THE UNIVERSITY OF CALGARY

THE EFFECT OF TEACHING COGNITIVE STRATEGIES ON THE GENERAL COGNITIVE DEVELOPMENT OF UNDERACHIEVING NATIVE INDIAN ADOLESCENTS, USING LOGO PROGRAMMING AS A TEACHING VEHICLE AND NATIVE ART AS A CULTURAL BRIDGE

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "The effect of teaching cognitive strategies on the general cognitive development of underachieving Native Indian adolescents, using LOGO programming as a teaching vehicle and native art as a cultural bridge" submitted by Kathleen M. Wenger in partial fulfillment of the requirements for the degree of Master of Arts.

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ABSTRACT

A set of 25 LOGO lessons, developed according to a behaviorally oriented systems approach, was pilot tested by four teachers working with underachieving Native Indian adolescents. Each lesson emphasized particular cognitive functions and incorporated teaching techniques developed by Reuven Feuerstein which appeared adaptable to the development and evaluation of a short-term training program in cognitive functioning with underachieving Native Indian students. Motifs from Cree beadwork provided a cultural 'bridge.'

Students were 71 Native Cree Indians aged 12 to 17 years, at school in Hobbema, Ponoka or Wetaskiwin, Alberta. They were divided into Intervention and Non-Intervention groups. Both groups were given a computer use questionnaire and parallel forms of three tests of general cognitive development. Teachers of the Intervention group attended two workshops, and then taught LOGO sessions of 50 minutes to 90 minutes per day for 7 weeks. Observational notes were kept.

A high baseline of students' prior computer use was found. Correlations revealed that Feuerstein's posttest forms of the Raven's Coloured and Standard Progressive Matrices were in fact not parallel forms. *Post hoc* selection of subsets of these tests did not improve correlations. Encouragingly, a univariate analysis revealed a significantly higher posttest score for the Intervention group on the Representational Stencil Design Test. Improvement on problem-solving, social and life skills was observed.

It is suggested that gains such as increased persistence and willingness to learn were not measured by the tests used, and that testing methods need to be reviewed. It is further suggested that Feuerstein's teaching techniques may not have been used effectively by teachers, and that teachers' training could be expanded and lessons rewritten to emphasize these techniques and encourage generalization of problem-solving skills. Support materials could also be written, encouraging both computer and written skills and incorporating peer teaching.

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TABLE OF CONTENTS

		Page
APPROVAL PAGE		ii
ABSTRACT		iii
ACKNOWLEDGMENTS		v
DEDICATION		vi
LIST OF TABLES		xi
CHAPTER		
1	INTRODUCTION	1
	Significance and Limitations of the Study	7
	Hypotheses	8
	Summary	9
2	LITERATURE REVIEW	11
	Teaching of Cognitive Strategies	11
	Feuerstein's Model of Instrumental Enrichment	13
	Teaching Techniques	16
	Mediation	16
	Discussion for Insight	17
	Measurement Techniques	17
	Native Indians	19
	Teaching Techniques	20
	Measurement of Cognitive Development	21
	The Microcomputer Environment	24
	LOGO	25

Page

Teaching of LOGO 28

LOGO and Native Indian Students. 33

Summary 34

3 DEVELOPMENT OF LOGO LESSONS 38

Target Audience 39

Course Content. 39

Cognitive Functions 42

Instructional Strategy. 45

Lesson Layout 48

Other Information 48

Summary 49

4 PILOT TEST OF LESSONS 50

Subjects. 50

Teaching and Testing Materials. 50

Procedure 51

Experimental Design. 51

Consent. 51

Computing Hardware and Software. 52

Teacher Training 53

Testing. 53

Psychologists' Reports 54

Teaching 55

Teacher Support. 55

Anecdotal Reporting. 56

Confidence Level 57

Page

5 RESULTS 58

Computer Use Questionnaire. 58

Psychologists' Reports. 60

Dropouts. 60

Preliminary Analyses. 62

Raw Scores. 62

Measures. 62

Findings. 64

Alternative Measures. 68

Feuerstein's Sets. 68

Matched Sets 69

Secondary Findings. 78

Feuerstein's Sets. 78

Matched Sets 80

Observations and Teachers' Reports. 82

Class Progress 82

Anecdotal Reports. 82

Criticisms of Lessons and Teachers' Suggestions 84

Student Attendance. 84

Supplementary Materials Used by Teachers. 85

Summary 86

6 DISCUSSION. 88

Measurement of Cognitive Development. 90

Teaching Techniques 93

Teaching of LOGO. 94

Teaching Materials. 96

Page

Further Research. 97

Conclusion. 99

REFERENCES. 101

APPENDIX A. 107

APPENDIX B. 112

APPENDIX C. 114

LIST OF TABLES

Table No.		Page
1	Cognitive skills based on those outlined by Feuerstein (1980a, pp. 73-74)	4
2	Lesson titles	40
3	Cognitive functions, related activities and associated lessons	43
4	Computer use questionnaire response summary	59
5	Dropouts	61
6	Mean raw scores and standard deviations for tests of general cognitive development	63
7	Mean percentage scores and standard deviations for overall scores	65
8	Correlations among pre- and posttest measures	66
9	Cognitive operations required for solution of Raven's items B8 and B9 and corresponding LPAD1 variations	70
10	Cognitive operations required for solution of Raven's item B10 and corresponding LPAD1 variations	71
11	Cognitive operations required for solution of Raven's item B11 and corresponding LPAD1 variations	72
12	Cognitive operations required for solution of Raven's item B12 and corresponding LPAD1 variations	73
13	Cognitive operations required for solution of Raven's item C7 and corresponding LPAD2 variations	74
14	Cognitive operations required for solution of Raven's items C8 and C12 and corresponding LPAD2 variations	75

Table No.		Page

15	Cognitive operations required for solution of Raven's item D12 and corresponding LPAD2 variations	76
16	Cognitive operations required for solution of Raven's item E12 and corresponding LPAD2 variations	77
17	Mean percentage scores and standard deviations for Feuerstein's sets	79
18	Mean percentage scores and standard deviations for matched sets	81
19	Comparison with Feuerstein's data	92

Chapter 1

INTRODUCTION

In 1968 Gagne, in a discussion of the role of technology in education, highlighted the educational shift from an earlier emphasis on informational content to a growing emphasis on the *process* of learning (Gagne, 1974). He pointed out that

> the idea that the major and primary purpose of instruction is to teach processes, or intellectual skills, rather than verbal information, is . . . reflected in statements of educational goals that say, in effect, that the purpose of education is to teach students to think. (p. 58)

Gagne warned, however, that it would be wrong to attribute this change of emphasis in education to the development of the hardware associated with educational technology; he suggested, rather, that it has been due to "the systematic development of procedures and techniques of instruction, based on psychological theory" (p. 59). This development has presented an opportunity for developing the thinking skills of students in a systematic manner.

It has, in fact, been established that cognitive strategies can be taught. For example, Das, Kirby, and Jarmon (1979) describe two training interventions with Grade 3 and 4 children of average or below average school achievement, which demonstrated that

> strategies can be taught. There is no need to assume that the only way to improve performance is to teach the test. Clearly, the children who improved [on a number of intelligence, memory and associated measures] were learning to use generalised strategies. (p. 169)

It should not necessarily be assumed, however, that all thinking skills can be taught to most learners if only the appropriate instructional paradigm can be developed. Narrol and Bachor (1975) review arguments on the relationship between learners' potential and performance, and suggest three competing emphases:

(1) the hereditarian, which emphasizes the relative independence of inherited potential and learning experience;

(2) the environmentalist, which emphasizes the learning environment as the only variable open to systematic manipulation;

(3) the interactionist, which "attempts to balance the two extremes. Both the person and the environment, both capacity and performance, contribute to the learning failure or success of the student" (p. 3).

Theorists in the last category do not deny the possibility of biological limits to change, but encourage the development of intervention programs offering possibilities for improvement of an individual's measured potential.

