee group correctly answered 67% of the questions.

Answers which demonstrated the use of logical reasoning, accurate recall of content and a solid knowledge base were evident more frequently in the low absentee group. Processing patterns leading to incorrect answers were more common for the high absentee group. For example, 10% of the responses of the high absentee group but only 3% of those of the low absentee group indicated difficulty with problem representation; 20% of the responses of the high absentee group indicated they were not able to remember or retrieve information from the text accurately, but only 13% of the responses of the low absentee group reflected this problem; 15% of the responses of the high absentee group indicated that they did not use all the information given in the question or reasoned illogically or superficially but only 10% of the responses of the low absentee group demonstrated this problem.

The high absentee members correctly answered 63% of the mathematics questions whereas the low absentee group correctly answered 71% of the questions. Good declarative and procedural knowledge was evident in 48% of the high absentee subjects' answers and in 58%

of the low absentee subjects' answers.

Grade Seven Female Asthmatics

The two grade seven female asthmatic subjects with high absentee rates were absent from school for 22 days (15 of which were consecutive), and 60 days for reasons not associated with her asthma. Their reading scores were 6 and 20; and their mathematics scores 15 and 26. The group mean for reading was 15.00 and for mathematics was 20.00. The reading profiles for these two individuals were markedly different. The individual who was absent for 60 days demonstrated a solid base of declarative and procedural knowledge whereas the individual who was absent for 22 days had difficulty remembering or retrieving information from the text, reasoned illogically or superficially, and had difficulty with problem representation. Their mathematics profiles exhibited similar contrasts. The subject who was absent for 22 days demonstrated weak procedural knowledge and had more difficulty with problem representation.

The high absentee members responded correctly to

44% of the questions with 37% reflecting good declarative and procedural knowledge. The low absentee group had 67% of their answers correct and 52% demonstrated good declarative and procedural knowledge. Twice as many of the responses of the high absentee group were incorrect because the subjects could not remember or retrieve the necessary information from the text.

The responses of the two groups were more similar on the mathematics questions. The high absentee group got 56% of the questions correct and the low absentee group got 52% of the questions correct. Good declarative and procedural knowledge was evident in 39% of the responses of the high absentee group and in 40% of the responses of the low absentee group.

<u>Grade Eight Male Diabetics</u>

Two subjects are within the high absentee category. One subject was absent for 35 days (30 of which were consecutive); the other subject was absent for 35 days (20 of which were consecutive).. Both had reading scores of 16 and their mathematics scores were 25 and 31. The group mean for reading was 14.83 and for mathematics 24.66. The individual reading profiles are similar. Both mathematics profiles demonstrate good declarative and procedural knowledge. Neither individual demonstrated major difficulties in mathematics problem solving although the individual with the higher score displayed more difficulty in arriving at the answer.

The high absentee individuals answered 60% of the questions correctly and all correct answers reflected good declarative and procedural knowledge. The low absentee group answered 70% correctly and demonstrated good declarative and procedural knowledge in 67% of their responses. Three information processing patterns contributed to error for the high absentee individuals: inability to remember or retrieve information from the text (23%); illogical or superficial thinking (13%); and difficulty with problem representation (3%). Individuals in the low absentee group displayed these problems to a slightly lesser extent. In mathematics the high absentee pair had 84% of their answers correct whereas the low absentee members had only 70%

of their answers correct. Seventy - one percent of the responses of the high absentee members and 48% of the low absentee members demonstrated domain specific knowledge resulting in proficient procedural strategies.

Grade Eight Female Diabetics

Two subjects were in the high absentee category, one was absent for 19 days, and the other for 70 days, 60 of which were in the most recent school year. Their reading scores were 20 and 11 and their mathematics scores 29 and 21. The group mean for reading was 13.66 and for mathematics 18.66. The individual with 70 days of absence much less frequently displayed good declarative and procedural knowledge than the individual absent for 19 days. From their reading profiles it can be noted that the individual with 70 days of absence used information processing patterns which contributed to error in 54% of her responses whereas the individual with 19 days of absence displayed the same difficulties in only 17% of her responses. In mathematics, the individual absent for 70 days when compared to the individual absent for 19 days more frequently (a) had difficulty forming a problem representation; (b) was unable to form a problem representation and abandoned the question; and (c) had weak procedural knowledge. Only the individual absent for 70 days skipped questions.

The high absentee members correctly answered 63% of the reading questions whereas the low absentee members only answered 53% correctly. Twenty-eight percent of the responses of the low absentee group were incorrect because they could not remember or retrieve information accurately from the text but this problem was evident in only 13% of the responses of the high absentee individuals. The high absentee members also experienced less difficulty with mathematics than their low absentee peer group. They correctly answered 77% of the questions whereas the low absentee members correctly answered only 47% of the questions. The low absentee members demonstrated weak procedural knowledge more frequently (27% as compared to 10%) and had more difficulty with problem representation.

Grade Eight Male Asthmatics

The high absentee rates were 36 days, 13 days, and 17 days. Their reading scores were 13, 20, and 15; and their mathematics scores 27, 31, and 28. The group mean in reading was 15.00 and in mathematics, 25.83. The reading profiles for the subjects absent for 13 days and for 17 days are similar. Both demonstrate a solid base of declarative and procedural knowledge. The individual absent for 36 days had more difficulty remembering or retrieving information from the text and also responded by eliminating answers or by reasoning not based on information in the text. The mathematics profiles for these individuals indicated similar patterns with all three individuals demonstrating good declarative and procedural knowledge.

High absentee members correctly answered 71% of the reading questions and 86% of the mathematics questions and the low absentee members correctly answered 58% of the reading questions and 71% of the mathematics questions. In both reading and mathematics the high absentee individuals had a better declarative and procedural knowledge base. On the reading test, 24% of the responses of the low absentee members were incorrect because answers were not based on the text. Individuals had difficulty remembering or retrieving information from the text. On the mathematics test, the low absentee members had more difficulty with problem representation and with procedural knowledge. The high absentee members demonstrated good declarative and procedural knowledge in 62% of their reading responses and in 78% of their mathematics responses.

Grade Eight Female Asthmatics

Both the grade eight female asthmatics and the grade seven male asthmatics had 4 individuals (the highest number among the groups) in the high absentee category. Absences for the grade eight female asthmatics were 22 intermittent days, 20 days, 45 days, and 64.5 days with 54 days in one year and 10.5 in the most recent year. Their reading scores were 17, 9, 9, and 15; and their mathematics scores were 12, 9, 18, and 17. The group mean for reading was 12.66 and for mathematics 16.33. The individual reading profiles show that both subjects who received a score of 9 had difficulty remembering or retrieving information from the text and reasoned illogically or superficially. From the individual profiles for mathematics it can be seen that the major problem for all subjects except the individual absent for 20 days was the inability to form a problem representation. The second most frequent reason for difficulty (and the primary reason for the subject with 20 days of absence) was weak procedural knowledge. They did not use all the information given in the question or they reasoned illogically and superfically.

The high absentee members correctly answered 48% of the reading questions whereas the low absentee members correctly answered 57% of the questions. Good declarative and procedural knowledge was evident in 37% of the responses of the high absentee members and in 43% of the responses of the low absentee members. Similar problem patterns were evident for both groups. On the mathematics test, the high absentee members correctly answered 44% of the questions whereas the low absentee members correctly answered 65%. Good declarative and procedural knowledge was evident in 53% of the responses of the low absentee group and in 30% of the responses of the high absentee group. The major difference between the two groups was in problem representation. Twenty-three percent of the responses of the high absentee group but only 2% of the low absentee group indicated that they could not form a problem representation and therefore abandoned the questions.

In summary, subjects with absences of 50 to 70 days more frequently skipped mathematics problems, had more difficulty with problem representation and used less efficient procedural strategies than subjects with less absenteeism. However, absences of over 35 days were not necessarily related to low reading and mathematics scores. For example, individuals with absences of 40 days, 46 days, 35 days and 36 days obtained mathematics scores of 31, 30, 31 and 27 respectively. A full discussion of the implications of these findings will be presented in Chapter 4.

The "Plan Your Day" Question

The "Plan Your Day" question is difficult because subjects not only have to establish their end goal and their intermediate goals but they must do so on the basis of acquired real world knowledge. They must be able to identify appropriate shops for required purchases and be aware of usual store, bank, and library hours of business. They also need to be able to estimate how long it will take to accomplish each goal, e.g. buying a bathing suit. In addition to time-event relationships, there are several time-distance relationships to be taken into consideration which require interpretation of bus schedules, estimation of distance as presented on the map, and reaching the end goal of being on the plane at 4:40 p.m. The question was open to comprehensive interpretation which could include non-stated personal goals such as beginning with breakfast, stopping for lunch, packing etc.

Planning as defined by Hayes-Roth & Hayes-Roth (1979), is the predetermination of a course of action aimed at achieving some goal and is the first stage of a two stage problem solving process. The second stage entails monitoring and guiding the execution of the plan. An analysis of the 48 subjects' verbal protocols related to this question reveals the following: 20 individuals (42%) completed all the given tasks; 32 (67%) identified appropriate shops or offices for the tasks they did complete; 15 (31%) met personal needs not directly stated in the problem; 4 (8%) had problems interpreting bus and/or plane schedules. Two individuals appeared anxious and upset by the problem and stated that they found the problem very difficult. One subject totally disregarded the problem statement and devised her own scenario. She took books out of the library, bought a box of kleenex, had her hair done and bought some clothes. However, she was one of the six who took the most appropriate bus to the airport. The article most frequently bought in unusual places was the bathing suit. Purchases of bathing suits were made at the beauty shop, drug store and the arena. Personal needs included in the subjects' planning were: packing (6); buying candy (3); breakfast, brushing teeth and going to school (1); relaxing (1); beauty shop ([illegible]) and saying goodbye (2). All subjects, even those who took the most appropriate bus to the airport had major problems with timing. Subjects did not introduce the possibility they might have to wait at the bank nor did they allot time to make purchase choices and only two subjects considered usual opening hours for stores, bank and library. Bus schedules were particularly confusing. No grade seven diabetic subject took the most appropriate bus to the airport. Six left too early but were on the right bus schedule, five left at times when buses to the airport were not scheduled to run, and one left at 4 p.m. and therefore would arrive after the plane had gone. Only one of the grade seven asthmatic subjects took the most appropriate bus to the airport. Seven left at times when buses to the airport were not scheduled, one left at 9 a.m., one felt the time to leave was 4 p.m. but decided to take the 3 o'clock bus "in case the bus stalls", another subject stated she would leave at 3 or 4 o'clock and one left an hour too soon. Three grade eight diabetics took the most appropriate bus to the airport, two individuals were indecisive, one said he could leave at 4, 12 or 1, and the other said 3, 3:30 or 4. One gave no time for departure and all others were too early. The grade eight asthmatics had similar problems. Two took the most appropriate bus to the airport, five left much too early, one took the 5 p.m. bus, one did not even mention going to the airport and the others left at times that buses were not scheduled to run to the airport.

A discussion of the results presented in this chapter follows in Chapter 4.

CHAPTER 4

DISCUSSION AND IMPLICATIONS

The objectives of this study were to

1) identify and describe Chronic Asthmatic and Insulin Dependent Diabetic children's strengths and weaknesses in curriculum related problem solving across the following variables:
   a) problem specific declarative knowledge
   b) problem specific procedural knowledge
   c) storage and recall of recently acquired information
   d) problem identification
   e) problem representation
   f) effectiveness of problem solving strategies
   g) automatic processing
   h) ability to plan, monitor and use feedback; and
2) identify information processing patterns which contribute to these children's strengths and

weaknesses in problem solving.

In order to meet these objectives a methodology was developed which identifies and describes children's information processing skills across these variables.

The background information on the children in the study will be presented before the results of the information processing analysis and the implications for the methodology are discussed.

Background Information

The age range of the children in this study is in keeping with the average chronological age of Canadian children in grades seven and eight (King, 1982). Based on the Sultz et al. (1972) report that 22.4% of chronic asthmatic and 16.6% of insulin dependent diabetic children are below grade level for their chronological age, it was anticipated that some of the children in the study would be older than the average Canadian child in grades seven and eight.

The percentage of children with at least one university educated parent (39.58%) is high when compared to the percentage of university graduates in the Canadian population. Statistics Canada data based on 1981 statistics indicates that 7.52% of the Canadian population over the age of 15 has a university education. Children who had at least one parent with a university education more frequently obtained the highest scores in reading and mathematics and less frequently obtained the lowest scores. This observation would support Pless' (1983) statement that chronically ill children's academic success is positively correlated with their parents' educational achievement level. However, it must be noted that five individuals whose parents did not have a university education also received the highest scores in reading and four received the highest scores in mathematics.

The fact that 64.58% of the subjects had career goals indicates that chronically ill children do make future career plans and consider themselves capable individuals. There is a difference of opinion in the literature with regard to chronically ill children's susceptability to depression and other motivational and psychosocial adjustment problems (Rodgers et al, 1981; Deasy-Spinetta, 1983; Weitzman, 1984). The positive attitude of the subjects toward participation in the study, their future career goals and the frequent question asked of the researcher "Why are you studying me, I'm just like everybody else?" would lend support to those who state that there are few statistical differences between chronically ill and physically healthy children given equivalent family and medical support systems (Tavormina et al, 1976; Gath et al, 1980; Brantley et al, 1981; and Matthews & Drotar, 1981).

Scores And Response Times

As previously stated, the value in identifying significant group differences even though there were only six individuals in each group, is in the comparison of information processing patterns between the groups. Grade seven female diabetics obtained significantly higher reading scores than grade seven male diabetics but there were no other significant differences between or within groups related to either reading or mathematics scores in grade seven.

The grade eight males had significantly higher mathematics scores than the females within their groups. There were no significant differences between the male diabetics and male asthmatics nor between the female diabetics and female asthmatics.

Of particular interest is the significant difference in mathematics response times between the grade seven female diabetics and grade seven female asthmatics and between the grade eight male diabetics and grade eight male asthmatics. The asthmatic subjects took longer to respond. Although little is available in the literature about the effects on cognitive functioning of medications commonly used to treat asthma in children, Alexander (1983) and Cropp (1985) suggest that concentration difficulties may be associated with the type of medications the children in this study were prescribed. Discussions with asthmatic children and their parents following the study have led to the empirical observation that these children metacognitively have to keep bringing themselves back to task. It is not that they have to work diligently to understand the problem or to find an appropriate solution strategy, but in the words of one subject "My mind goes fuzzy sometimes and I get very anxious..but then it clears up again. I rarely finish tests though".

It is important to note that at levels 13 and 14 in the Canadian Tests of Basic Skills, students are expected to answer 57 (level 13) or 58 (level 14) reading questions in 42 minutes (King,1982). The 23 reading items presented to the grade seven subjects should therefore have been completed in 1016.8 seconds and the 24 items presented to the grade eight subjects, in 1042.75 seconds. Nine grade seven and four grade eight subjects took longer than 1016.8 seconds and 1042.75 respectively to respond to these items. The mathematics problems section of the Canadian Tests of Basic Skills was allotted 25 minutes for 30 level 13 questions and 32 level 14 questions. The 35 mathematics items presented to the grade seven subjects and the 34 items presented to the grade eight subjects should therefore have taken approximately 1750.0 seconds and 1593.7 seconds respectively. (Questions on the mathematics portion of the test which were taken from the visual materials portion of the Canadian Tests of Basic

Skills were allotted even less time per question therefore the above estimate is generous.) Nineteen grade seven subjects and eighteen grade eight subjects took longer than 1750 and 1593.7 seconds to respond to the test items. The only mean mathematics response times below 1750 seconds for grade seven and 1593.7 seconds for grade eight are those of the grade seven female diabetics and the grade eight male diabetics. Ericsson & Simon (1984) state that there is no evidence to suggest that concurrent verbalizations change the course, structure or speed of the thought processes and Hafner (1957), Dansereau & Gregg (1966), and Tell (1971) suggest that verbalization may facilitate the solution process. Therefore, it is suggested that had there been time restrictions placed on the reading and mathematics portions of the test, the performance of the Insulin Dependent Diabetic and the Chronic Asthmatic subjects in this study would have been drastically affected, particularly in mathematics. Further investigations of the academic abilities of chronically ill children should consider the effect of time restrictions on the children's performance. If in fact these children do have the declarative and procedural knowledge but take longer than their healthy peers to process their responses, then it is unfair to judge their academic abilities by time-limited tests. Further studies comparing the performance of chronically ill children and their healthy peers across time-limited and non time-limited test items would be informative.

Processing Patterns Across Reading Skill Objectives

The reading comprehension section of the test examines how well individuals, or groups of individuals, (1) encode the information presented in the reading passages; (2) store the information in long term memory; (3) represent the critical features of the task environment in their problem space; (4) retrieve the specific data required to answer the question from long term memory; (5) chunk the information in working memory; (6) operate on the information in working memory using previously stored declarative and procedural knowledge and (7) respond to the question. Subjects who immediately understood the question and quickly responded with the correct answer (coded CO) as well as subjects who gave a comprehensive response based on accurate recall of the reading passage and logical reasoning (coded CB) were the high ability readers. These individuals were able to efficiently match patterns of information held briefly in the sensory registers and patterns previously stored in long term memory (Gilmartin & Newell, 1976; Klatzky, 1984). New information was stored through elaboration of their recognition memory and through linkage with an orderly and established associative network in long term memory (Simon, 1979; Millward, 1980). The more easily new material was assimilated and then subsequently recalled depends not only on the organization of information in long term memory (Eylon & Reif, 1984), but also on the individual's ability to chunk information (Miller, 1956; Chi, 1976). Individuals who gave comprehensive responses were able to access and activate larger networks and therefore process the information with the help of a richer store of knowledge (Ingram, 1984).

Across each reading skill, the grade seven female diabetics had a greater percentage of responses demonstrating more accurate recall and logical comprehensive reasoning than did the grade seven male diabetics. The major reason for difficulty for the male diabetics across all three reading skills was an inability to retrieve or recall content from the text accurately and this difficulty was considerably more pronounced for the males than the females. These patterns were the major contributors to the significant difference in reading scores between the grade seven male and female diabetics.

Recognizing and understanding factual information was the most difficult skill objective for all but the grade eight male asthmatics. The factual information in the text had to be encoded and then accurately recalled, or the subject had to return to the appropriate location in the text to extract the answer. In contrast, questions which required making generalizations or inferring relationships involved "old" knowledge to some extent. In order for new information to be stored in semantic memory, elaboration of the recognition memory must take place so that the new information will be readily accessible (Simon, 1979). The subjects who did poorly probably did not have sufficient time to elaborate recognition memory. It is of interest to note that the grade seven female asthmatics who correctly answered only 47% of the factual information questions also had the longest reading mean response time.

Making generalizations and inferring underlying relationships both involve the recognition of relationships based on common attributes or other cues drawn from past experience. However, three groups who had difficulty making generalizations received their highest reading scores on questions which required inferring underlying relationships. It is suggested that making generalizations requires inductive reasoning which according to Glaser & Pellegrino (1982) involves a number of processes. These are (1) encoding or representational processes dependent on information in long term memory; (2) inference processes that can identify and/or generate relational features shared by two or more encoded elements; (3) rule assembly and rule monitoring that organizes features into relational structures; (4) match processes which evaluate similarities among relational structures; (5) discrimination processes capable of selecting among competing structures; and (6) decision and response processes. Glaser & Pellegrino (1982) also state that the reason individuals have difficulty making inferences is because their knowledge has been encoded at surface levels and they have not employed conceptual forms of knowledge that constrain their induction of relations.

Processing Patterns Across Mathematics Skill Objectives

Analysis of the verbal protocols on the mathematics questions clearly identified different processing skills across the various skill objectives. The primary reason for difficulty with geometry questions was difficulty with problem representation whereas the primary reason for difficulty with questions dealing with fractions was weak domain specific knowledge which led to superficial or illogical reasoning (e.g." 1/6 is bigger than 1/5 because 6 pieces of pie is more than 5 pieces of pie"). Both the grade eight male diabetics and asthmatics did significantly better than their female peers on the mathematics portion of the test. Across each skill objective there was a notable difference in the percentage of responses demonstrating good declarative and procedural knowledge. The grade eight females had more difficulty with problem representation and a greater number of their responses demonstrated weak procedural knowledge. There was no significant difference in mathematics scores between the grade seven male and female subjects.

The protocols support Simon's (1978) finding that different information processing strategies may produce functionally equivalent results. There were a number of strategies evident in the solutions to the same problem across the subjects. Subjects who had to work diligently at understanding the problem or who used ineffficent strategies such as trial and error or hill climbing arrived at the same answer but had a longer latency time. Individuals who answered the mathematics questions correctly and efficiently were those who (1) could recognize the principles behind, or classification of, the problem (Hinsley et al, 1977); (2) could represent the critical features of the task environment in their problem space (Frederiksen, 1984); (3) had past experience with similar problems and could therefore engage in more efficient strategies for problem solving (Hayes & Simon, 1974); and (4) had automatized certain arithmetic skills with resultant increased memory capacity (Shiffrin & Dumais, 1981). Some individuals had developed their own heuristics with resulting shortcuts in processing time.

Effects of Absenteeism on Problem Solving

Twenty-two of the 48 subjects (11 males and 11 females), were absent from school for 11 days or more over the 6 semesters (2 academic years) prior to testing. Eliminating the absentee rates of individuals who were absent for reasons other than their chronic illness (e.g. orthopedic surgery), then 29% of the diabetics and 50% of the asthmatics were in the high absentee category. Seventeen percent of the diabetics and 25% of the asthmatics were absent for 35 days or more over the previous six semesters.

Parcel et al (1979) found the absentee rate for asthmatic children to be 8.4% of school days and the absentee rate for school children at large 5.9% of school days. Since there are 198 school days per academic year of three semesters, the anticipated absentee rate for asthmatic children over six semesters would be 35 days and for the individual who does not have a chronic health problem, 23 days. Fifty-four per cent of the children in this study had less than 11 days of absenteeism over 6 semesters which is less than half the anticipated absentee rate for children who are not chronically ill. The Sultz et al (1972) study found that 31% of the asthmatic children and 19.4% of the diabetic children were absent from school for more than six weeks during an academic year. Although the subjects in this study had fewer number of days absent from school per academic year than is reported in previous studies, asthmatic children did have more school absences than the diabetic children. Conway & Littlewood (1985), based on their study of hospital admissions for acute asthma, suggested that closer medical supervision and aggressive treatment protocols (i.e. medication regimes) would lower school absenteeism. All children in this study were closely followed by their respective medical teams and all were on medication regimes. This may have contributed to the lower school absentee rates for the children in this study as compared to absentee rates in the literature.

Nine of the high absentee subjects had reading scores below their group mean and six had mathematics scores below their group mean. Three of the individuals had below mean scores in both reading and mathematics. Comparing each group across the high and low absentee members, the high absentee grade seven male and female diabetics, the grade eight female diabetics and the grade eight male asthmatics had a higher percentage of reading questions correct than their low absentee peers. The high absentee grade seven female asthmatic, and the grade eight male and female diabetics and male asthmatics had a higher percentage of mathematics questions correct than their low absentee peers. These results do not support Rutter et al's (1970) finding that there is a strong positive relationship between reading retardation and absenteeism. The more recent statements by Weitzman et al (1980), and Walker & Jacobs (1984), that several factors impinge on the effect of absenteeism on school achievement needs further investigation. There is evidence that subjects with long absences (50-70 days) more frequently skip questions, especially mathematics questions, have more difficulty with problem representation and use less efficient procedural strategies. However, the percentage of responses demonstrating good declarative and procedural knowledge was the same or greater for the high absentee members of four of the eight groups in reading and three of the eight groups in mathematics, therefore suggesting that absenteeism alone is not the major cause of academic underachievement in reading and mathematics in Chronic Asthmatic and Insulin Dependent Diabetic children.

Ability to "Plan Your Day"

If the responses to this question are examined in terms of Sternberg's concept of metacomponents as executive processes used in planning, monitoring and decision making, it will be noted that the subjects had difficulty with each of the metacomponents he identified. Only 42% of the subjects completed all the tasks specifically identified in the problem statement and only 31% even minimally considered adding tasks related to personal needs to the global directions to "plan your day". The subjects had difficulty with problem identification and with problem representation. Had the question specifically asked what time the bank usually opens or how long it might take to try on and chose a bathing suit, the subjects would probably have given a response. However, subjects dealt with this problem at a very local level and had difficulty attending to even the defined tasks because of the novelty of the question. Because they were novices at answering this type of question, they perceived the problem on the basis of the clearly defined tasks and were not exhaustive in their processing of information (Schoenfeld & Herrman, 1982; Reif, 1980). ~~Had~~ there been more solution monitoring, more subjects would have completed all the tasks stated in the problem. Subjects who took buses that were either too early or too late would have realized their error had they stopped to work out the time of arrival and relate it to the plane's departure time.

The proposal by Hayes-Roth & Hayes-Roth (1979) that planners use opportunistic approaches to complex planning is also evident in the responses of the subjects to the planning question. The Hayes-Roth & Hayes-Roth planning model is multidirectional rather than orderly and sequential and suggests that planners pursue whatever seems promising at the time. Subjects displayed opportunistic choices dependent on the routes and the stores along the routes they chose to take. Opportunistic planning can lead to a greater variety and richness of plans across the subjects but in this case it also led to several inefficient routes being taken along with the failure to finish all the task requirements.

The aspect of the problem which presented the greatest difficulty was the element of time. Subjects could neither relate time-events nor time-distances. All 48 subjects had difficulty interpreting the bus schedules and only one grade seven subject took the most appropriate bus to the airport. Five grade eight subjects took the most appropriate bus to the airport indicating some improvement with the higher grade level. The time-management problem deserves further study. Children with chronic illnesses such as the insulin dependent diabetics are on set medication times and food intake times. It would be useful to know the extent of these subjects' problems with time schedules and time-event relationships.

Value of Information Processing Profiles

The individual information processing profiles in reading and in mathematics are useful diagnostic tools. They allow the educator to identify the child's problem solving strengths and weaknesses. Teaching methodologies best suited to the child's needs can then be employed. Similarly, teachers can use group profiles to better understand how groups of children process reading or mathematics questions. For example, the teacher who knows that 70% of the class could not correctly answer the question on averages because they could not identify or represent the problem, but who has evidence that the students can add and divide accurately, will focus instruction on the formation of problem representations from different task environments, rather than on addition and division. Similarly, inefficient solution strategies can be identified which would lead to a focus on developing better procedural knowledge skills. By graphing the frequency of the various information processing codes across a wide selection of domain specific problems, the major strengths and weaknesses of the group or individual can be readily identified and appropriate teaching strategies can be implemented.

It is important that the health educator understand a child's information processing abilities. Children with chronic illnesses, especially those who must learn several self-care procedures, are often given age appropriate demonstrations accompanied by material to read. Those who must learn to give their own insulin injections and weigh food or make food substitutions need to know basic mathematics concepts. The individual profiles can be helpful to individualize self-care teaching methodologies. On an empirical level it has been interesting to note that subjects presenting health management concerns also have had difficulty remembering or recalling reading information from the text and have frequently reasoned illogically or superficially in mathematics. Knowing that specific children have certain information processing weaknesses allows the health educator to provide a more appropriate teaching program.

CHAPTER 5

CONCLUSION

Evaluative Summary

In order to acquire a better understanding of the process of problem solving by children of varying abilities, it was necessary to extract from the literature on cognitive processing, the factors that relate to information processing abilities during problem solving, and then to identify an established method for collecting the data. To gain a better understanding of strengths and weaknesses in processing across high and low ability problem solvers, it was advantageous to analyze the problem solving abilities of a population of children expected to exhibit a wide range of abilities. It seemed most relevant to present the children with problems similar to those upon which their scholastic abilities are generally assessed and with which they have the greatest difficulty according to the literature (i.e. reading and mathematics).