Reuven Feuerstein (1979, 1980a) may be classified as an interactionist. He sees teaching as best directed at the correction of cognitive deficiencies, which in turn will provide the opportunity for improvement of the individual's cognitive development. He coined the term "cognitive modifiability" to describe "a process of autonomous and self-regulated change set into motion . . .; the dynamics of modifiability propel the individual along a course of development that could not be anticipated on the basis of his previous performance" (1980a, pp. 2-3).

Working in Israel with "retarded performers," who were displaced adolescents and many of whom could be classified as culturally deprived, he identified a number of distinct deficits in cognitive functioning among this population (Feuerstein, 1980a, pp. 73-74). He categorized these according to three types of performance:

(1) 'Input' or information intake processes;

(2) 'Elaboration' or analysis processes;

(3) 'Output' or communication processes (Table 1).

Feuerstein has also developed methods of both measuring and teaching to overcome these deficiencies in cognitive functioning. In measurement of cognitive deficiencies, he has either devised or established the use of particular tests, accumulating results against which results with other groups can be compared. In teaching, he has identified the necessity for mediated learning experience and discussion aimed at insight into the use of particular cognitive functions (Feuerstein, 1979, 1980a).

This thesis is concerned with a particular application of Feuerstein's methods for developing effective cognitive strategies, using a cultural group different from that studied by Feuerstein. Specifically, it is concerned with the development and pilot testing of a teaching program, employing some of Feuerstein's teaching and testing methods, designed to teach strategies for effective cognitive functioning to underachieving Native Indian adolescents.

This problem statement raises two questions. Firstly, the question of whether the cognitive functions identified by Feuerstein are in fact deficient among the Native Indian adolescents to be studied must be addressed. The retardation in school performance of these students by one or more years is an initial indication that this is the case; this question will be dealt with further in chapter 5 of this thesis.

Table 1

Cognitive Skills Based on Those Outlined by Feuerstein (1980a, pp. 73-74)

At the input stage of gathering information from the environment

1. Clear perception; search for complete information
2. Planned, systematic exploration
3. Precision and accuracy in data gathering
4. Adequate verbal tools; adequate labelling; adequate decoding and encoding skills
5. Capacity for considering two or more sources of information at once
6. Ability to orient spatially (this helps to identify where changes take place)
7. Ability to orient temporally (this helps to identify when changes take place)
8. Appreciation of constancy, conservation and object permanence (these help to identify which dimensions are stable when others change, and which dimensions are interrelated)

At the problem elaboration and solving stage

1. Ability to perceive that a problem exists, and to define that problem adequately
2. Appreciation of the need for logical evidence
3. Widening of the mental field, which increases the amount of information which can be handled at once
4. Appreciation of the interrelatedness of events
5. Labelling and subsequent elaboration of mental categories
6. Planning
7. Selection of relevant (as opposed to irrelevant) information in problem solving

Table 1 (cont'd)

8. Ability to develop mental pictures or symbols (interiorization) which can then be mentally manipulated
9. Projection of relationships which have not yet been applied to new situations
10. Making of comparisons
11. Inferential or hypothetical thinking
12. Strategies for testing of hypotheses (If I try this, what will happen?)
13. Summing up of the information needed to make a decision

At the output of the problem solution

1. Clear, complete communication
2. Adequate verbal tools and labels for communicating
3. Precision and accuracy in communicating
4. Willingness to respond
5. Appreciation of the need to avoid unplanned trial and error responses
6. Appreciation of the need to avoid impulsive responses
7. Ability to carry visual images from one point to another (visual transport)

Secondly, it should be established that the teaching techniques and tests used by Feuerstein are appropriate for use with this different cultural group. This question will be addressed in chapter 2 of this thesis.

The question of program content also arises. What characteristics are required of content which can act as an appropriate vehicle for Feuerstein's teaching techniques? Feuerstein himself uses a set of paper and pencil exercises which present the student with problems to be defined and solved, requiring about 200 hours for completion. In seeking solutions to the problems, students are required to exercise particular cognitive functions which have previously been identified as those in which they are deficient. Feuerstein's exercises may be characterized as "culture-reduced," requiring minimal reading and writing skills and being largely free of subject content, and as highly motivating to students. For further discussion of "culture-reduced" tests, see chapter 2 of this thesis.

Lessons teaching LOGO programming may be similarly described. LOGO is a computer language developed at the Massachusetts Institute of Technology and popularized by Seymour Papert in *Mindstorms: Children, computers and powerful ideas* (Papert, 1980). The version of LOGO now in use on microcomputers permits the user to direct a small triangular 'turtle' around the video monitor to create graphic designs, using a limited set of basic instructions or 'primitives' (e.g., FORWARD, BACK, RIGHT). These primitives can also be combined into more complex sets of instructions, or procedures, by the user. These procedures can, in turn, be used within other procedures, and thus the capacity for developing a highly structured programming language is available.

Papert has observed that LOGO offers students a concrete computer model which allows them to think about thinking—students need to be aware of their own thinking processes to program a computer. As well, LOGO particularly lends itself to supporting the development of certain learning strategies which are closely related to those identified by Feuerstein as deficient in many underachieving students:

(1) the breaking of problems into manageable subproblems;

(2) the development of systematic planning, or means-end analysis;

(3) debugging, or isolation and correction of errors;

(4) the adoption of a positive attitude towards error.

It should also be noticed that the learning of LOGO, if it is taught orally, requires a minimum of reading and writing skills, and that it has been found highly motivating by many students (Papert, 1980).

Thus it is suggested here that the teaching of LOGO may act as a suitable basis for the development of a program of lessons designed to teach strategies for effective cognitive functioning identified by Feuerstein, and incorporating some of Feuerstein's teaching methods.

Significance and Limitations of the Study

The innovative combination of Feuerstein's methods and the teaching of LOGO inevitably raises the problem of limited comparison with earlier work, including that of Feuerstein's. The use of a student group which, although underachieving, is culturally quite different from that used by Feuerstein further limits comparison. On the other hand, some limited generalizations of application of Feuerstein's work to a different cultural group and with different subject content may be possible as a result of this study to the extent that testing methods used are comparable with those of Feuerstein.

The study may also provide empirical evidence concerning the generalizability of problem-solving skills from a LOGO environment. If students' scores on measures of general cognitive development improve, this may indicate that more efficient cognitive strategies, learned in the LOGO environment, are being used in the testing situation, and presumably in other problem-solving situations also. According to Krasnor and Mitterer (1984) such empirical evidence is sparse, the literature to date being primarily anecdotal or concerned with the development of curriculum materials.

It should be kept in mind that this study amounts to a formative evaluation of materials under continuing development. The study may allow the development of a viable, intrinsically motivating teaching method for use with Native Indian adolescents, and perhaps with other groups of academic underachievers. However, the pilot nature of the use of the program of lessons is further confounded by many limitations to experimental control in what was essentially a field situation. The above issues will be discussed further in chapter 6.

Hypotheses

The present study examined the effect of a set of LOGO lessons, designed to teach strategies for effective cognitive functioning and incorporating some of Feuerstein's teaching techniques, on the general cognitive development of Native Indian adolescents.

In particular, the following questions were explored:

1. Does the teaching intervention (LOGO lessons) affect cognitive

development as measured by parallel forms of Raven's Coloured Progressive Matrices (R-L1)?*

2. Does the teaching intervention (LOGO lessons) affect cognitive development as measured by parallel forms of Raven's Standard Progressive Matrices (R-L2)?*

3. Does the teaching intervention (LOGO lessons) affect cognitive development as measured by parallel forms of the Representational Stencil Design Test (Stencil Design)?*

It was predicted in each case that the teaching intervention would improve cognitive development as measured by the tests specified.

Summary

Recent emphasis on the process of learning, rather than on the informational content of teaching materials, has in part found expression in Reuven Feuerstein's interactionist approach to the correction of cognitive deficiencies. His concept of cognitive modifiability, activated by a specifically designed teaching program, suggests possibilities for the design of programs for use with underachieving students.