Factors that relate to cognitive processing abilities during problem solving are the richness and organization of relevant declarative and procedural knowledge in long term memory and the child's ability to access this knowledge (the knowledge base the child brings to the task); the child's ability to acquire and organize new knowledge during the execution of the task (this relates to memory span, the amount an individual can encode in a single chunk, the present knowledge structures with which new material can be associated etc.); the child's ability to extract the critical features from the problem statement and form an appropiate knowledge representation; the amount of automatic processing used by the child, the depth of processing and the time taken to process the information; the efficiency and effectiveness of the strategies used by the child to work through the problem; and the child's ability to plan, monitor and use feedback. In order to identify and examine these variables, the literature provided examples of how tasks could be decomposed into components through the analysis of verbal protocols. Although there is much related information in the literature (studies of problem solving during

Tower of Hanoi, series completion, university physics questions etc.), there is little information relating specifically to curriculum-type problems at the elementary level.

The literature indicates that chronically ill children are at higher risk for academic problems than their healthy peers. Some of the studies based their conclusions on medical records, school records, parent or teacher interviews or on studies which did not adequately match control groups. However, indications that chronically ill children are more vulnerable to academic problems is clearly present in the literature and reading and mathematics are two curriculum areas with which these children appear to have particular difficulty.

A pool of test items reflective of the type of questions the children confront in school, appropriate for their grade level, and about which something was known regarding their degree of difficulty for non-chronically ill children was sought. The Canadian Tests of Basic Skills has limitations as a test battery and the methodology used in this study exposed some of the short comings, but there were advantages to using test items reflective of the type of questions teachers were giving these children at school, and which have national norms for the individual test items. The items presented to the subjects in this study were chosen so that a range of difficulty levels were offered. Permission from Nelson Canada to extract items for the purpose of this research was also an advantage. Used in the traditional sense the Canadian Tests of Basic Skills test items do discriminate against the creative thinker, but the think aloud method identified creative responses as well as the Canadian Tests of Basic Skills' correct response. Brown et al. (1982) discuss reading comprehension as internalized problem solving which takes place through the interaction of top-down (comprehension) and bottom-up (letter and word recognition) processes. This study analyzed children's responses to the type of reading questions still used by the school systems from which the children in the study were drawn and did not attempt to identify the cueing system used (graphophonic, syntactic or semantic).

Research objectives rather than hypotheses were formulated because predictions about information processing differences between the Chronic Asthmatic and Insulin Dependent Diabetic children could not be made. The study was exploratory in nature. The number of subjects in the study is limited if compared to quantitative studies, but if compared to studies in the information processing field, forty-eight subjects is not a small number (e.g. Schoenfeld (1979), had seven subjects; Holmes et al. (1983) had twelve subjects). A great deal of data is generated in this type of research and the analysis of the data is laborious but rich in information. A control group would have had to be matched for intelligence, age, sex, and possibly educational system since the subjects came from a wide geographical area served by several school boards. It was possible to determine the component processes related to individual differences in problem solving without a control group. Where the quantitative analysis identified significant between-group and within-group differences, information processing patterns contributing to these differences were identified and described. Healthy peers may have similar information processing patterns and it would be valuable to compare information processing differences. However, from a diagnostic point of view, to know from an individual's or a group's information processing profile that the correct answer was based on good declarative and procedural knowledge, or that there was no evidence of depth of processing and problem solving strategies were inefficient, or that the subjects could not extract the critical features from the problem statement, contributes to a better understanding of the children's strengths and weaknesses in problem solving.

The methodology developed and used in this study has implications for further use. The teachers who coded the verbal protocols for intercoder agreement did not know who the subjects were or whether they were Asthmatic or Diabetic children. Intercoder agreement ranged from .77 to .92. The coding system was used with 2,832 protocols and it provides an initial diagnostic framework for examining the problem solving process. The objective of the study was to identify and describe, not to compare. The value in determining significant differences in scores between and within groups was to identify and describe the information processes that contributed to the significant differences in performance. The item norms were used to select a range of easy to difficult questions and to serve as a point of reference. The Canadian Tests of Basic Skills' time limitations for answering the questions were not enforced and in some situations thinking aloud may have proved an advantage, therefore, if the subjects scored below the fall norms on certain skill objectives it is probably safe to say that these children are having more difficulty with these problems than is usual for children of the same grade level.

Finding that grade eight males are better at mathematics than grade eight females is not surprising, but being able to identify factors that contributed to the differences in performance enables the teacher to address these differences in performance. For example, on the single step mathematics problems, the grade eight female asthmatics demonstrated difficulty with problem representation in 38% of their responses but their male counterparts in only 4% of their responses. In 21% of the responses the females obtained incorrect answers because of weak procedural knowledge whereas this was the case in only 13% of the males' responses. This information demonstrates why 71% of the males' answers were correct but only 31% of the females' answers were correct. Whether the sex differences were related to self concept, parental or teacher expectations, role models, perceptual-spatial factors or right-left hemispheric differences was not addressed.

It is important to note differences in response times. Two groups of asthmatic subjects took significantly longer than their diabetic peers to respond to mathematics problems even though there was no significant difference in scores between the groups. The mean mathematics response time for the grade seven female diabetics was 65.38% less than the mean response time for the grade seven female asthmatics. When the literature suggests that asthmatic children may have concentration difficulties and the children state that they rarely finish tests at school, this becomes an important observation. These children appear to process information more slowly. It is also important to note that had there been time restrictions on the reading portion of the test, eight asthmatics and five diabetics would not have finished; and on the mathematics portion, 20 asthmatic and 17 diabetic children would not have finished. Out of 48 subjects, 77% would not have finished the mathematics test had there been the usual Canadian Tests of Basic Skills time restrictions.

With regard to absenteeism, asthmatics were absent more frequently than diabetics (17% of the diabetics and 25% of the asthmatics were absent for 35 days or more over the previous six semesters), but 44% of the chronically ill children in this study were absent for less than one-half the anticipated absentee rate for non-chronically ill children according to Parcel et al. (1979) figures. The percentage of responses demonstrating good declarative and procedural knowledge was the same or greater for the high absentee members in four out of eight groups in reading and three out of eight groups in mathematics. Subjects with absences of 50-70 days more frequently skipped questions, especially mathematics questions, had difficulty with problem representation and used less efficient procedural strategies.

Contributions Of The Study

1) The provision ~~of~~ a methodology for analyzing the information processing strengths and weaknesses of children associated with problem solving tasks in reading and mathematics.

2) The demonstration of the methodology through individual and group profiles of information processing strengths and weaknesses and a discussion of the diagnostic value of the information processing analysis.

3) The identification of response time differences which indicate a need for further study of the effects of time restrictions placed on chronically ill children during tests at school.

4) The provision of reading and mathematics

information processing profiles of subjects in this study which can contribute to changes in health care instruction methods.

5) The identification of information processing patterns of problem solving strengths and weaknesses which provide for school teachers, indicators of the type of information processing difficulties experienced by the diabetic and asthmatic children in this study.

6) Information about the effects of absenteeism on academic performance; on information processing variables; and absentee rates for children in this study who were on strict medical regimes is provided.

Suggestions For Further Study

Further research using the methodology of this study should be undertaken to examine information processing differences in children with no known health problems and children with known health problems as well as between children with known academic problems in reading and mathematics and those who perform well in these domains. There are a number of health related situations in which children's cognitive functioning is believed to be impaired, either in conjunction with a disease process or related to neurological involvement. The literature suggests there are differences in cognitive functioning when children are on corticosteroids and the question of the effects of beta adrenergic substances and theophylline on response times requires further examination. An indepth analysis of these children's information processing strengths and weaknesses would contribute further knowledge to an area which has been left largely unexplored.

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Consent Form

Information Processing Analysis Of Chronically Ill Children's Problem Solving Abilities

The purpose of the research project is to understand more fully why many chronically ill children have difficulty with academic subject material such as reading and mathematics. The research also is trying to identify the children's strengths and weaknesses in problem solving.

Involvement in the study will require 1½ to 2 hours of your child's time. Individual testing appointments will be made at your convenience. Your child will be asked to think-aloud and her/his responses will be tape recorded. The questions will be mainly math and reading questions suitable for his/her grade level in school. Since it is the thinking processes involved which are being sought, there is no need to be concerned about ability to answer the questions.

There will be no negative side effects to this procedure and although this investment of time on your child's part may be of no direct benefit to your child, it will be helpful to school teachers and health educators.

All information collected will be confidential and any publication arising from this research will not permit identification of any individuals.

You may withdraw from this research at any time, even after signing this consent without influencing the care your child receives at the Children's Hospital.

The research is being carried out by Denise Alcock, M.A., and she can be reached at 746-6242.

All my questions regarding this study have been answered by_______________ and I agree to participate.

Parent's Name	Signature	Date
Patient's Name	Signature	Date
Witness' Name	Signature	Date

APPENDIX B

TEST INSTRUMENT

NELSON CANADA
A DIVISION OF INTERNATIONAL THOMSON LIMITED

Publishers in Canada since 1914

1985 05 22

Miss Denise Alcock,
1 Massey Lane,
Gloucester, Ontario
K1J 6C7

Dear Miss Alcock,

Permission is granted for you to use the CTBS items as described in your letter May 14, 1985. This permission is subject to the following conditions:

1) The test be used only as described.
2) The test may not be sold.
3) The test may not be distributed outside the University of Ottawa.
4) A copy of your thesis, as it relates to CTBS, is to be forwarded to the publisher.

Good luck with your project. If I may be of any further assistance, please do not hesitate to contact me.

Yours sincerely,
NELSON CANADA

Peter D. Cameron

Peter D. Cameron, Manager
Measurement & Guidance Department

PDC/mn

1120 Birchmount Road, Scarborough, Ontario M1K 5G4 (416) 752-9100 Telex 06-963813

Test Format

Reading Items	Grade Level
1 - 15	Grade 7 & Grade 8
16 - 23	Grade 7
24 - 32	Grade 8

Mathematics Items	Grade Level
33 - 36	Grade 7
37 - 39	Grade 8
40 - 70	Grade 7 & Grade 8

Additional Test Item

Plan Your Day Question

(1.) Glaciers are an interesting fact of nature. They are moving bodies of ice that begin as heavy snowfall in areas of perpetual snow and intense cold. At present, glaciers are found on every continent except Australia.

(2.) Most common are valley, or alpine glaciers, frequent in the Alps. These form in mountains and move down valleys like rivers of ice. Some end with melting as they get below the snow line. Others travel far, like the glacier at the Columbia Icefield in Alberta, which is 286 km². Normally, it travels 27-30 m a year. Quite frequently, glaciers end at the head of rivers, lakes, or bays; and their melting feeds the body of water. Several valley glaciers may move together onto a plain and spread out. They are then known as piedmont (foot-of-the-mountain) glaciers. These persist only on high plateaus, and there are few of them. In very cold climates, in the polar regions, are found continental glaciers or icecaps. These may be hundreds of kilometres deep and cover entire mountain ranges. The Greenland Icecap has an area of more than 1 872 000 km², and the Antarctic Icecap covers an area larger than the United States. Piedmont and continental glaciers may move to the sea and break off as icebergs.

(3.) The absorbing thing about glaciers is that they do move — maybe centimetres a day or, in the summer, as much as 15 to 20 m. "How" is the question. Geologists now believe that glaciers consist, not of solid ice, but of large ice crystals that are in some way interlocked. They move, not by flowing but by splitting (called "shearing"), then closing up again. This series of cracking and closing works earth, pebbles, rocks, and boulders up through the glacier, sometimes to the surface. It is hastened in some way by the melting and refreezing of the ice. This movement is like the flowing of a river, faster at the top and centre and slower at the sides. It is not easy to see, but it can now be measured. It is known that the rate of movement varies with such factors as steepness of slope on which the glacier is moving, thickness of the glacier, and the weather.

(4.) Glaciers of past and present are of great interest to scientists. Those that have disappeared left marks that scientists recognize. By such marks, scientists know that, in the last Ice Age 10 000 years ago, all of Canada and much of northern United States were under glaciers. There is much evidence of this in the Great Lakes area and northern Minnesota, and many small glaciers still are found in Glacier National Park in Montana. One mark of the glacier is the path eaten into the bedrock of the earth as the glacier moved over it like a giant rasp. Others are the earth, the pebbles, the broken stone, and the rocks left behind as the glacier melted. This debris is left in patterns that show the direction of the glacier movement. Sometimes a huge boulder, unlike any other around it, tells the scientist that a glacier has carried it there. We might call these marks the writing of glaciers in the history of the earth.

1. Why are scientists especially interested in glaciers?
    1) Glaciers are very rare.
    2) Glaciers are disappearing from the earth.
    3) An understanding of glaciers may reveal important facts about the history of the earth.
    4) The reasons for the movement of glaciers has long been a comple puzzle to scientists.

2. Which of these is not a name for a type of glacier?
    1) Alps
    2) Continental
    3) Piedmont
    4) Valley

3. Where are glaciers formed today?
    1) Only in deep valleys
    2) Only in the Swiss Alps
    3) Only in the Arctic or Antarctic
    4) Only where there is heavy snow and bitter cold

4. Why do not all glaciers disappear in the summer?
    1) Mountains protect glaciers from the sun.
    2) Many glaciers are found where it is cold the year around.
    3) There is no summer in places where glaciers occur.
    4) Rocks and earth in glaciers keep them from melting.

5. Paragraph 2 is about which of these?
    1) The movement of glaciers
    2) The shape of glaciers
    3) The thickness of glaciers
    4) The kinds of glaciers

6. Which of these phrases tells best how continental glaciers differ from piedmont or valley glaciers?
    1) Faster melting
    2) More extensive
    3) Faster in motion
    4) More common

7. Paragraph 3 is mostly about which of these?
    1) The kinds of glaciers
    2) The marks glaciers leave behind
    3) How glaciers move
    4) The effect of weather on glaciers

8. Which of these is true of the movement of glaciers?
    1) It cannot be measured.
    2) It occurs only in summer.
    3) It is fast in the winter and slow in the summer.
    4) The rate varies greatly.