The purpose of the present study was to develop and pilot test a set of LOGO lessons designed to teach selected cognitive functions and incorporating teaching techniques developed by Feuerstein (1979, 1980a). In particular, the study evaluated the use of these lessons with a group of Native Indian adolescents, assessing their improvement on a number

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* For a description of the tests used see chapter 4, and of measures derived from these tests see chapter 5.

of general measures of cognitive development which have also been used by Feuerstein.

Chapter 2

LITERATURE REVIEW

A number of issues underlying the design and evaluation of lessons which aim to teach cognitive functions need to be addressed. The following review outlines approaches to the teaching of cognitive strategies, with particular emphasis on Feuerstein's Model of Instrumental Enrichment. Teaching and testing techniques developed by Feuerstein and used with culturally disadvantaged adolescents will be described, and the appropriateness of the use of some of these techniques with Native Indian students will be discussed. As well, the philosophy underlying the development and teaching of LOGO will be reviewed and its suitability as a vehicle for the developing of deficient cognitive functions, particularly with Native Indian students, will be discussed.

Teaching of Cognitive Strategies

Narrol and Bachor (1975), in reviewing the stances of several sociological and educational theorists, suggest that a sizable proportion of the school population have a potential for thinking and learning not previously accorded them. They point out that this contention has led to a resurgence in the 'nature-nurture' controversey, which concerns the relative influence of genetic and environmental factors on cognitive capacity and performance. Three emphases emerge here:

(1) the hereditarian, which regards inherited capacity to be a fixed limiting factor (e.g., Jensen, 1969);

(2) the environmental, which is the opposite point of view and regards environmental influences as crucial in determining performance (e.g., Skinner, 1968); and

(3) the interactionist, which acknowledges the dual influence of both inherited capacity and environmental influence on displayed ability (e.g., Feuerstein, 1980a).

These emphases highlight a distinction between capacity and performance or displayed ability. In the past, capacity has been seen largely as fixed or predetermined, whereas performance has been seen as manipulable (to a variable extent) through environmental influences. However, if both heredity and environment (nature and nurture) contribute to displayed ability (the interactionist stance), then both should be considered when steps are taken to develop educational intervention programs. Moreover, if inherited capacity and environmental influences interact with each other, the possibility exists of devising intervention programs which allow for improvement in measured capacity.

Das, Kirby, and Jarmon (1979) suggest two deficiencies which may contribute to learning failure, one of which is the "production deficiency" which relates to a block in performance. Of particular interest here is the other deficiency, called the "mediational deficiency," which relates to the capacity to use verbal processes in intellectual tasks; a new way of saying that one has to think and understand before performing an intellectual task.

Das, Kirby, and Jarmon argue that, which much has been made of the possibilities of correction of production deficiencies, mediational deficiencies or deficiencies of capacity can also be corrected. They review studies by Krywaniuk (1974) and Kaufman (1978) in which training interventions were used in an attempt to develop cognitive strategies to overcome mediational deficiencies in Grade 3 and 4 students. Krywaniuk's study was performed with Native Indian students at Hobbema, Alberta. Both studies showed improvement in displayed ability on a battery of verbal, memory and general intelligence tests for students who learned to use generalized strategies.

Of more peripheral interest, but worth noting here, is a study by Willis, Blieszner, and Baltes (1981) which investigated the effectiveness of cognitive training on the displayed ability of 58 older adults (mean age = 70 years) on several figural relations measures of fluid intelligence. The training involved some modelling of relational rules, practice items and group discussion. The authors conclude that the "findings suggest the continued modifiability of intellectual performance through cognitive intervention across the adult life span" (p. 313).

The literature would seem to suggest, therefore, that the interactionist stance is justified in considering the dual influence of heredity and environment on displayed ability; even more provocative is the evidence that deficiencies related to both factors may possibly be corrected by educational intervention among students of any age.

Feuerstein's Model of Instrumental Enrichment

Reuven Feuerstein (1979, 1980a) adopts the interactionist stance. He does not preclude differential inherited capacities, but he sees such capacity as enabling the individual to use experience, i.e., to learn.

He considers environmental influences to be of two types: (a) direct exposure to stimuli and (b) learning experience mediated by an experienced, intentioned adult, and believes that cognitive structure is developed in an individual as a product of the interaction of inherited capacity and these two types of environmental influence.

It is important to note, however, that in the development of cognitive structure Feuerstein does not give equal weight to both of the environmental influences listed above. He believes that mediated learning experience is crucial in encouraging "cognitive modifiability," which then enables an individual to benefit from direct exposure to stimuli. Feuerstein's predicted effect of adequate mediated learning experience is not merely in the transmission of specific skills or abilities, but in the development of generalized cognitive structures or schema which allow the individual to derive increased benefit from direct exposure to stimuli. Thus, a "retarded performer" is one who lacks adequate mediated learning experience and who therefore demonstrates a low level of modifiability through direct exposure to stimuli, obscuring a higher endowed capacity.

It should be noticed here that the concept of cognitive modifiability is a positive or optimistic one in that Feuerstein suggests that it can change over time and that it is influenced by the quality and quantity of mediated learning experience to which the individual is exposed. Thus, the ill effects of inadequate mediated learning experience are reversible and amenable to modification.

Feuerstein's studies have been undertaken in Israel with displaced adolescents from a variety of North African, Asian and European cultural groups. He has identified a number of deficient cognitive functions

(Table 1) among these students, which he believes indicate low levels of cognitive modifiability and are related to inadequate mediated learning experience. These functions "are conceived of as being a product of a lack of, or insufficiency of, mediated learning experience and are responsible for, and reflected in, retarded cognitive performance" (1980a, p. 71). Cognitive modification is the major goal of Feuerstein's program of Instrumental Enrichment (1980a, p. 115), which is a series of paper and pencil exercises requiring about 200 hours for completion, designed to remediate observed cognitive dysfunction. Feuerstein uses these exercises in daily lessons of 1 hour, 3 to 5 days a week, over a period of 2 to 3 years.

Feuerstein believes that mediated learning experience is closely connected to the process of acculturation of an individual. He has been very careful to distinguish between the three terms cultural difference, cultural deprivation and cultural disadvantage, and is particularly concerned with cultural deprivation, which he defines as "the result of a failure on the part of a group to transmit or mediate its culture to the new generation" (1980a, p. 13). He suggests that cultural difference may often be the very opposite of cultural deprivation, and that neither are necessarily connected with extrinsic conditions of disadvantage: "we contend that there are no necessary causal links between cultural difference or conditions of disadvantage . . . and cultural deprivation." He does point out, however, that "these conditions may overlap and cognitive dysfunction may accompany any of these conditions" (p. 14). The correction of such cognitive dysfunction is the major subgoal of Feuerstein's program of Instrumental Enrichment (1980a, p. 115).

The overall effectiveness of Feuerstein's program of Instrumental Enrichment is indicated by reported case studies and follow-up studies (1980a, pp. 63-66), and by a two-year empirical study (1980a, pp. 325-381; Feuerstein, Rand, Hoffman, Hoffman, & Miller, 1970; Rand, Tannenbaum, & Feuerstein, 1979) in which it was shown that groups receiving Instrumental Enrichment performed better on tests of general and specific cognitive functioning, scholastic achievement and some classroom interaction scales than groups receiving a general enrichment program, with a supplementary input of curriculum-oriented experiences, over the same time.

Teaching Techniques

Mediation

Feuerstein advocates mediated learning experience as a method of improving cognitive modifiability, where the mediation is by a teacher, parent, sibling or other caregiver. This mediator, "guided by his intentions, culture, and emotional investment, selects and organizes the world of stimuli . . . frames, filters, and schedules them" (1980a, p. 16). Feuerstein believes that, through this mediation process, cognitive structure is developed and cognitive deficiencies may be overcome. "The effects of mediated learning experience may be conceptualised as inducing in the organism a great variety of orientations and strategies that become crystallized in the form of sets and habits and constitute the prerequisites for proper cognitive functioning" (1980a, p. 17).

The techniques of mediation involve selecting stimuli, relating these to appropriate times and places, scheduling stimuli, mediating positive and negative anticipation of outcomes, providing a role model, repeating and varying stimuli, transmitting the past and representing the future, and encouraging comparative behavior (1980a, p. 34).

Discussion for Insight

As well as mediating learning experience, Feuerstein (1980a, p. 278) advocates the production of reflective, insightful thought processes in students. To this end, Feuerstein suggests that a small part of every lesson should be devoted to discussion of related problem-solving errors, solutions and the associated thought processes. He hypothesizes that such activity will encourage introspection on the students' part and will encourage delay or inhibition of response to allow a more organized and differentiated response to be given. He further suggests that part of this discussion should be aimed at creating an awareness of the role of cognitive functions, strategies and planning behavior in other areas of everyday living.

Measurement Techniques

In an attempt to measure cognitive modifiability Feuerstein has developed the Learning Potential Assessment Device (LPAD) (Feuerstein, 1979). He has made a distinction between measures derived from conventional psychometric tests and those which might measure an underachieving individual's potential capacity for modifiability. Rather than using conventional tests of a static nature which tap a repertoire of well-established existing behaviors, he has developed a testing-training-testing system ("dynamic testing") which is designed to yield a measure of cognitive modifiability in 5 to 25 hours of training and testing.

In a dynamic testing situation, the individual is tested, trained on the test and then tested again using a parallel variation of the original test. It is intended that the training period should involve mediated learning. In the dynamic testing situation four major changes in the traditional testing approach are required (Narrol & Bachor, 1975):

(1) the tester simultaneously becomes a trainer, inducing sympathetic instructional conditions;

(2) the test must be graduated and well sequenced, similar to educational curricular materials;

(3) the learning process, rather than the learning product, must be emphasized;

(4) notable successes should be emphasized above an average low performance.

The LPAD uses a variety of graduated, sequenced tests and employs all of the above techniques.

Feuerstein (1980a) claims that it is possible over such a short time, using the LPAD,

> to observe individuals who were incapable of grasping simple relations become able to produce inferential and even syllogistic reasoning. Similarly, children with manifest perceptual and discrimination difficulties are able, in a relatively short span of time, to solve problems that demand a high level of proficiency in these abilities. (p. 62)

It should be noted that it was the development of the LPAD that enabled Feuerstein to identify the cognitive functions (Table 1) deficiency in which he associates with deficient cognitive performance.

The LPAD consists of the following tests:

Organization of Dots Test (Rey & Dupont, 1953);

Raven's Coloured Progressive Matrices (Raven, 1956) and Raven's Standard Progressive Matrices (Raven, 1958);

Plateaux Test (Rey, 1934);

Representational Stencil Design Test (developed from Arthur, 1943).

These tests are described in more detail in Narrol and Bachor (1975). The above list is in the order in which they are usually administered. Feuerstein (1979) has developed training sheets and/or variations of items in these tests to allow for the dynamic, within-task training approach to proceed.

It is of particular interest to notice here that, since the LPAD is designed to provide a measure of an individual's potential capacity for cognitive modification as revealed over relatively short periods of training, it would appear to have potential use in pretest-posttest evaluation of any short-term training program designed to develop deficient cognitive functioning. In such a situation, the program under investigation could substitute for the LPAD training component of the testing-training-testing system. Any revealed potential for further cognitive modification over a longer period would then presumably be due to the program under investigation and would indicate that a longer term program, such as Feuerstein's Instrumental Enrichment program, may be beneficial.

The tests of the LPAD for which Feuerstein has devised variations, and for which parallel forms are therefore available for use as pre- and posttests, are Raven's Coloured Progressive Matrices, Raven's Standard Progressive Matrices and the Representational Stencil Design Test.

Native Indians

The appropriateness of the use of some of Feuerstein's teaching and measurement techniques with a Native Indian group are discussed below.

Teaching Techniques

In extending Feuerstein's work to Native Indian students, the concepts of cultural difference, disadvantage and deprivation must be reconsidered. The Hawthorn report (Hawthorn, 1966), prepared by a team of scholars from the University of British Columbia, characterized Native Indians as culturally different, as well as often economically disadvantaged, but not culturally deprived. It was recognized, however, that this cultural difference had unfortunate consequences when students were faced with the routines and activities of formal schooling: "There is nothing in the school or in the classroom which is familiar nor is there any set of values or procedures which he can relate to his world" (p. 120). Feuerstein's teaching technique of discussion for insight, aimed at creating an awareness of the role of cognitive functions and planning behavior in everyday living, may help such students to relate classroom work to everyday life.

It should also be noticed that Native Indian students who are *not* culturally different are likely to be suffering from cultural deprivation, falling somewhere between white and Native Indian cultures and deprived of consistent cultural transmission or mediation in either group. Both of Feuerstein's teaching techniques, mediation and discussion for insight, were devised for use with such a group.

In the context of Native Indian educational needs highlighted by the Hawthorn report, Bowd (1977) has outlined three implied educational models appearing in the psychological literature between 1967 and 1976:

(1) remedial education, which is least flexible and is aimed at correcting deficiencies in the child and fitting the child to the system;

(2) supplementary education, which emphasizes mutual adaptation between Native groups and schools;

(3) instrumental education, which recognizes the alien and imposed nature of formal white schooling and highlights self-determination in education as a preferred option for Native Indian communities.

Feuerstein's techniques of mediation and discussion for insight are compatible with the aims of the second of these models; supplementary education for the Native student "should utilize and develop his styles of learning and doing, capitalizing on his knowledge and his strengths as well as correcting his weaknesses" (Lazure, 1973, p. 51). As well, a step may be made towards the third model, instrumental education, if more continuity between school experiences and those of everyday life is made apparent as part of the mediation process.

For a number of years now, spatial-perceptual skills have been recognized as a particular strength of Native Indian students (e.g., Bowd, 1973; Vernon, 1969), and MacArthur (1969) has suggested more extensive use of nonverbal media of instruction with these students. Exercises comparable with Feuerstein's would satisfy this suggestion; these activities would build on students' strengths identified by MacArthur, and may be more rewarding for, and attractive to, students than materials calling for written English comprehension and expression at which students may have a history of failure.

Measurement of Cognitive Development

The tests of particular interest here are Raven's Coloured Progressive Matrices, Raven's Standard Progressive Matrices and the Representational Stencil Design Test. These are the LPAD tests for which Feuerstein has devised variations (Learning Potential Assessment Device, Variations I; Learning Potential Assessment Device, Variations II; and the Representational Stencil Design Test, Parallel Test; respectively) and which could therefore be used as pre- and posttests in evaluation of a short-term cognitive skills training program.

There is a voluminous literature concerning the development and use of "culture-fair," "culture-free" and "culture-reduced" tests for cross-cultural testing purposes. While the development of truly culture-fair and culture-free tests is no longer thought possible (e.g., Anastasi, 1976; Vernon, 1969), culture-reduced tests which minimize the influence of specific information, skills and personality factors associated with particular cultures have been identified.

In particular, a considerable amount of work by MacArthur and colleagues (e.g., MacArthur, 1962, 1965; Rattan & MacArthur, 1968; West & MacArthur, 1964) among Native Indian children across Canada has led to the conclusion that the Raven's Progressive Matrices (including both Coloured and Standard Matrices) is one of three tests most suitable for cross-cultural assessment of intellectual potential (MacArthur, 1968), because of the graduated nature of the test items which parallel human developmental and learning stages from perception-dominated items, through reversible concrete operations, to propositional or formal operations. Also, the stimuli symbols used in the test are those which might be learned in a variety of cultures. MacArthur also observes that the culture-reduced tests which he studied hold intrinsic interest for Native Indian pupils, are economical and can be readily administered in group situations.