9. Which paragraph shows how scientists are able to tell where glacier were in the past?
   1) One
   2) Two
   3) Three
   4) Four

10. Which of these is most like the " writing of glaciers in the history of the earth"?
    1) The minerals taken from mines deep under the earth
    2) The remains of ancient plants and animals in rock formations
    3) The hieroglyphic writings of the Egyptians
    4) The writings of historians of ancient Greece

11. Which of these is important in the movement of all glaciers?
    1) Changing weather
    2) Width of valleys
    3) Nearness to water
    4) Location of snow line

12. The "debris" in the last paragraph is which of these?
    1) Earth, stones, and other matter carried by glaciers
    2) The bedrock of the earth over which glaciers pass
    3) The water that runs off from the melting of glaciers
    4) The path made by a glacier as it moves

13. Paragraph 4 is mostly about
    1) how the Great Lakes were formed.
    2) what glaciers were like during the last Ice Age.
    3) changes made by glaciers in some areas of Canada and the U.S.
    4) why there are strange rocks in northern Minnesota.

14. Three of the following are indicated in the article as being caused by glaciers. Which is not?
    1) Icebergs
    2) A colder climate
    3) Flooded rivers
    4) Removal of topsoil

15. What appears to be the purpose of this selection?
    1) To persuade
    2) To entertain
    3) To inform
    4) To question

1. Brian and Sonia entered the woods just as the sun was rising. They might have been any two friends off on a day's hike, except for one thing. Brian was in a wheelchair, and Sonia was pushing him. They took turns looking through a pair of field glasses. Every so often, Brian would whisper a number. Sonia would then turn to a page in a book. She would show the page to Brian, and the two would nod and smile.

2. Brian and Sonia were bird watchers. Although they shared this common interest, they were different in many ways. Sonia enjoyed the outdoors, but until she met Brian, all her outdoor activities involved sports. Brian was born with cerebral palsy. His mind was sharp, but he could not control his arm and leg movements very well.

3. Sonia felt sorry for Brian. She wanted to help him. Since there was a woods nearby, she offered to push Brian's wheelchair over the bumpy path so Brian could enjoy the outdoors. Sonia's offer pleased Brian. But Brian surprised Sonia. Every time he spotted a bird, he would tell Sonia its name and interesting ~~things about~~ it. Brian had made good use of the many hours he had to spend indoors. Brian could answer most of the questions Sonia asked about a bird.

4. Sometimes their talks would be so long and loud that the bird had flown away by the time they finished. So, they decided on a new plan of action. They took along a birdwatching guide when they went walking in the woods. When they spotted a bird, Brian would whisper the number of the page in the book that he thought told about the bird. Sonia would verify it and read the information silently. Since Brian already knew what was on the page, he spent all his time looking. When they returned from their outing, they made a bird chart. On it they drew and painted true-to-life pictures of the birds they had seen. They also wrote down when and where the birds had been found.

5. As time went on, Sonia stopped feeling sorry for Brian. She realized they both had something to give as well as receive.

16. Why had Sonia offered to push Brian's wheelchair?
    1) Brian couldn't handle a wheelchair at all.
    2) Sonia wanted to tell Brian all about the birds.
    3) Sonia wanted to do a good deed.
    4) Sonia wanted to get some fresh air and exercise.

17. What is the main topic of paragraph 2?
    1) Brian's accident
    2) The background of the two friends
    3) How Sonia helped Brian
    4) Sonia's interest in sports

18. In what way had Brian made good use of his time indoors?
    1) He had written a book.
    2) He had taught Sonia how to paint.
    3) He had learned something.
    4) He had exercised his arms and legs.

19. What does the story suggest about Brian's knowledge of the bird watcher's guide?
    1) He had practically memorized the information in it.
    2) He knew it well because he helped write it.
    3) He was familiar only with certain parts of the book.
    4) He knew about how many pages it contained.

20. As Sonia got to know Brian better, her attitude toward him changed from
    1) dislike to admiration.
    2) jealousy to friendship.
    3) worry to unconcern.
    4) pity to respect.

21. What do the words, "Sonia would verify it," in paragraph 4 mean?
    1) She could read what the book said to Brian.
    2) She would check to see if Brian was right.
    3) She would memorize what the book said.
    4) She would write down what Brian had whispered.

22. In what way had Sonia been helped?
    1) Her eyes had been opened to something she didn't know.
    2) She had gotten answers to some difficult questions.
    3) She had been given a beautiful bird chart.
    4) She had been taken someplace she would not have been able to go by herself.

23. In an outline of paragraph 4, " Observing the bird " is one topic. Which of these would be the other topic in the outline?
    1) "Unusual birds of the forest"
    2) "Following the bird's flight"
    3) " Painting and selling bird pictures"
    4) " Recording the information"

What do you look for when you buy shoes? Do you buy shoes to match your clothes? Or, are you more interested in the latest fashion? Actually, the colour and style of your shoes are a matter of personal taste. In fitting shoes, though, there are a few rules you can follow.

Make sure the shoe clerk measures both your feet. One foot may be smaller than the other. It is usually best to buy the larger size. Have the length and width of your foot measured in both a standing and a sitting position. Some feet stretch or spread when standing. A shoe that feels comfortable while you are sitting may not be comfortable to walk in. Your shoes should be two to three centimetres longer than your foot when you are standing. The shoe should be widest at the ball of your foot. It should give good support under the arch, and should fit snugly over the instep and at the heel. A shoe should not pinch when you bend your foot. It should not slip at the heel. You should be able to wiggle your toes freely in it.

The next time you buy shoes, look for colour, style, and fit. You will then, indeed, be able to put your best foot forward!

24. Where should a shoe be roomy?
 1) Over the instep
 2) At the heel
 3) At the toe
 4) Under the arch

25. About how much longer than your foot should your shoe be when you are standing?
 1) 1 cm
 2) 2.5 cm
 3) 3.5 cm
 4) 5 cm

26. Why is it usually best to buy the larger size shoe if one foot is smaller than the other?
 1) So only one shoe will be too small
 2) So one shoe will not be too big
 3) So your feet will have room to grow
 4) So both shoes will be large enough

27. What does the closing phrase, "put your best foot forward," mean?
 1) Make a good appearance
 2) Favour your strongest foot
 3) Show off your new shoes
 4) Wear the best shoes money can buy

BELIEF

Fallen, a giant aspen blocked the spring.
The water rose to form a pool, mirroring
Leaf-lace.

Over the moss-green log to moss below,
As mist, as rain, with its own shining bow,
It fell.

There - and we saw it - in that magic wood,
Wing'ed and crowned, a tiny fairy stood,
Tiptoe.

Look! Look! And there was only water sheen.
Four eyes were certain of what they had seen?
They were.

28. The scene in the poem might be described as which of these?
   1) One of quiet beauty
   2) One of lingering mystery
   3) One of haunting loneliness
   4) One of gaiety and dancing

29. What is the meaning of "its own shining bow"?
   1) The tiny fairy was bowing.
   2) The pool reflected the sky above.
   3) The water fell in a curve.
   4) Sun on the falling water created a tiny rainbow.

30. What does the first line in the last stanza of the poem show?
   1) The fairy was seen for only an instant.
   2) The fairy cried out before it disappeared.
   3) The persons in the wood were shouting.
   4) Their cries frightened the fairy away.

31. The person who wrote the poem was
   1) alone.
   2) with one other person.
   3) part of a crowd.
   4) not really in the wood.

32. What was the fairy in the poem?
   1) A spirit of the magic wood
   2) The movement of the falling water
   3) Something the poet believed she saw
   4) A small figure someone had left in the wood

33. The owner of a local greenhouse gave the scouts 176 tulip bulbs to beautify the neighbourhood playground. They made 11 flower beds and planted the same number of bulbs in each bed. HOW MANY TULIP BULBS DID THEY PLANT IN EACH BED?

1) 11
2) 16
3) 17
4) (Not Given)

34. Last week Rod put 17 cases of tomato soup on the shelves of the supermarket. There were 24 cans of soup in each case. HOW MANY CANS OF TOMATO SOUP DID ROD PUT ON THE SHELVES?

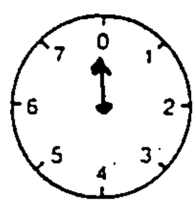
1) 41
2) 308
3) 408
4) (Not Given)

35. Since Rod has worked at the supermarket he has saved \$285.35. IF HE SPENDS \$ 109.95 FOR A NEW BICYCLE, HOW MUCH MONEY WILL HE HAVE LEFT?

1) \$ 175.40
2) \$ 185.40
3) \$ 395.30
4) (Not Given)

36. Below is a picture of a time clock at a factory. The clock has only one hand, which takes 8 h to go around once. IF THE HAND STARTS AT 0, WHERE WOULD IT BE AFTER 15 h?

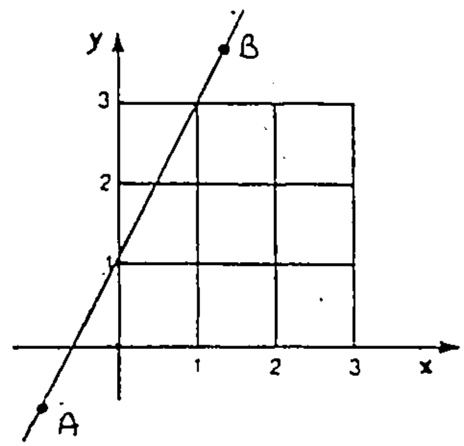
1) 0
2) 3
3) 5
4) 7



37. Which of the following has the same value as 48 x 6?
1) (50 x 6) - (2 x 6)
2) (48 x 2) + (48 x 3)
3) (40 x 8) + (6 x 1)
4) (48 + 2) x (6 - 2)

38. Mr. and Mrs. King bought a 2-year fire insurance policy on the house with $40 000 of coverage. The 2-year rate was 1.75 times the annual rate of $4.00 per $1 000. What did the insurance cost for 2 years?
1) $160
2) $280
3) $320
4) (Not Given)

39. Which equation gives a formula for line AB shown on the graph below?
1) $y = 2x + 1$
2) $y = 2x - 1$
3) $y = \frac{1}{2}x + 1$
4) $y = \frac{1}{2}x - 1$



40. What is the missing numeral in the number series below?

$\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{7}$, , $\frac{5}{11}$,

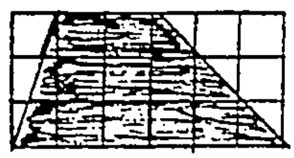
1) $\frac{3}{8}$ 2) $\frac{4}{7}$ 3) $\frac{4}{8}$ 4) $\frac{4}{9}$

41. The average of three numbers is 8. two of the numbers are 11 and 9. What is the other number?
1) 3 2) 4 3) 8 4) 10

42. What is the area of the shaded part of the figure below?

□ = unit of area

1) 6
2) 12
3) 15
4) 18



43. Which number sentence below is false?

1) $\frac{3}{6} > \frac{2}{3}$

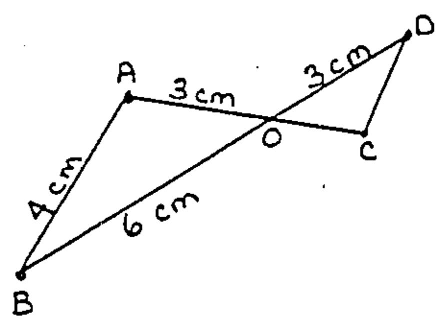
2) $\frac{1}{2} < \frac{3}{4}$

3) $\frac{1}{5} > \frac{1}{6}$

4) $\frac{3}{6} = \frac{6}{12}$

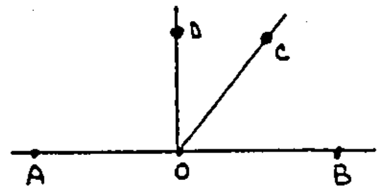
44. The scale on a map of Canada is 1cm = 300 km. Bill's hometown is approximately 2.67 cm from Sudbury. About how far does Bill live from Sudbury?
1) 900 km
2) 800 km
3) 600 km
4) 200 km

45. In the drawing below, line segments AB and CD are parallel. What is the length of line segment CD?
1) 1.5 cm
2) 2 cm
3) 3 cm
4) 4 cm