The above reasons are similar to those which underlay Feuerstein's choice of the Raven's Progressive Matrices for use with displaced adolescents of North African, Asian and European descent (Feuerstein, 1979, p. 150). It is also interesting to note here that MacArthur and his colleagues developed a testing technique which preceded use of the Raven's Standard Progressive Matrices by up to 30 minutes of teaching of the Raven's Coloured Progressive Matrices, item by item, with reinforcement for success on each item. Parallels with Feuerstein's testing-training-testing approach to establishing a measure of cognitive modifiability are obvious.

The Representational Stencil Design Test is based on the Stencil Design Test of Arthur (1943) which requires the physical manipulation of a series of stencils to recreate a model design. Arthur's Stencil Design Test was, in its turn, preceded by the Kohls Block Design Test which was one of a battery of tests called the Point Scale of Performance Tests (Arthur, 1930). Early results of the use of this test battery with 52 American Native Indian students are reported in Arthur (1941), who comments that the Kohls Block Design Test produced "astonishingly good" (p. 189) results; this was a judgement based on Arthur's dissatisfaction with the predictive value of other intelligence measures available to her. A subsequent study of 670 Native Indian students aged between 6 and 15 years in eleven American Indian communities reinforced the usefulness of this performance-based test battery in the educational placement and guidance of Native Indian children (Havighurst & Hilkevitch, 1944). Later, however, it became clear that the Kohls Block Design Test showed a high practice effect on repeated testing, and the Stencil Design Test was designed as an alternate test (Arthur, 1944; Boulger & Arthur, 1944).

Feuerstein then developed the Representational Stencil Design Test from the Stencil Design Test because he perceived the need for a test which measured planned, delayed reflective thinking. The Representational Stencil Design Test requires that the process of manipulation required by the test be done mentally, rather than physically; the manipulation required is mental manipulation of stencil designs presented on a wall poster to achieve a model design, also printed on a flat sheet. Thus, necessary problem-solving behavior is representational and internalized.

The Representational Stencil Design Test, then, has evolved from the search for a culture-reduced test which is performance oriented and internalized rather than requiring verbal or motor skills. Its precursors have been found useful in predicting academic success among Native Indian students; it should also be noticed that it meets all of MacArthur's criteria, outlined above, of tests suitable for cross-cultural assessment.

The Microcomputer Environment

Taylor (1980) has outlined three ways in which microcomputers can be used in educational settings. These are:

(1) as a tutor, in which computer-assisted instruction is presented step by step to a student;

(2) as a tool, in which the computer is used to accomplish a task more efficiently (e.g., word processing);

(3) as a tutee, in which students first need to learn computer programming, so that they can then program the computer to accomplish a task.

Microcomputer applications associated with the teaching of cognitive skills, such as the project reported in this thesis, involve the use of the last of these alternatives, the use of the computer as tutee, and require the learning of computer programming by students.

Lepper (1985), in his review of research issues associated with the rapid introduction of microcomputers into education, outlines the potential benefits to be gained from learning computer programming. They include the possibility of acquisition of problem-solving skills that should generalize to other settings, the ability to conduct "thought experiments" that can be visually represented, and mathematical knowledge and intuition. The programming language of particular interest here is LOGO. In the context of teaching LOGO, however, Lepper predicts that these "effects will prove to be neither as robust or general as proponents would claim, nor as evanescent as opponents would argue" (p. 12), and he calls for continuing research to investigate the validity of these suggested benefits.

The following section will describe the philosophy underlying the development and teaching of LOGO, and will review research shedding light on Lepper's prediction.

LOGO

LOGO computer language has been developed over the last 15 years by Seymour Papert and colleagues, at the Massachusetts Institute of Technology. Papert is convinced "that children can learn to use computers in a masterful way, and that learning to use computers can change the way they learn everything else" (1980, p. 8). LOGO has developed from his efforts to create an environment in which children of different ages and stages of intellectual development can learn to communicate with computers. Rather than emphasize the role of computers in learning, however, Papert's focus is on the mind and on the development of children's intellectual structures as they learn.

Papert's work is based on a Piagetian model of children as innately gifted learners, who learn 'naturally' through a process of self-generated interaction with the environment (Atkinson, 1983, Chapter 1). This model credits children with being builders of their own intellectual structures, prompted by materials drawn from their surrounding culture. Papert diverges from Piaget, however, in the view that children will develop appropriate intellectual structures to deal with concepts only if their environment provides them with the necessary stimuli at the appropriate developmental stage. Papert cuts across the more rigid intellectual development stages established by Piaget in suggesting that if environmental 'poverty' of particular types of stimuli can be redressed, then children can learn to deal with concepts of a level of complexity or formality not previously thought possible (Papert, 1980, Introduction). This approach is, of course, reminiscent of Feuerstein's interactionist stance.

Papert declares his "interest in intellectual structures that could develop as opposed to those that actually at present do develop in the child, and the design of learning environments that are resonant with them" (1980, p. 161). He is particularly concerned with the development of mathematical knowledge in children, and interested in the isolation of scientifically fundamental structures which can then be used to create "microworlds" of knowledge which are accessible to children. The LOGO 'turtle' is a tool for creating such microworlds, allowing the demonstration and exercise of many fundamental principles of both mathematics and physics.

Papert acknowledges close connections between his work and the cognitive science of artificial intelligence (AI). The study of AI necessitates deep probing of the nature of intelligent functions, such as the use of language, with the aim of giving "concrete form to ideas about thinking that previously might have seemed abstract" (1980, p. 158). Papert's extension of this is to propose that these concrete ideas be made accessible to children, who can then use them to think about their own thinking processes. "And obviously I believe this to be a good thing in that the ability to articulate the processes of thinking enables us to improve them" (1980, p. 158). Again, there is an obvious connection here with Feuerstein's emphasis on discussion for insight in the process of developing effective cognitive functioning.

The LOGO 'turtle' is a small triangular shape which can be directed around a microcomputer screen by a user. Over several years as the subject of a number of LOGO manuals, the turtle has acquired a personality of its own. It is a friendly character, who is an intrepid, determined explorer and is always excited by new ideas. The turtle leaves a track or trace behind it and so can be used to create a huge variety of graphic designs. In support of its activities, simple calculation is also possible in LOGO.

The turtle responds to simple commands or 'primitives' such as FORWARD, BACK, RIGHT, LEFT. Quantities can also be specified in terms of 'turtle steps' (e.g., FORWARD 10) or angles (e.g., RIGHT 90). The turtle may or may not leave a trace (PENDOWN, PENUP). A user can work in graphics mode or text mode (no picture appears), and a split screen (graphics with text at screen bottom) is possible. Cursor control keys need to be learned for efficient typing. As well, pictures and text can be saved to, or read from, disk.

'Primitive' commands can be combined into 'procedures' using the edit mode. This is a text mode in which a series of commands can be grouped together under a procedure name. Subsequently, whenever this procedure is 'called,' the series of commands which constitute it will be executed. Procedures can be used within other procedures, and so each user is offered the capacity of developing a unique, highly structured programming language of his own.

As users develop their own computer language, which is an elaboration of procedures available within the LOGO language, they are given the opportunity of thinking concretely about thinking. The turtle is moved with reference to its current location as opposed to a fixed set of coordinates, and so the user can 'put himself in the turtle's place' and translate his own physical movements along a particular path into instructions to the turtle. In this process of attempting to recreate a design, problems may be broken down into subproblems, hypotheses can be tested out and errors may be located; more importantly, the importance of each of these processes in the production of the final design must be recognized. It is this thinking about thinking which Papert sees as the real value of LOGO.

Teaching of LOGO

In the context of this thesis, LOGO is being examined in terms of its suitability as a vehicle for developing the deficient cognitive functions identified by Feuerstein (Table 1), using his testing and teaching techniques.

Krasnor and Mitterer (1984) summarize the skills or learning strategies which it has been argued can be developed using LOGO:

> One is the strategy of breaking problems into manageable subproblems. Another is means-end analysis or the systematic planning of actions to achieve goals. . . . A third is debugging, the principle that problem solutions can be successively refined. The development of a more positive attitude to errors is a fourth powerful idea. (p. 134)

These strategies each involve several of the cognitive functions on Feuerstein's list. For example, breaking problems into subproblems involves:

(1) the ability to perceive that a problem exists, and to define it adequately;

(2) appreciation of the interrelatedness of events;

(3) planning;

(4) selection of relevant information in problem solving; and presumably also

(5) summing up of the information needed to make a decision; as well as

(6) adequate verbal tools for communicating.

Lacking further evidence, it seems likely that the learning of LOGO will exercise most or all of the functions on Feuerstein's list. As well, as noted above Papert's philosophy is sympathetic with Feuerstein's teaching techniques of mediated learning and discussion for insight; the use of Feuerstein's teaching techniques should be compatible with Papert's intended method of learning LOGO.

It should be noted here that Krasnor and Mitterer are less optimistic than Papert regarding the usefulness of LOGO in developing cognitive strategies across Piagetian developmental levels. They point out that "on the basis of current evidence, it appears that only formal operational children of at least 12 years of age will be able to benefit fully from attempts to foster general problem-solving through LOGO" (1984, p. 141). Their argument is an extension of Folk's (1972) suggestion that the extent of LOGO learning depends upon developmental level, and rests on the hypothesis that skills such as subgoal analysis and means-end analysis may well demand formal operational thought. Michayluk and Yackulic (1984), on the other hand, have reported suggestions that the learning of LOGO may encourage formal operational thinking among concrete operational thinkers, and Chambers (1985) has reported a positive effect of LOGO experience on the performance on Raven's Progressive Matrices in a two-year study of 312 children aged 5 years 6 months to 12 years 2 months.

An earlier-mentioned problem is also raised by Krasnor and Mitterer (1984), that of the generalizability of problem-solving skills from a LOGO environment. Their review of the sparse empirical evidence available (Chait, 1978; Statz, 1973) indicates mixed benefits from learning LOGO in the areas of mathematical skills and general problem-solving skills. This research has been criticized by Krasnor and Mitterer on the grounds of inadequate experimental method. In general, they summarize the related literature as consisting primarily of testimonials, curriculum guides and studies based on ancedotal evidence. A more recent example of such evidence is that of Dog (1985) who reported that, of 385 students using LOGO for 40 hours of a school year, half were thought by their teachers to have improved in "some aspect of their academic performance" (p. 46). He logged the change in reported effects over time, suggesting that effects on social and behavioral skills may have preceded and paralleled cognitive effects. Such results need to be confirmed experimentally. Meanwhile, due to doubt over the existence of a single set of general problem-solving skills divorced from content, Tetenbaum and Mulkeen (1984) have called for "a moratorium on the implementation of programming as a generalised problem-solving model until further research can be conducted" (p. 18).

Michayluk and Yackulic (1984) similarly report mixed results in a review of LOGO environment studies investigating the generalizability of problem-solving skills. They do point out, however, that almost all of the observational data indicate that "LOGO does improve a subject's reasoning and problem solving skills" (p. 4), as indicated by reports of improved arguing skills and problem-solving strategies among students.

A related study by Stowbridge and Kugel (1983) throws some light on the generalizability of problem-solving skills. This study was not done in a LOGO environment but, rather, taught high-risk freshmen to play computer games. In the process of this, students were encouraged to think about how they were learning and to make written notes on their thinking processes. These notes were later discussed in class, with the aim of providing the opportunity for changes of thinking habits by students and of formulating a general strategy for solving learning problems. Students were then taught a programming language, with continuing discussion of the application of general problem-solving strategies in this new situation. Stowbridge and Kugel affirm their underlying assumption that transfer of learning strategies will be achieved "if one pays attention to the transfer process and does not assume that it will happen automatically" (p. 183).

Gallini (1985) takes this argument one step further, in the LOGO context, by suggesting two conditions necessary for the potential transfer of acquired skills: a given content area should be used as the focus of the teaching of LOGO programming which is taught as a means to the solution of problems in the area; and guided discovery should be used to make learners aware of the problem-solving process (metacognitive skills), at both the content-based and general skills levels.

Evidence of the success of a guided or mediated approach is also suggested by Delclos, Littlefield, and Bransford (1985) who compared three methods of teaching LOGO to fifth graders:

(1) unstructured discovery learning;

(2) structured tutorials;

(3) teacher as mediator, providing links to a broader context and bridging of specific principles to other comparable situations.

They suggest that the mediated approach is most successful in encouraging the generalization of problem-solving strategies.

In the absence of more concrete empirical evidence, Krasnor and Mitterer (1984) summarize their review of the issues involved in the development of problem-solving skills using LOGO as follows:

> the effective use of LOGO to develop problem-solving skills likely depends on three central conditions: (a) the use of techniques which foster awareness of the general utility of problem-solving heuristics; (b) selection of an appropriate group of children; and (c) the inclusion of the major components of the LOGO environment, since it is possible that LOGO programming per se will not be sufficient to produce transfer. (p. 141)

With this summary in mind, it seems worthwhile reiterating that Feuerstein's teaching techniques of mediation and discussion for insight should be useful both in establishing an appropriate LOGO learning environment according to Papert's aims and perhaps in fostering generalization of problem-solving skills acquired in the LOGO environment. It also appears from the foregoing discussion that, for an initial investigation of the benefits of LOGO learning in general problem solving, a student group potentially capable of formal operational thought, i.e., adolescent, would be most appropriate.

LOGO and Native Indian Students

One study of the use of LOGO with Native Indian students has been reported. Michayluk and Yackulic (1984), in an exploratory project at the University of Saskatchewan, introduced LOGO to 15 second-year university students of Native origin. Students spent 10 hours working through a LOGO manual, after an introductory supervised session. No control group was used. One student dropped out for health reasons, and 4 others dropped out after the first session at a terminal. The remaining 10 students showed a significant increase in formal operational thinking in a posttest of logical reasoning.

The meeting of computer technology with Native culture is of some concern here. Michayluk and Yackulic report that their students' designs were largely dictated by those used in the manual and "were simplistic in nature, consisting of trucks, apartment buildings and similar block shapes" (p. 5). They also report that students "expressed discomfort, even conflict, with a technology for which they were not prepared by their culture" (p. 6). This is at odds with the report of W. B. Clark (personal communication, October 1984) concerning the introduction of LOGO to Native Indian education students at Old Sun College in Gleichen, Alberta. He reports "that students (a) did not appear to have any cultural bias against the use of computers and (b) tended to use LOGO to construct patterns similar to their native art" when no effort was made to encourage students to construct images associated with white culture.

A related factor is the relative superiority of spatial-perceptual abilities over verbal abilities among Native Indian students (e.g., Bowd, 1973; MacArthur, 1969; Vernon, 1969). LOGO design activities would seem to offer a potentially successful, and attractive, environment in which students can develop cognitive strategies without the necessity for sophisticated verbal expression.

Michayluk and Yackulic's (1984) study serves as an indication that the learning of LOGO may encourage more effective cognitive functioning among Native Indian students at both concrete and formal operational levels of thinking. Their study, and Clark's observations, also provoke the suggestion that a LOGO design environment as free as possible from white cultural design stereotypes may be desirable; LOGO examples and 'building block' procedures based on Native Indian design motifs, with students being allowed to create their own overall design, may provide a suitable cultural bridge for LOGO activities with Native Indian students.

Summary

In the controversy over the relative influence of genetic and environmental factors in cognitive capacity and performance, the interactionist stance (e.g., Feuerstein, 1980a) acknowledges the interaction of these factors as they affect displayed ability. This interaction suggests the exciting possibility of devising intervention programs which result in improvement in capacity, which has previously been seen as predetermined or fixed. Das, Kirby, and Jarmon (1979) have reviewed evidence which suggests that such programs can be effective.

One such program is that of Reuven Feuerstein. His program of Instrumental Enrichment (1979, 1980a) is based on the concept of "cognitive modifiability" which, according to Feuerstein, is determined by the quality and quantity of mediated learning experience to which the individual is exposed. More importantly, Feuerstein believes that the effects of inadequate learning experience can be reversed by appropriate mediated experiences which will then enable the individual to benefit more fully from direct exposure to stimuli. Feuerstein's program of Instrumental Enrichment is a series of paper and pencil exercises, taking about 200 hours to complete, designed to remediate a number of cognitive deficiencies (Table 1). He has devised and successfully tested this program in Israel working with displaced adolescents from a wide variety of cultural backgrounds.