46. Which sign if placed in the O will make 2 O $\frac{1}{2}$ = 1 a true number sentence?
1) + 2) − 3) × 4) ÷

47. In the diagram below, which angle has a measure of about 60 degrees?
1) AOD
2) AOC
3) DOC
4) BOC



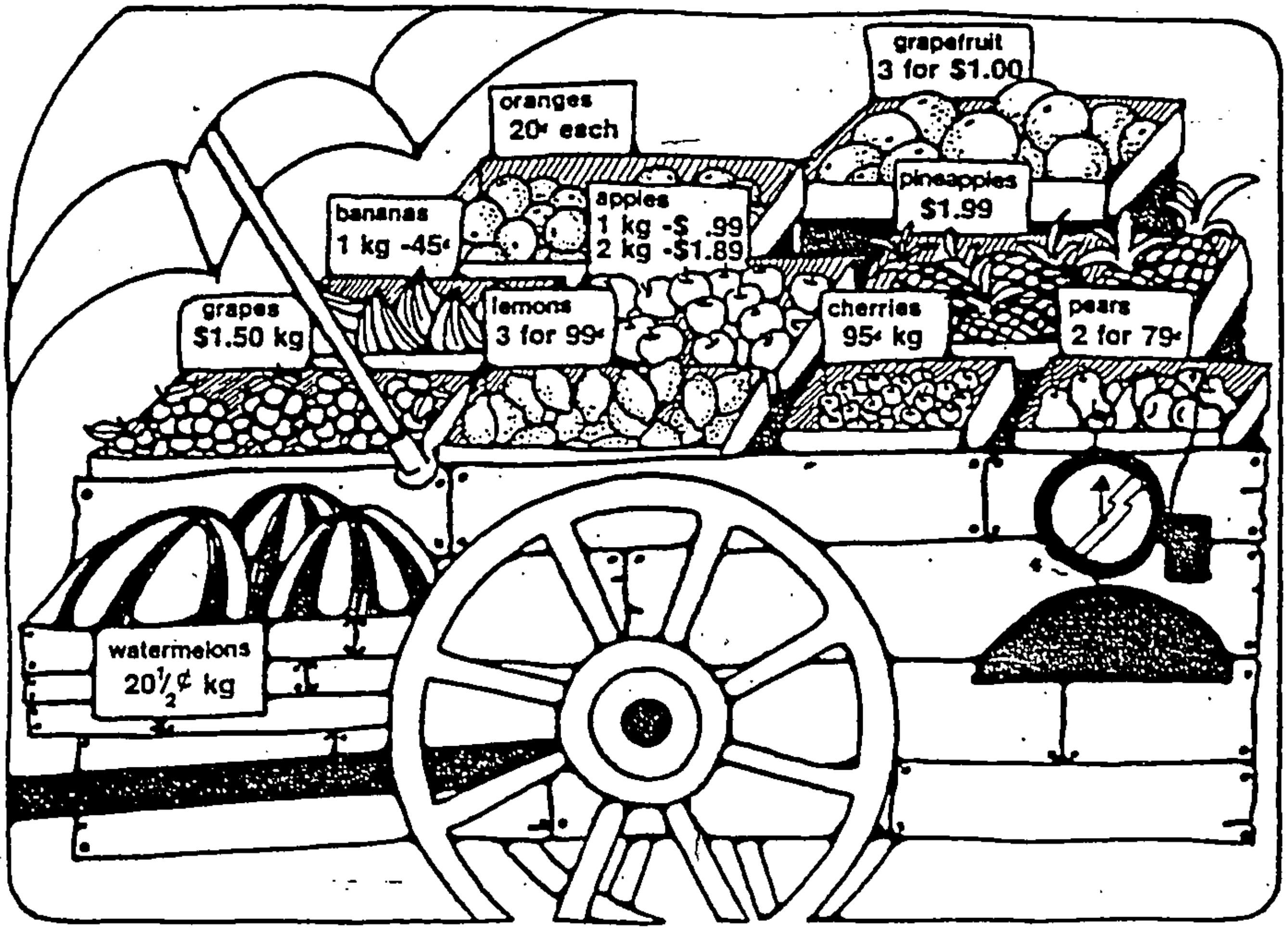
48. One day the members of Vera's cabin went fishing. The fish Vera caught had a mass of 1 kg. One of her friends caught a fish that had a mass of 700 g. How much greater was the mass of Vera's fish than her friend's fish?
1) 1 300 g
2) 1 700 g
3) 300 g
4) (Not Given)

49. The class printed 360 copies of the first issue, 400 copies of the second issue, and 425 copies of the third issue. What was the increase in number of copies printed from the first to the third issue?
1) 65
2) 60
3) 40
4) (Not Given)

50.

Hot Chocolate
900 mL milk
75 mL cocoa
120 mL sugar
1 mL salt
5 mL vanilla
serves 4

Gwen had 225 mL of cocoa. How many servings of hot chocolate will this make?
1) 6
2) 12
3) 16
4) (Not Given)

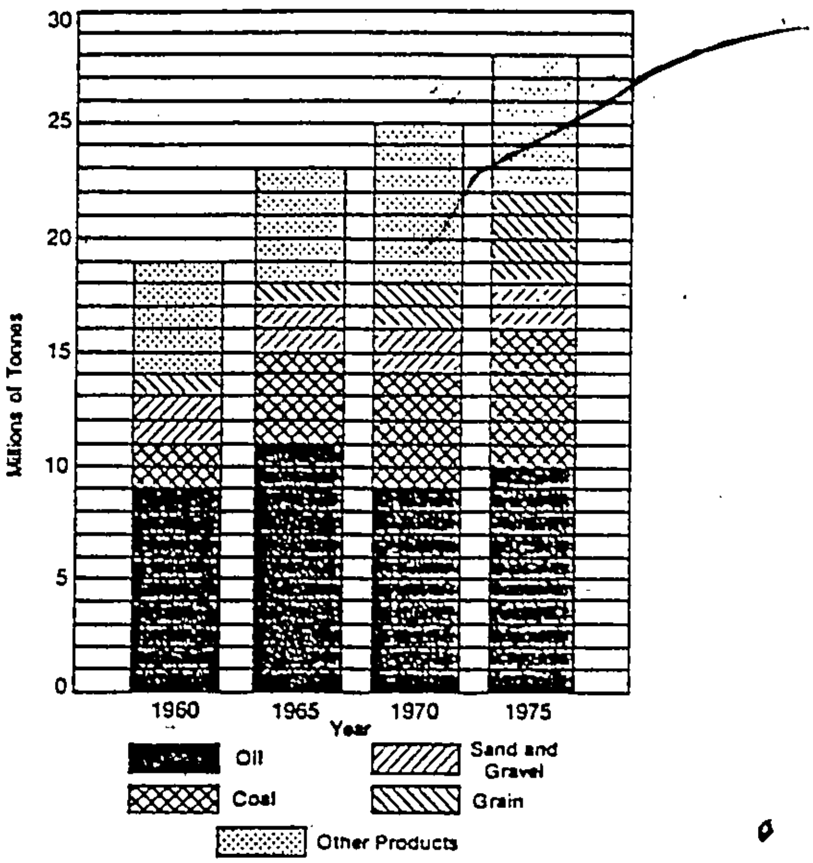


51. The watermelon Sam selected had a mass of 8 kg. How much did the watermelon cost?
    1) 82 cents
    2) $1.60
    3) $1.64
    4) (Not Given)

52. Mel paid $2.00 for some grapes. What was the mass of the grapes?
    1) 2 kg
    2) 1.5 kg
    3) 1.33 kg
    4) 1 kg

53. How much did Mrs. Johnson pay for 6 grapefruit and a 2 kg bag of apples?
    1) $2.89
    2) $3.89
    3) $7.89
    4) (Not Given)

ANNUAL SHIPMENTS ON A MAJOR RIVER



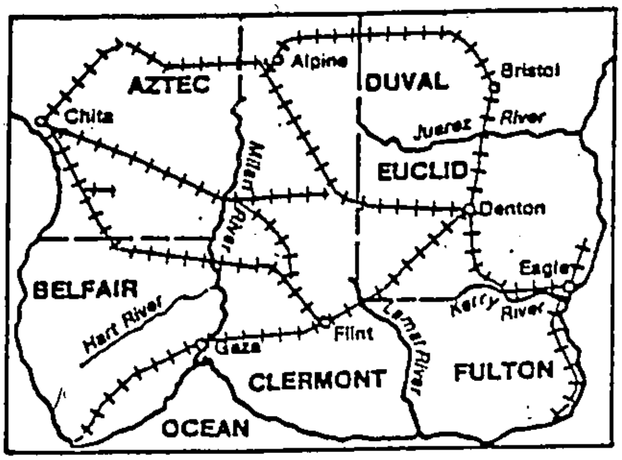
54. How did the amount of coal shipped in 1975 compare with that shipped in 1970?
    1) One million more tonnes were shipped in 1975.
    2) Twice as much was shipped in 1975.
    3) Three times as much was shipped in 1975.
    4) The same amount was shipped each year.

55. For how many of these years was the amount of oil shipped greater than the amount of any other one thing?.
    1) 1   2) 2   3) 3   4) 4

56. The shipments of which product increased every year?
    1) Oil   3) Coal
    2) Grain   4) Other products

57. About what part of all material shipped in 1965 was oil?
    1) One-fifth   3) One-third
    2) One-fourth   4) One-half

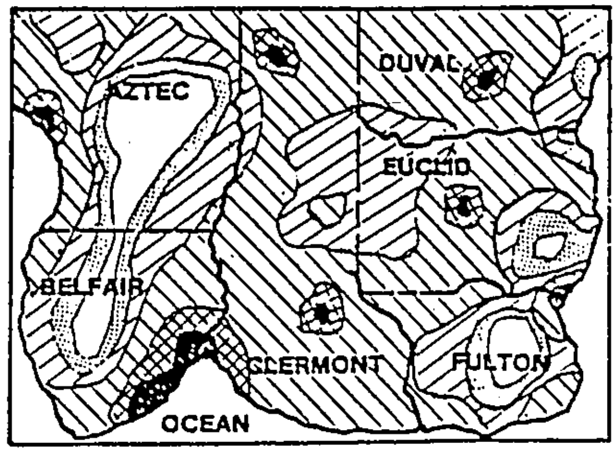
58. The amount of sand and gravel shipped in 1965 was half as great as what other material?
    1) Oil   3) Grain
    2) Coal   4) Other products



OUTLINE MAP

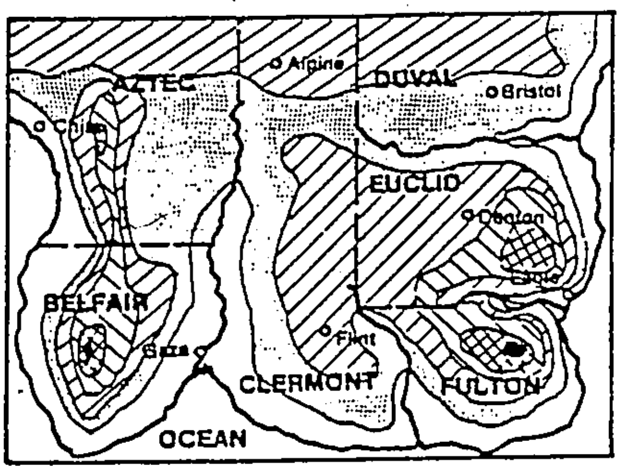
Main Railroads

km 0 100 200 300 400 500



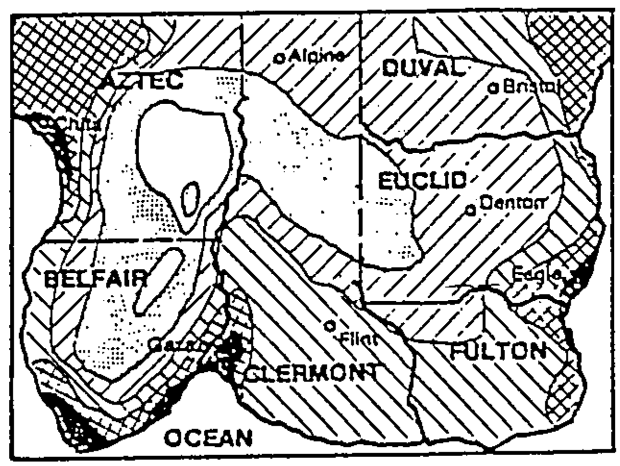
POPULATION (in number of people per km²)

Under 2 | 2-6 | 6-18 | 18-45 | 45-90 | Over 90



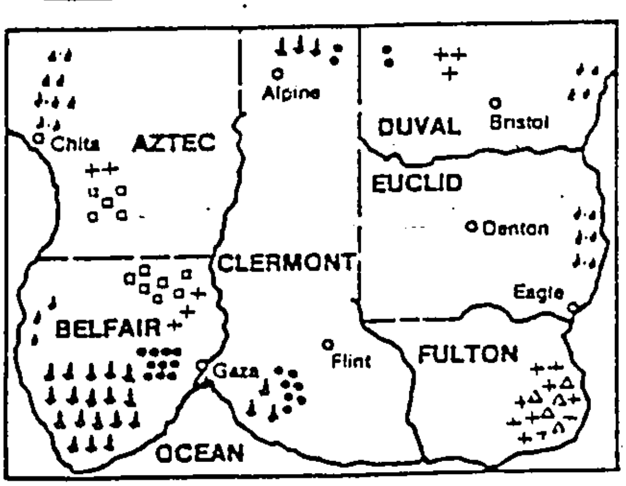
ELEVATION (in number of metres above sea level)

0-150 | 150-300 | 300-600 | 600-1500 | 1500-3000 | OVER 3000



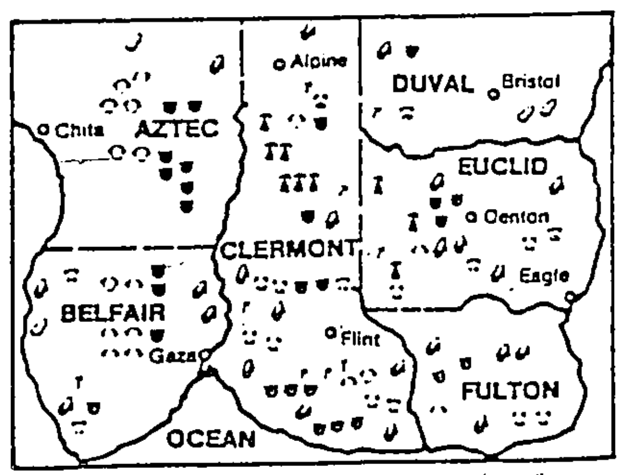
PRECIPITATION (in millimetres per year)

250-500 | 500-750 | 750-1000 | 1000-1250 | 1250-1500 | OVER 1500



RESOURCES (each figure represents $1 000 000)

Coal | Copper | Petroleum | Iron | Forests | Natural Gas



CROPS (each figure = 250 000 t) LIVESTOCK (each figure = 500 000 head)

Corn | Wheat | Sheep | Hogs | Oats | Potatoes | Cattle

On the opposite page are six different maps of a small country. There are six provinces in this land. The maps show the population, elevation, precipitation, resources, crops, and livestock in these provinces.

59. In what direction does the Hart River flow?
1) Northeast
2) Northwest
3) Southeast
4) Southwest

60. In Belfair, which of these resources brings in the greatest annual income?
1) Copper
2) Coal
3) Natural gas
4) Petroleum

61. Where are the areas of greatest precipitation?
1) Along the rivers
2) Along the coasts
3) In the mountains
4) In the agricultural regions

62. Which province has the greatest income from forest products?
1) Aztec
2) Belfair
3) Duval
4) Euclid

63. Where is the greatest population centre located?
1) Along the west coast
2) In southeastern Fulton
3) Near the mouth of the Milan River
4) Near the centre of Euclid

64. In Aztec, what use is made of the land with the least annual precipitation?
1) Mining
2) Grazing
3) Raising hogs
4) Growing lumber

65. Where are most of the cattle in Aztec raised?
1) In the mountains
2) In forested regions
3) On low, flat plains
4) Where there is plenty of corn for feed

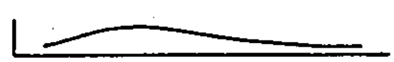
66. Which of these cities would most likely have large oil refineries?
1) Chita
2) Eagle
3) Flint
4) Gaza

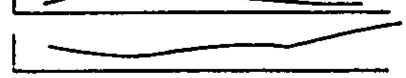
67. About how many millimetres of precipitation do the greatest wheat-producing regions get?
1) 650
2) 900
3) 1150
4) 1650

68. What is the total annual corn production in Clermont?
1) 200 000 t
2) 800 000 t
3) 2 000 000 t
4) 2 500 000 t

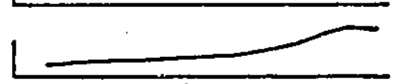
69. A pipeline for natural gas runs directly from the fields in southern Clermont to Denton. About how long is it?
1) 110 km
2) 330 km
3) 400 km
4) 483 km

70. Which of these line graphs best shows the change in elevation along the railroad from Denton to Eagle?

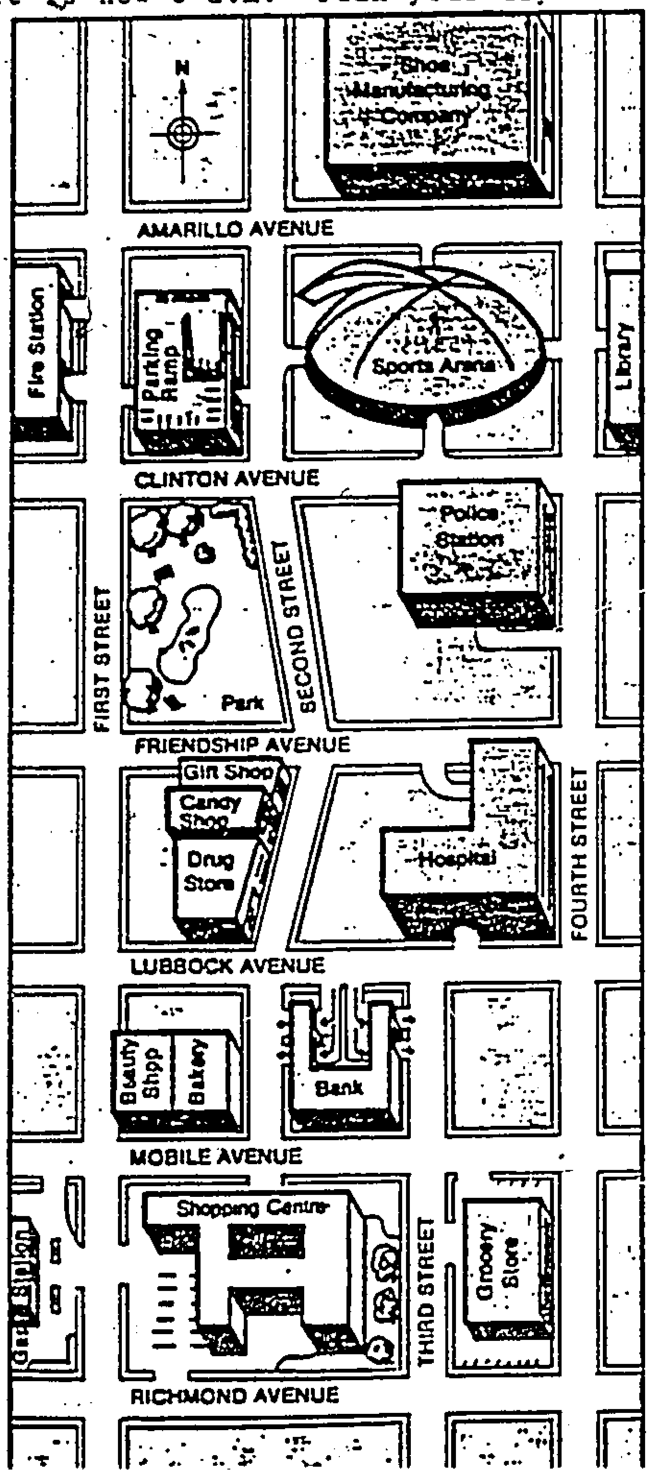
1) 

2) 

3) 

4) 

You live with your family on First Street North, 14 blocks from the Fire Station. Today will be a busy day for you. At 4:30 this afternoon you are taking a plane to Quebec City because you are taking part in a student-exchange program. Before leaving you have to return library books; buy a gift for the family you will be staying with; go to the bank and get traveller's cheques; and buy a bathing suit. Also, your mother has asked you to bring home a carton of milk. The bus to the airport leaves every hour (1 o'clock, 2 o'clock etc.) from the corner of First Street and Richmond Avenue, and takes 45 minutes to get to the airport. The First Street bus from your home to Richmond Avenue takes 15 minutes and runs every 30 minutes. It is now 8 a.m. Plan your day.



Appendix C

Reading Code Definitions

Code	Definition
CO	Correct answer only Appears to understand the problem right away
CB	Correct answer with basis for answer Appears to understand the problem right away Uses logical reasoning to arrive at the right answer or accurately recalls content and fully explains basis for answer
CNB	Correct answer not based on text Appears to understand the problem May respond by eliminating answers or by reasoning not based on information in the text
INB	Incorrect answer not based on text Appears to understand the problem Does not remember or retrieve content from the text accurately or at all May choose the "best" answer
CWK	Correct answer but demonstrates weak domain specific knowledge Appears to understand the problem May not use all the information given in the question or may reason illogically or superficially
IWK	Incorrect answer - demonstrates weak domain specific knowledge Appears to understand the problem May not use all the information given in the question or may reason illogically or superficially
CDR	Correct answer but difficulty with problem representation May not understand the problem fully Domain specific knowledge weak
IDR	Incorrect answer - has difficulty with problem representation May not understand the problem fully Domain specific knowledge weak
UPR	Unable to form a problem representation Abandons the problem or seeks help
CE	Correct answer but elaborates the story content, the question or the answer
IE	Incorrect answer - elaborates the story content, the question or the answer
CW	Correct answer but had to work at understanding or solving the problem
IW	Incorrect answer but worked diligently at understanding or solving the problem
SP	Skipped the problem without attempting to do it

Appendix D

Mathematics Code Definitions

Code	Definition
CO	Correct answer only Appears to understand the problem right away
CB	Correct answer with basis for answer Appears to understand the problem right away Demonstrates domain specific knowledge Procedural strategy efficient
CWK	Correct answer but demonstrates weak domain specific knowledge Appears to understand the problem May not use all the information given in the question or may reason illogically or superficially
IWK	Incorrect answer - demonstrates weak domain specific knowledge Appears to understand the problem May not use all the information given in the question or may reason illogically or superficially
CEA	Correct answer by eliminating answers Appears to understand the problem but arrives at answer through elimination of incorrect responses
IEA	Incorrect answer by eliminating answers Appears to understand the problem Eliminates the answers to arrive at response which is incorrect
CCE	Correct answer but makes calculation error Appears to understand the problem
ICE	Incorrect answer because of calculation error Appears to understand the problem
CDR	Correct answer but difficulty with problem representation May not understand the problem fully Domain specific knowledge weak
IDR	Incorrect answer - has difficulty with problem representation May not understand the problem fully Domain specific knowledge weak
UPR	Unable to form a problem representation Abandons the problem or seeks help
CW	Correct answer but had to work at understanding or solving the problem
IW	Incorrect answer but worked diligently at understanding or solving the problem
SP	Skipped the problem without attempting to do it

Appendix E

Scores And Response Times Of Diabetic Subjects

Subj	Grade	Group	Absent	Reading Response Time	Reading Score	Math Response Time	Math Score
1	7	MD	1	628	13	2034	20
2	7	MD	0	440	16	1532	19
3	7	MD	0	448	12	1503	26
4	7	MD	0	1126	13	3255	23
5	7	MD	0	375	9	1847	28
6	7	MD	1	1720	16	2765	14
7	7	FD	0	566	15	1819	26
8	7	FD	0	410	19	1815	19
9	7	FD	1	976	17	2018	26
10	7	FD	0	1095	17	1781	28
11	7	FD	1	1223	14	1467	13
12	7	FD	1	464	21	1054	28
13	8	MD	1	467	16	823	25
14	8	MD	0	408	16	1862	22
15	8	MD	1	1403	16	1998	21
16	8	MD	0	264	16	810	23
17	8	MD	0	1028	14	1985	26
18	8	MD	0	442	11	1852	21
19	8	FD	0	1078	14	2314	17
20	8	FD	0	859	13	1784	12
21	8	FD	1	1078	20	1976	29
22	8	FD	0	467	9	1797	15
23	8	FD	1	408	11	1545	21
24	8	FD	0	605	15	2747	18

Note: Subj = Subject; MD = Male Diabetic; FD = Female Diabetic; Absent 0 = Absent from school for 10 days or less over the past 2 school years; Absent 1 = Absent from school for 11 days or more over the past 2 school years; Time in seconds.

Appendix F

Scores And Response Times Of Asthmatic Subjects

Subj	Grade	Group	Absent	Reading Response Time	Reading Score	Math Response Time	Math Score
25	7	MA	1	656	21	2612	31
26	7	MA	1	567	8	2199	24
27	7	MA	0	476	18	1186	33
28	7	MA	1	860	16	1915	30
29	7	MA	1	1572	13	1782	7
30	7	MA	0	727	17	2315	19
31	7	FA	0	1106	19	3121	26
32	7	FA	1	711	6	1762	15
33	7	FA	0	801	16	2241	24
34	7	FA	0	1106	18	2529	13
35	7	FA	0	1343	11	2946	16
36	7	FA	1	1111	20	2624	26
37	8	MA	1	678	13	2551	27
38	8	MA	1	1122	20	2429	31
39	8	MA	0	207	16	2322	28
40	8	MA	0	385	13	1981	14
41	8	MA	1	475	15	1309	28
42	8	MA	0	828	13	2685	27
43	8	FA	1	616	17	2453	12
44	8	FA	1	358	9	1201	9
45	8	FA	0	811	14	1853	26
46	8	FA	1	381	9	2004	18
47	8	FA	1	838	15	2356	17
48	8	FA	0	308	12	1402	16

Note: Subj = Subject; MA = Male Asthmatic; FA = Female Asthmatic; Absent 0 = Absent from school for 10 days or less over past 2 school years; Absent 1 = Absent from school for 11 days or more over the past 2 school years; Time in seconds.

Appendix G

Table G-1

Means And Standard Deviations Of Reading And Mathematics Scores And Response Times

Sex/Group (n=6)	MD	FD	MA	FA
		Grade 7		
Reading Score				
M	13.16	17.16	15.50	15.00
SD	2.41	2.34	4.11	4.96
Reading Response Time				
M	789.50	789.00	809.66	1029.66
SD	485.75	320.40	361.55	212.24
Math Score				
M	21.66	23.33	24.00	20.00
SD	4.64	5.27	8.94	5.45
Math Response Time				
M	2156.00	1659.00	2001.50	2537.17
SD	646.12	315.33	452.89	447.99
		Grade 8		
Reading Score				
M	14.83	13.66	15.00	12.66
SD	1.86	3.45	2.52	2.98
Reading Response Time				
M	668.50	749.16	615.83	552.00
SD	406.33	272.37	301.48	215.78
Math Score				
M	24.66	18.66	25.83	16.33
SD	3.29	5.37	5.46	5.31
Math Response Time				
M	1555.00	2027.16	2212.83	1878.16
SD	525.11	397.42	459.46	458.35

Note. MD = Male Diabetic; FD = Female Diabetic; MA = Male Asthmatic; FA = Female Asthmatic. Time in seconds.

Appendix G

Table G-2

Mann-Whitney U Statistic

Groups	Reading Scores	Reading Response Times	Math Scores	Math Response Times
		Grade 7		
MD & FD	32*	20	22.5	27
MA & FA	18	27	24.5	28
MD & MA	26	23	23.5	19
FD & FA	20.5	27	25.5	32*
MD, FD & MA, FA	80	95	73.5	100
		Grade 8		
MD & FD	25	23	30.5*	22
MA & FA	24.5	21	31*	25
MD & MA	21	26	25.5	30*
FD & FA	20	27	22.5	27
MD, FD & MA, FA	80	88	73.5	96

Note: For $\alpha = 0.05$, the critical values are U* = 29 for $n_1 = n_2 = 6$, and U* = 102 for $n_1 = n_2 = 12$

MD = Male Diabetic; FD = Female Diabetic;
MA = Male Asthmatic; FA = Female Asthmatic

Appendix H

Table H-1

Information Processing Code Frequencies And Percentage Occurrences: Reading - Recognizing And Understanding Factual Information

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
	Grade 7			
CO	5 (13.88)	5 (13.88)	7 (19.44)	1 (2.77)
CB	6 (16.66)	12 (33.33)	9 (25.00)	14 (38.88)
CNB	7 (19.44)	5 (13.88)		1 (2.77)
INB	10 (27.77)	7 (19.44)	7 (19.44)	5 (13.88)
CWK	1 (2.77)			
IWK	1 (2.77)	2 (5.55)	7 (19.44)	5 (13.88)
CDR			1 (2.77)	
IDR	6 (16.66)	4 (11.10)	3 (8.33)	5 (13.88)
UPR		1 (2.77)	1 (2.77)	1 (2.77)
CE			1 (2.77)	
IE				
CW				1 (2.77)
IW				3 (8.33)
SP				
Total	36	36	36	36
% Correct Responses	53	61	50	47
	Grade 8			
CO	9 (18.75)	7 (14.58)	16 (33.33)	11 (22.91)
CB	16 (33.33)	12 (25.00)	11 (22.91)	5 (10.41)
CNB		3 (6.25)	6 (12.50)	4 (8.33)
INB	18 (37.50)	14 (29.16)	9 (18.75)	17 (35.42)
CWK	1 (2.08)	1 (2.08)	1 (2.08)	
IWK	2 (4.16)	3 (6.25)	4 (8.33)	4 (8.33)
CDR		1 (2.08)		3 (6.25)
IDR	1 (2.08)	2 (4.16)	1 (2.08)	3 (6.25)
UPR				
CE		1 (2.08)		
IE				
CW		2 (4.16)		1 (2.08)
IW	1 (2.08)	2 (4.16)		
SP				
Total	48	48	48	48
% Correct Responses	54	56	71	50