Feuerstein has emphasized particular teaching techniques in his Instrumental Enrichment program. These are the *mediation* or scheduling of exposure to stimuli in a way which encourages the development of particular cognitive skills and strategies or habits, and *discussion for insight* which is intended to encourage reflective, insightful thought processes in students. These teaching techniques would appear to be potentially useful with both culturally different and culturally deprived Native Indian groups, in the role of supplementary, and perhaps instrumental, education (after Bowd, 1977).

Feuerstein has also devised the Learning Potential Assessment Device (LPAD) as a measuring instrument intended to be used in a "dynamic testing" situation to measure cognitive modifiability. Feuerstein's variations on two subtests of the LPAD suggest the possibility of using them for pre- and posttesting in evaluation of other short-term training programs in cognitive functioning. Experience with these culture-reduced subtests (Raven's Progressive Matrices and the Representational Stencil Design Test) indicates that they are appropriate for use in measuring the cognitive functioning of Native Indian students (MacArthur, 1968).

LOGO is a computer programming language designed to encourage children to develop more complex intellectual structures (Papert, 1980). Papert's view is reminiscent of Feuerstein's interactionist stance, in that Papert also suggests that if cultural 'poverty' of particular types of stimuli can be redressed then children will develop more sophisticated cognitive skills. Papert's emphasis on encouraging students to think about thinking is also reminiscent of Feuerstein's discussion for insight technique. Further, the learning of LOGO appears to be a suitable vehicle for developing the deficient cognitive functions identified by Feuerstein (Table 1).

The question has been raised, however, as to whether the learning of LOGO is of benefit to children below 12 years of age, or those not capable of formal operational thinking. This has yet to be established. One reported study of the use of LOGO with Native Indian students indicates that LOGO may encourage more effective cognitive functioning among these students at both concrete and formal operational levels (Michayluk & Yackulic, 1984). Meanwhile, an adolescent group, more likely to be capable of formal operational thinking, may be the most suitable group to research.

Another question which has been raised about the use of LOGO concerns the generalizability of problem-solving skills from the LOGO environment. Available research has been criticized on methodological grounds, although some favourable evidence has been reported (Krasnor & Mitterer, 1984; Michayluk & Yackulic, 1984).

Finally, LOGO would also seem attractive because it offers a non-verbal environment in which Native Indian students can work (as suggested by MacArthur, 1969). Further to this, Clark's (personal communication, October 1984) observations suggest that Native Indian design motifs may provide a suitable cultural bridge between LOGO activities and Indian culture.

In conclusion, the above literature review suggests that a program of LOGO lessons, designed to exercise the deficient cognitive functions identified by Feuerstein (Table 1) and incorporating mediation, discussion for insight and Native Indian design motifs, could be devised and suitably tested with underachieving Native Indian adolescents. Appropriate evaluation could be performed using Raven's Progressive Matrices and the Representational Stencil Design Test, and Feuerstein's variations of these tests.

Chapter 3

DEVELOPMENT OF LOGO LESSONS

The as yet unexplored potential of LPAD tests for use in pretest-posttest evaluation of any short-term training program designed to develop deficient cognitive functioning and the likely capacity of LOGO to exercise a variety of cognitive functions are discussed in chapter 2 of this thesis. Taken together, these two considerations suggest the possibility of devising and evaluating a cognitive skills training program of a length more manageable than Feuerstein's Instrumental Enrichment program. The development of a set of LOGO lessons, designed to exercise cognitive functions found by Feuerstein to be underdeveloped in underachieving adolescents (Table 1), was undertaken.

Feuerstein (1980a, chapters 2 and 8) recommends the development of these deficient functions by practice, mediation of learning experience and discussion aimed at insight into, or awareness of, successful cognitive strategies. As outlined in chapter 2 of this thesis, it is apparent that the learning of LOGO offers the opportunity for exercise or practice of all the functions on Feuerstein's list. However, the linking of LOGO teaching, mediation of learning experience and discussion aimed at insight into associated cognitive functions was a novel undertaking, of unpredictable outcome. Because of this lack of predictability, it was decided to incorporate the elements of practice of deficient cognitive functions, mediation and discussion aimed at insight into every LOGO lesson.

It was also thought desirable to offer a cultural 'bridge' to students, who may otherwise see little connection between the learning of LOGO and their everyday life. This is in sympathy with Feuerstein's emphasis on the mediation of learning experience. It was, therefore, decided to adopt motifs from Cree Native art, in particular beadwork, to present as building blocks or simple procedures whenever the opportunity arose throughout the lessons.

Target Audience

An important distinction was made concerning the target audience to whom the lessons were directed. Because of the probable necessity of instructing teachers as well as students in LOGO, and the necessity for guidance of teachers unfamiliar with conducting discussion sessions aimed at insight into cognitive strategies, it was decided to write the lessons for an audience of Junior High school teachers, rather than for their students. Ideally, the lessons would then equip these teachers to pass on LOGO lessons to their students orally, using Feuerstein's recommended teaching techniques. Specifically, the lessons were written for teachers concerned with introducing LOGO to underachieving Native Indian adolescent students deficient in at least some of the cognitive functions listed by Feuerstein.

Course Content

Lesson titles are listed in Table 2. The introduction explained the purpose of the course as teaching both LOGO and cognitive functions ("thinking skills"), while the main purpose of the lessons was identified as "to develop thinking skills in students." The Introduction

Table 2

Lesson Titles

Introduction (for teachers)

1. Introduction to the computer/Disk maintenance/Turning on the computer
2. Review/Keyboard - 'Apple presents Apple'/LOGO loading and copying
3. Review keyboard/PRINT/DRAW, LOGO primitives
4. Review primitives/More primitives/Turtling around
5. Screen control/Exploring/Initializing a disk/SAVEPICT, READPICT
6. REPEAT/Editor - Writing procedures
7. Revise Editor/Pattern building/SAVE, READ
8. Circles/List commands/Erase commands
9. Review/Free drawing
10. More exploring - Little steps and tiny angles
11. Circles and arcs/Review SAVE, READ and related commands
12. More procedures/Review screen control commands
13. More procedures
14. Variables
15. Variables/MAKE/Calculation
16. Review/Free drawing
17. Recursion
18. Recursion with variables
19. STOP/Growing procedures
20. POLY
21. Design planning and breakdown
22. Defining repeated elements/Linking repeated elements

Table 2 (cont'd)

23. Defining unique parts

24. Linking parts/Subprocedures with variables/Growing

25. Writing procedure for whole design

also outlined the teacher's role in mediating students' learning experiences and in developing insight into cognitive functions. This was in recognition of the fact that the target audience of teachers would be unlikely to use these techniques regularly or consistently in day-to-day teaching.

The introduction also explained the framework of each lesson (see Instructional Strategy below), and included a short discussion of peer tutoring. The cognitive functions to be exercised by the lessons were then listed (Table 1).

The content of lessons 1 to 20 was selected to teach LOGO techniques in a logical and progressive fashion, with lessons 21 to 25 providing a summative design exercise allowing practice of skills acquired in earlier lessons.

Cognitive Functions

While a variety of cognitive functions might have been exercised within any particular lesson, particular functions were chosen for emphasis in each lesson. Table 3 lists each cognitive function, the lessons in which it was emphasized, and the corresponding activities which exercised that function.