Note: For code definitions see Appendix C
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix H

Table H-2

Information Processing Code Frequencies And Percentage Occurrences: Reading - Making Generalizations

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
		Grade 7		
CO	8 (14.81)	8 (14.81)	18 (33.33)	6 (11.10)
CB	16 (29.62)	31 (57.41)	15 (27.77)	22 (40.70)
CNB	3 (5.55)	4 (7.41)	3 (5.55)	4 (7.41)
INB	20 (37.04)	6 (11.10)	6 (11.10)	8 (14.81)
CWK	1 (1.85)		1 (1.85)	3 (5.55)
IWK	2 (3.70)	3 (5.55)	2 (3.70)	3 (5.55)
CDR	1 (1.85)		1 (1.85)	3 (5.55)
IDR	3 (5.55)	2 (3.70)	4 (7.40)	2 (3.70)
UPR			1 (1.85)	
CE				
IE				
CW			3 (5.55)	2 (3.70)
IW				1 (3.70)
SP				
Total	54	54	54	54
% Correct Responses	54	80	76	74
		Grade 8		
CO	17 (25.76)	18 (27.27)	25 (37.88)	22 (33.33)
CB	27 (40.90)	15 (22.73)	10 (15.15)	8 (12.12)
CNB		1 (1.52)	2 (3.03)	1 (1.52)
INB	7 (10.61)	10 (15.15)	13 (19.70)	14 (21.21)
CWK		1 (1.52)		
IWK	13 (19.70)	13 (19.70)	12 (18.18)	14 (21.21)
CDR	1 (1.52)			2 (3.03)
IDR		4 (6.06)	3 (4.55)	3 (4.55)
UPR	1 (1.52)	2 (3.03)		1 (1.52)
CE				
IE				
CW		1 (1.52)	1 (1.52)	1 (1.52)
IW		1 (1.52)		
SP				
Total	66	66	66	66
% Correct Responses	68	55	58	52

Note: For code definitions see Appendix C
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics

Appendix H

Table H-3

Information Processing Code Frequencies And Percentage Occurrences: Reading - Inferring Underlying Relationships

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
		Grade 7		
CO	7 (14.58)	8 (16.66)	6 (12.50)	6 (12.50)
CB	17 (35.42)	28 (58.33)	19 (39.58)	19 (39.58)
CNB	3 (6.25)		3 (6.25)	3 (6.25)
INB	7 (14.58)	4 (8.33)	8 (16.66)	8 (16.66)
CWK		1 (2.08)	1 (2.08)	2 (4.16)
IWK	6 (12.50)	4 (8.33)	5 (10.41)	5 (10.41)
CDR	1 (2.08)		1 (2.08)	
IDR	2 (4.16)	1 (2.08)	1 (2.08)	2 (4.16)
UPR	1 (2.08)			
CE	1 (2.08)	1 (2.08)	3 (6.25)	
IE	1 (2.08)			
CW	2 (4.16)		1 (2.08)	3 (6.25)
IW				
SP		1 (2.08)		
Total	48	48	48	48
% Correct Responses	65	79	71	69
		Grade 8		
CO	6 (20.00)	12 (40.00)	7 (23.33)	12 (40.00)
CB	11 (36.66)	5 (16.66)	7 (23.33)	2 (6.66)
CNB		2 (6.66)	4 (13.33)	3 (10.00)
INB	4 (13.33)	2 (6.66)	3 (10.00)	4 (13.33)
CWK	1 (3.33)			
IWK	8 (26.66)	7 (23.33)	7 (23.33)	8 (26.66)
CDR				
IDR		1 (3.33)	2 (6.66)	
UPR				
CE				1 (3.33)
IE				
CW				
IW		1 (3.33)		
SP				
Total	30	30	30	30
% Correct Responses	60	63	60	60

Note: For code definitions see Appendix C
MD = Male Diabetic; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix H

Table H-4

Information Processing Code Frequencies And Percentage Occurrences: Reading Questions 1 - 15

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
		Grade 7		
CO	12 (13.33)	14 (15.55)	23 (25.55)	7 (7.77)
CB	18 (20.00)	38 (42.22)	22 (24.44)	35 (38.88)
CNB	10 (11.11)	7 (7.77)	4 (4.44)	4 (4.44)
INB	28 (31.11)	15 (16.66)	16 (17.77)	16 (17.77)
CWK	2 (2.22)	1 (1.11)		2 (2.22)
IWK	7 (7.77)	8 (8.88)	12 (13.33)	10 (11.11)
CDR	2 (2.22)		1 (1.11)	2 (2.22)
IDR	8 (8.88)	5 (5.55)	7 (7.77)	8 (8.88)
UPR	1 (1.11)	1 (1.11)	1 (1.11)	
CE		1 (1.11)		
IE			2 (2.22)	
CW	2 (2.22)		2 (2.22)	3 (3.33)
IW				3 (3.33)
SP				
Total	90	90	90	90
% Correct Responses	51	68	58	59
		Grade 8		
CO	22 (24.44)	24 (26.66)	32 (35.55)	28 (31.11)
CB	36 (40.00)	19 (21.11)	16 (17.77)	7 (7.77)
CNB		5 (5.55)	9 (10.00)	5 (5.55)
INB	19 (21.11)	21 (23.33)	15 (16.66)	28 (31.11)
CWK	1 (1.11)		1 (1.11)	
IWK	8 (8.88)	10 (11.11)	12 (13.33)	12 (13.33)
CDR	1 (1.11)	1 (1.11)		5 (5.55)
IDR	1 (1.11)	5 (5.55)	5 (5.55)	3 (3.33)
UPR	1 (1.11)			1 (1.11)
CE				
IE				
CW		2 (2.22)		1 (1.11)
IW	1 (1.11)	2 (2.22)		
SP		1 (1.11)		
Total	90	90	90	90
% Correct Responses	67	57	64	62

Note: For code definitions see Appendix C

MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix I

Table I-1

Information Processing Code Frequencies And Percentage Occurrences: Mathematics : Single Step Problems

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
	Grade 7			
CO	1 (2.38)	3 (7.14)	4 (9.52)	2 (4.76)
CB	23 (54.76)	21 (50.00)	24 (57.14)	18 (42.85)
CWK		1 (2.38)	1 (2.38)	1 (2.38)
IWK	7 (16.66)	4 (9.52)	5 (11.90)	8 (19.04)
CEA	1 (2.38)	1 (2.38)		
IEA				
CCE	3 (7.14)			1 (2.38)
ICE	1 (2.38)	4 (9.52)		4 (9.52)
CDR				1 (2.38)
IDR	4 (9.52)	6 (14.28)	3 (7.14)	2 (4.76)
UPR	1 (2.38)	1 (2.38)	2 (4.76)	2 (4.76)
CW	1 (2.38)	1 (2.38)	3 (7.14)	3 (7.14)
IW				
SP				
Total	42	42	42	42
% Correct Responses	69	64	76	62
	Grade 8			
CO		2 (8.33)	7 (29.16)	3 (12.50)
CB	15 (62.50)	13 (54.16)	8 (33.33)	4 (16.66)
CWK	1 (4.16)	1 (4.16)	1 (4.16)	
IWK	4 (16.66)	7 (29.16)	3 (12.50)	5 (20.83)
CEA	1 (4.16)			
IEA				1 (4.16)
CCE	1 (4.16)			1 (4.16)
ICE	1 (4.16)		2 (8.33)	1 (4.16)
CDR			1 (4.16)	
IDR		1 (4.16)		6 (25.00)
UPR			1 (4.16)	3 (12.50)
CW	1 (4.16)			
IW			1 (4.16)	
SP				
Total	24	24	24	24
% Correct Responses	79	67	71	33

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix I

Table I-2

Information Processing Code Frequencies And Percentage Occurrences: Mathematics: Multiple Step Problems

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
		Grade 7		
CO		1 (8.33)	1 (8.33)	
CB	6 (50.00)	5 (41.66)	7 (58.33)	5 (41.66)
CWK				
IWK	2 (16.66)		3 (25.00)	2 (16.66)
CEA	1 (8.33)			
IEA				
CCE				
ICE				1 (8.33)
CDR				1 (8.33)
IDR	3 (25.00)	3 (25.00)		1 (8.33)
UPR		2 (16.66)		2 (16.66)
CW			1 (8.33)	
IW		1 (8.33)		
SP				
Total	12	12	12	12
% Correct Responses	58	50	75	50
		Grade 8		
CO		3 (16.66)	3 (16.66)	1 (5.55)
CB	9 (50.00)	3 (16.66)	7 (38.88)	4 (22.22)
CWK				1 (5.55)
IWK	5 (27.77)	1 (5.55)	2 (11.11)	
CEA			1 (5.55)	1 (5.55)
IEA		1 (5.55)		1 (5.55)
CCE				1 (5.55)
ICE	1 (5.55)			
CDR				
IDR	1 (5.55)	6 (33.33)		1 (5.55)
UPR	1 (5.55)	2 (11.11)	2 (11.11)	7 (38.88)
CW	1 (5.55)	1 (5.55)	2 (11.11)	
IW		1 (5.55)	1 (5.55)	1 (5.55)
SP				
Total	18	18	18	18
% Correct Responses	56	39	72	44

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix I

Table I-3

Information Processing Code Frequencies And Percentage Occurrences: Mathematics: Number Systems

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
		Grade 7		
CO	2 (16.66)	4 (33.33)		
CB	6 (50.00)	5 (41.66)	11 (91.66)	4 (75.00)
CWK		1 (8.33)	1 (8.33)	
IWK	1 (8.33)			
CEA		1 (8.33)		
IEA				
CCE				
ICE				
CDR		1 (8.33)		1 (8.33)
IDR				2 (16.66)
UPR	1 (8.33)			
CW	2 (16.66)			
IW				
SP				
Total	12	12	12	12
% Correct Responses	83	100	100	83
		Grade 8		
CO			1 (8.33)	1 (8.33)
CB	10 (83.33)	7 (58.33)	8 (66.66)	7 (58.33)
CWK				
IWK				
CEA				
IEA				
CCE				1 (8.33)
ICE		1 (8.33)	1 (8.33)	
CDR	1 (8.33)	1 (8.33)		
IDR	1 (8.33)	3 (25.00)		2 (16.66)
UPR				
CW			2 (16.66)	1 (8.33)
IW				
SP				
Total	12	12	12	12
% Correct Responses	92	67	92	83

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthamtics

Appendix I

Table I-4

Information Processing Code Frequencies And Percentage Occurrences: Mathematics: Fractions

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
	Grade 7			
CO			1 (8.33)	
CS	3 (25.00)	3 (25.00)	6 (50.00)	3 (25.00)
CWK	1 (8.33)	2 (16.66)	1 (8.33)	
IWK	4 (33.33)	3 (25.00)	2 (16.66)	4 (33.33)
CEA	1 (8.33)	1 (8.33)	1 (8.33)	
IEA	2 (16.66)			1 (8.33)
CCE				
ICE		2 (16.66)	1 (8.33)	2 (16.66)
CDR				
IDR				
UPR		1 (8.33)		1 (8.33)
CW				
IW	1 (8.33)			1 (8.33)
SP				
Total	12	12	12	12
% Correct Responses	42	50	75	25
	Grade 8			
CO	1 (8.33)	2 (16.66)	1 (8.33)	
CS	7 (58.33)	2 (16.66)	6 (50.00)	2 (16.66)
CWK		1 (8.33)	1 (8.33)	
IWK	4 (33.33)	6 (50.00)	3 (25.00)	7 (58.33)
CEA			1 (8.33)	
IEA				1 (8.33)
CCE				
ICE				1 (8.33)
CDR				
IDR				
UPR				1 (8.33)
CW				
IW		1 (8.33)		
SP				
Total	12	12	12	12
% Correct Responses	67	42	75	17

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics

Appendix I

Table I-5

Information Processing Code Frequencies And Percentage Occurrences: Mathematics: Operational And Relational Symbols

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
		Grade 7		
CO				2 (33.33)
CB	1 (16.66)	1 (16.66)	1 (16.66)	
CWK				
IWK	1 (16.66)			1 (16.66)
CEA				
IEA	1 (16.66)			
CCE				
ICE				
CDR		2 (33.33)	1 (16.66)	2 (33.33)
IDR	1 (16.66)		2 (33.33)	
UPR		1 (16.66)	1 (16.66)	1 (16.66)
CW		2 (33.33)	1 (16.66)	
IW	2 (33.33)			
SP				
Total	6	6	6	6
% Correct Responses	33	83	50	67
		Grade 8		
CO		1 (16.66)	1 (16.66)	1 (16.66)
CB			2 (33.33)	
CWK				1 (16.66)
IWK	2 (33.33)	2 (33.33)	2 (33.33)	
CEA				
IEA				1 (16.66)
CCE				
ICE				
CDR	1 (16.66)			
IDR	2 (33.33)			
UPR		2 (33.33)	1 (16.66)	3 (50.00)
CW	1 (16.66)	1 (16.66)		
IW				
SP				
Total	6	6	6	6
% Correct Responses	33	33	50	33

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix I

Table I-6

Information Processing Code Frequencies And Percentage Occurrences:

Mathematics: Geometry

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
	Grade 7			
CO	1 (5.55)	4 (22.22)	3 (16.66)	1 (5.55)
CB	6 (33.33)	8 (44.44)	5 (27.77)	6 (33.33)
CWK	1 (5.55)		1 (5.55)	
IWK	2 (11.11)		2 (11.11)	4 (22.22)
CEA			1 (5.55)	
IEA				
CCE				1 (5.55)
ICE				
CDR	1 (5.55)	2 (11.11)	1 (5.55)	
IDR	6 (33.33)	4 (22.22)	3 (16.66)	5 (27.77)
UPR			2 (11.11)	
CW	1 (5.55)			1 (5.55)
IW				
SP				
Total	18	18	18	18
% Correct Responses	56	78	61	50
	Grade 8			
CO		3 (12.50)	4 (16.66)	3 (12.50)
CB	13 (54.16)	5 (20.83)	8 (33.33)	6 (25.00)
CWK			1 (4.16)	
IWK	1 (4.16)	2 (8.33)	1 (4.16)	1 (4.16)
CEA			2 (8.33)	
IEA			1 (4.16)	1 (4.16)
CCE				1 (4.16)
ICE				
CDR	4 (16.66)	6 (25.00)	1 (4.16)	4 (16.66)
IDR	4 (16.66)	4 (16.66)	3 (12.50)	3 (12.50)
UPR	2 (8.33)	1 (4.16)	2 (8.33)	1 (4.16)
CW				
IW		1 (4.16)		
SP		2 (8.33)	1 (4.16)	4 (16.66)
Total	24	24	24	24
% Correct Responses	71	58	67	58

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix I

Table I-7

Information Processing Code Frequencies And Percentage Occurrences: Mathematics: Determining Differences / Rates / Ratios

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
	Grade 7			
CO	8 (22.22)	9 (25.00)	4 (11.11)	3 (8.33)
CB	13 (36.11)	15 (41.66)	12 (33.33)	11 (30.50)
CWK			3 (8.33)	1 (2.77)
IWK	5 (13.88)	3 (8.33)	6 (16.66)	9 (25.00)
CEA				
IEA				1 (2.77)
CCE	4 (11.11)		1 (2.77)	
ICE		2 (5.55)	1 (2.77)	
CDR			1 (2.77)	2 (5.55)
IDR	1 (2.77)	5 (13.88)		3 (8.33)
UPR		1 (2.77)	1 (2.77)	3 (8.33)
CW	3 (8.33)		2 (5.55)	1 (2.77)
IW				
SP	2 (5.55)	1 (2.77)	5 (13.88)	2 (5.55)
Total	36	36	36	36
% Correct Responses	77	67	64	50
	Grade 8			
CO	4 (11.11)	10 (27.77)	8 (22.22)	15 (41.66)
CB	19 (52.77)	6 (16.66)	12 (33.33)	4 (11.11)
CWK		1 (2.77)		
IWK	5 (13.88)	8 (22.22)	4 (11.11)	4 (11.11)
CEA				1 (2.77)
IEA				
CCE	2 (5.55)			
ICE	4 (11.11)	1 (2.77)	2 (5.55)	1 (2.77)
CDR	1 (2.77)	3 (8.33)	1 (2.77)	2 (5.55)
IDR	1 (2.77)	3 (8.33)	5 (13.88)	3 (8.33)
UPR		3 (8.33)	1 (2.77)	6 (16.66)
CW		1 (2.77)	3 (8.33)	
IW				
SP				
Total	36	36	36	36
% Correct Responses	72	58	67	61

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix I

Table I-8

Information Processing Code Frequencies And Percentage Occurrences: Mathematics: Interpreting And Relating Data From Maps And Graphs

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
		Grade 7		
CO	6 (12.50)	8 (16.66)	5 (10.42)	7 (14.58)
CB	12 (25.00)	18 (37.50)	23 (47.92)	20 (41.66)
CWK	5 (10.42)	3 (6.25)	2 (4.16)	3 (6.25)
IWK	13 (27.08)	1 (2.08)	4 (8.33)	5 (10.42)
CEA				
IEA		1 (2.08)		
CCE	1 (2.08)			1 (2.08)
ICE		4 (8.33)		
CDR	1 (2.08)	2 (4.16)	2 (4.16)	2 (4.16)
IDR	3 (6.25)	6 (12.50)	1 (2.08)	2 (4.16)
UPR	1 (2.08)	3 (6.25)	3 (6.25)	3 (6.25)
CW	5 (10.41)		1 (2.08)	1 (2.08)
IW	1 (2.08)			
SP		2 (4.16)	7 (14.58)	4 (8.33)
Total	48	48	48	48
% Correct Responses	63	65	69	71
		Grade 8		
CO	12 (25.00)	12 (25.00)	17 (35.42)	7 (14.58)
CB	25 (52.08)	11 (22.91)	22 (45.83)	10 (20.83)
CWK		2 (4.16)	2 (4.16)	3 (6.25)
IWK	5 (10.41)	7 (14.58)	2 (4.16)	11 (22.92)
CEA	1 (2.08)	1 (2.08)		3 (6.25)
IEA		3 (6.25)		
CCE	2 (4.16)			2 (4.16)
ICE		4 (8.33)	1 (2.08)	
CDR				1 (2.08)
IDR	2 (4.16)	4 (8.33)		3 (6.25)
UPR	1 (2.08)	3 (6.25)	3 (6.25)	7 (14.58)
CW		1 (2.08)	1 (2.08)	
IW				
SP				
Total	48	48	48	48
% Correct Responses	83	56	85	54

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix I

Table I-9

Information Processing Code Frequencies And Percentage Occurrences: Mathematics: Inferring From Maps And Graphs

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
		Grade 7		
CO	2 (11.11)	1 (5.55)	1 (5.55)	
CB	3 (16.66)	7 (38.88)	6 (33.33)	4 (22.22)
CWK				
IWK	6 (33.33)	4 (22.22)	3 (16.66)	6 (33.33)
CEA		1 (5.55)	2 (11.11)	1 (5.55)
IEA				
CCE				
ICE			1 (5.55)	1 (5.55)
CDR				1 (5.55)
IDR	3 (16.66)	1 (5.55)		
UPR	1 (5.55)	2 (11.11)		1 (5.55)
CW	1 (5.55)		2 (11.11)	1 (5.55)
IW				
SP	2 (11.11)	2 (11.11)	3 (16.66)	3 (16.66)
Total	18	18	18	18
% Correct Responses	33	50	61	39
		Grade 8		
CO	2 (11.11)	1 (5.55)	5 (27.55)	2 (11.11)
CB	8 (44.44)	3 (16.66)	8 (44.44)	1 (5.55)
CWK	1 (5.55)	1 (5.55)	1 (5.55)	
IWK	5 (27.77)	7 (38.88)	1 (5.55)	7 (38.88)
CEA				1 (5.55)
IEA		1 (5.55)		1 (5.55)
CCE				
ICE				
CDR		1 (5.55)	1 (5.55)	1 (5.55)
IDR	1 (5.55)	1 (5.55)	1 (5.55)	2 (11.11)
UPR		3 (16.66)	1 (5.55)	3 (5.55)
CW				
IW	1 (5.55)			
SP				
Total	18	18	18	18
% Correct Responses	61	33	83	28

Note: For code definitions see Appendix D
MD = MAle Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix I

Table I-10

Information Processing Code Frequencies And Percentage Occurrences: Mathematics Questions 40 - 70

Group (n=6)	MD	FD	MA	FA
Code	Frequencies and (Percentage Occurrences)			
		Grade 7		
CO	19 (10.21)	28 (15.05)	18 (9.67)	15 (8.06)
CB	60 (32.25)	74 (39.78)	77 (41.39)	59 (31.72)
CWK	8 (4.30)	6 (3.22)	9 (4.83)	6 (3.22)
IWK	40 (21.50)	15 (8.06)	23 (12.36)	39 (20.96)
CEA	3 (1.61)	2 (1.07)	3 (1.61)	2 (1.07)
IEA	3 (1.61)	1 (.53)		2 (1.07)
CCE	7 (3.76)		1 (.53)	3 (1.61)
ICE		11 (5.91)	3 (1.61)	6 (3.22)
CDR	2 (1.07)	7 (3.76)	5 (2.68)	10 (5.37)
IDR	20 (10.75)	22 (11.82)	10 (5.37)	14 (7.52)
UPR	5 (2.68)	12 (6.45)	13 (6.98)	15 (8.06)
CW	11 (5.91)	3 (1.61)	9 (4.83)	5 (2.68)
IW	4 (2.15)			1 (.53)
SP	4 (2.15)	5 (2.68)	15 (8.06)	9 (4.83)
Total	186	186	186	186
% Correct Responses	59	65	66	54
		Grade 8		
CO	20 (10.75)	34 (18.27)	46 (24.73)	33 (17.74)
CB	104 (55.91)	48 (25.80)	81 (43.54)	37 (19.89)
CWK	2 (1.07)	6 (3.22)	6 (3.22)	5 (2.68)
IWK	27 (14.51)	40 (21.50)	17 (9.13)	35 (18.81)
CEA	2 (1.07)	1 (.53)	3 (1.61)	7 (3.76)
IEA		4 (2.15)		6 (3.22)
CCE	5 (2.68)			4 (2.15)
ICE	6 (3.22)	5 (2.68)	5 (2.68)	4 (2.15)
CDR	4 (2.15)	9 (4.83)	4 (2.15)	8 (4.30)
IDR	9 (4.83)	18 (9.67)	8 (4.30)	18 (9.67)
UPR	4 (2.15)	12 (6.45)	9 (4.83)	29 (15.59)
CW	2 (1.07)	8 (4.30)	6 (3.22)	
IW	1 (.53)	1 (.53)	1 (.53)	
SP				
Total	186	186	186	186
% Correct Responses	75	57	79	51

Note: For code definitions see Appendix D
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics.

Appendix J

Table J-1

Information Processing Code Percentage Occurrences By Absenteeism: Reading Questions 1 - 15

Group	MD		FD		MA		FA	
Absent	0	1	0	1	0	1	0	1
				Grade 7				
n =	4	2	3	3	2	4	4	2
Code								
CO	13.33	13.33	17.77	13.33	33.33	21.66	11.66	
CB	26.66	6.66	40.00	44.44	30.00	21.66	40.00	36.66
CNB	8.33	16.66	8.88	6.66		6.66	5.00	3.33
INB	31.66	30.00	13.33	20.00	13.33	20.00	13.33	26.66
CWK		6.66		2.22			1.66	3.33
IWK	6.66	10.00	11.11	6.66	10.00	15.00	3.33	
CDR		6.66			3.33		3.33	
IDR	10.00	6.66	8.88	2.22	3.33	10.00	8.33	10.00
UPR	1.66			2.22		1.66		
CE				2.22				
IE					6.66			
CW	1.66	3.33				3.33	5.00	
IW							1.66	6.66
SP								
% Correct Responses	50	53	67	69	67	53	67	43
				Grade 8				
n =	4	2	4	2	3	3	2	4
CO	33.33	6.66	16.66	46.66	37.77	33.33	30.00	31.66
CB	33.33	53.33	25.00	13.33	6.66	28.88	13.33	5.00
CNB			8.33		11.11	8.88	10.00	3.33
INB	20.00	23.33	28.33	13.33	24.44	8.88	30.00	31.66
CWK	1.66				2.22			
IWK	6.66	13.33	10.00	13.33	8.88	17.77	10.00	15.00
CDR	1.66			3.33			3.33	6.66
IDR		3.33	5.00	6.66	8.88	2.22	3.33	3.33
UPR	1.66							1.66
CE								
IE								
CW			3.33					1.66
IW	1.66		3.33					
SP				3.33				
% Correct Responses	70	60	53	63	58	71	57	48

Note: For code definitions see Appendix C.
Absent 0 = Absent from school 10 days or less over the past two school years; Absent 1 = Absent from school 11 days or more over the past two school years;
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics

Appendix J

Table J.- 2

Information Processing Code Percentage Occurrences By Absenteeism: Mathematics Questions 40 - 70

Group	MD		FD		MA		FA	
Absent	0	1	0	1	0	1	0	1
				Grade 7				
n =	4	2	3	3	2	4	4	2
Code								
CO	12.09	6.45	11.83	18.27	8.06	10.48	8.06	8.06
CB	38.70	19.35	44.08	35.48	50.00	37.09	32.25	30.64
CWK	4.83	3.22	2.15	4.30	6.45	4.03	1.61	6.45
IWK	17.74	29.03	9.67	6.45	11.29	12.90	21.77	19.35
CEA	2.41		1.07	1.07	3.22	.80	1.61	
IEA	1.61	1.61		1.07			.80	1.61
CCE	3.22	4.83				.80	1.61	1.61
ICE			3.22	8.60	3.22	.80	.80	8.06
CDR	1.61		4.30	3.22		4.03	5.64	4.84
IDR	7.25	17.74	16.12	7.52	8.06	4.03	6.45	9.68
UPR	3.23	1.61	4.30	8.60	6.45	7.25	9.67	4.84
CW	4.03	9.67	3.22		3.22	5.64	1.61	4.84
IW	1.61	3.22					.80	
SP	1.61	3.22		5.37			7.25	
% Correct Responses	67	44	67	62	71	63	52	56
				Grade 8				
n =	4	2	4	2	3	3	2	4
CO	14.51	3.22	14.51	25.81	27.95	21.50	20.96	16.12
CB	48.38	70.96	19.35	38.71	30.10	56.98	32.25	13.70
CWK	.80	1.61	4.03	1.61	4.30	2.15	3.22	2.42
IWK	16.93	9.67	27.42	9.67	10.75	7.52	19.35	18.55
CEA	1.61		.81		3.22			5.65
IEA			3.22				3.22	3.22
CCE	1.61	4.83					4.83	.80
ICE	4.03	1.61	3.22	1.61	3.22	2.15	1.61	2.42
CDR	1.61	3.22	4.83	4.83	2.15	2.15	3.22	4.83
IDR	5.65	3.22	12.90	3.22	5.37	3.23	9.67	9.67
UPR	3.22		5.65	8.06	8.60	1.07	1.61	22.58
CW	1.61		3.22	6.45	3.22	3.22		
IW					1.07			
SP								
% Correct Responses	70	84	47	77	71	86	65	44

Note: For code definitions see Appendix D
Absent 0 = Absent from school 10 days or less over the past two school years; Absent 1 = Absent from school 11 days or more over the past two school years;
MD = Male Diabetics; FD = Female Diabetics;
MA = Male Asthmatics; FA = Female Asthmatics