For example, the ability to orient spatially (Input stage, 6) was emphasized in lesson 4 and exercised by "turtling around" or learning to put oneself in the turtle's place, and in lessons 21 and 24 in the process of breakdown and linking up of elements or parts of a design. Conversely, lessons 3 (Review keyboard/PRINT/DRAW, LOGO primitives) emphasizes four cognitive functions:

(1) the use of adequate verbal tools (Output stage, 2);

Table 3

Cognitive Functions, Related Activities and Associated Lessons

Cognitive Skill	Activities	Lesson
Input		
1	Debugging, Planning a linked design	6,21&24
2	Keyboard, Turtling around, Pattern building, Exploring, Design planning	2,4,7 10,21
3	REPEAT, Planning a linked design	6,21&23
4	Starting computer, POLY procedure	1&2,20
5	Screen control, Variables, Planning a linked design	5,14,21
6	Turtling around, Design breakdown and linking	4,21&24
7	Starting computer, Turtling around, Writing complete design procedure	1,4,25
8	Loading LOGO, Wrap around, Variables	2,5,14
Elaboration		
1	Debugging typing errors, Variables	3&5,14
2	REPEAT, POLY procedure, Testing design parts	6,20,23
3	Variables, Recursion with variables, Growing procedures	14,18, 19
4	Starting up the computer, REPEAT, Variables, STOP	1,6,15, 19
5	Writing procedures, Recursion, Recursion with variables	12&13, 17,18
6	Pattern building, ERASE commands, Design planning	7,8,23
7	Pattern building, MAKE, Linking design parts	7,15,22
8	Exploring, Writing procedures, Variables, Recursion with variables, Growing procedures	5,6,15, 17&18, 19
9	Recursion with variables, Growing procedures, Writing subprocedures	17&18, 19,24
10	PRINT, Circles & arcs, Writing procedures, Debugging	3,11,12 &13,24
11	Exploring, Circles & arcs, Variables/ MAKE/Calculation	10,11, 15
12	Pattern building, Circles, Writing complete design procedure	7,8,25
13	Exploring, POLY procedure, Writing complete design procedure	10,20, 25

Table 3 (cont'd)

Cognitive Skill	Activities	Lesson
Output		
1	Debugging	7&12&13
2	Introductory LOGO, Keyboard, Writing procedures	2&4,3,6
3	Keyboard, Debugging	2,3&22
4	Circles & arcs, POLY procedure	11,20
5	Starting computer, Turtling around, ERASE commands, POLY procedure	1,4,8, 20
6	Starting computer, Turtling around, ERASE commands	1,4,8
7	Circles & arcs, Writing procedures, Linking design elements	11,12& 13,22

Note: Cognitive functions can be identified from their numbers, using Table 1.

(2) precision and accuracy in communication (Output stage, 3);

(3) the ability to perceive and define problems (Elaboration stage, 1);

(4) the making of comparisons (Elaboration stage, 10).

It should be noticed that there is no inherent order among cognitive functions within each stage, and that the stages of Input, Elaboration and Output can occur many times within one problem situation, or within one lesson. Therefore, particular cognitive functions were not presented in any particular order, but as the opportunity to emphasize them arose.

Instructional Strategy

Each lesson had the same framework, as the extract below from the Introduction to the lessons explains:

> Each lesson follows a similar pattern:
>
> Class activity
> - this describes the LOGO-related activity to be completed in class
>
> Goals
> - these describe the particular thinking skills to be emphasized in this lesson
>
> Motivation
> - some suggestions are made here as to how to introduce the lesson, and connect it with what has gone before
>
> Presenting class activity
> - the LOGO-related activity is outlined here, along with some suggestions for mediating the learning experiences involved
>
> Student participation
> - this can be used as a checklist, to help you keep track of what each student should be able to do at the end of each lesson

Discussion for insight
- this is the most important part of each lesson; the principles to be identified in this discussion are listed here. (p. Intro. 4)

A sample lesson (Appendix A) illustrates the use of this framework.

This framework was developed according to a behaviorally oriented systems approach model (Dick & Carey, 1978). For each class activity, primary Goals and Subgoals were specified. Because of the difficulty of specifying and measuring the adequacy of a teacher's success in developing specific cognitive functions among students, these were not written as behavioral objectives; rather, the goals were framed in terms of encouraging or discouraging particular cognitive functions. This was also useful from a motivational point of view, since it was considered that teachers may otherwise be daunted by too rigid or apparently unattainable objectives.

The Motivation section of each lesson was designed to motivate teachers by offering them suggestions for motivating students. These suggestions depended upon looking ahead and telling students what they would be able to do when they had completed the lesson, and pointing out bridges or links with earlier and preexisting knowledge.

Information was presented to teachers in the guise of the Presenting Class Activity section of each lesson. The LOGO material was usually written in a hierarchical sequence or series of sequences intended to teach new practical skills (e.g., turning on the computer), commands (primitives) or LOGO procedure writing. Whenever LOGO techniques were generalizable (e.g., using variables, recursion) the material began with the comparison of specific examples and encouraged induction of the general case.

Information related to cognitive functions was also presented to teachers in this section. The cognitive functions on which the particular lesson's goals were based were highlighted at points in the lesson plan where it was likely that these functions would be exercised (see Lesson Layout below). These functions were further emphasized by the isolation of associated principles in the Discussion for Insight section at the end of each lesson.

The Student Participation section identified several behaviors expected of students during the lesson and often specified a frequency (e.g., "each student should have saved and read a picture file at least once"). The Discussion for Insight section listed principles to be identified in class discussion held during the lesson. These sections were designed so that they could be used as a checklist by teachers for evaluation of their teaching. Follow-through assignments, which exercised cognitive functions and might also initiate reflection on or insight into these functions, were also suggested in the Discussion for Insight section.

The participation required of teachers was specified in the Motivation, Presenting Class Activity, Student Participation and Discussion for Insight sections of each lesson. In these sections, direct instructions were given to teachers concerning (a) the motivation of students, (b) provision of information to students, (c) participation required from students, (d) mediation of students' learning experiences and discussion for insight, and (e) follow-through assignments to be given to students.

In summary, these lessons were designed as lessons within lessons. While following Dick and Carey's (1978) systematic approach model in terms of what was presented to teachers, it was also intended that teachers would be guided by the lessons to use a similar framework when working with students, i.e., in their own lessons with students teachers would motivate students according to the content to be presented, present specified information, require certain participatory activities and encourage targeted follow-through activities.

Lesson Layout

A split-page layout (see Appendix A) was decided upon as giving maximum readability and clarity. The framework headings were always typed on the left of the page, with the remaining text on the right. This had the added advantage of allowing teachers to refer readily to particular sections of the text.

As well, particular cognitive functions were highlighted in italics on the left of the page whenever they were emphasized in the body of the text. These were stated briefly and in a consistent fashion, again for teachers to be able to recognize them readily.

Other Information

Throughout the lessons, whenever a particular LOGO procedure was judged to be instrumental in later lessons, the complete procedure was written out and a simple line diagram given. Also, whenever it was suggested that teachers ask a particular question of students to draw out a particular point, the answer was given in the text for teachers' information.

Summary

A set of 25 LOGO lessons was developed according to a behaviorally oriented systems approach model (Dick & Carey, 1978). These lessons were targeted to Junior High school teachers and intended to teach them techniques for encouraging the use and awareness of selected cognitive functions while introducing LOGO to underachieving Native Indian adolescent students. Particular cognitive functions were emphasized in each lesson as the opportunity presented itself, using a split-page layout, and Feuerstein's (1979, 1980a) techniques of mediation and discussion aimed at insight were incorporated into each lesson. Motifs from Cree beadwork were used as a cultural 'bridge.'

Chapter 4

PILOT TEST OF LESSONS

Subjects

The students were 71 Native Cree Indian students at schools in Hobbema, Ponoka and Wetaskiwin, Alberta. The subject group comprised 34 females and 37 males, whose ages ranged from 12 years to 17 years (mean age = 14.9 years). All had previously been identified by school administrators and teachers as underachieving students, i.e., with age-grade retardation of one or more years. Students were grouped in six classes, as part of their ongoing school program. These were the special class at Ponoka Junior High School (8 students), classes 7B and 8B at Hobbema Junior High School (19 and 11 students respectively), a class under the auspices of the Ermineskin Achievement Training Project (EATP) at Hobbema (21 students), and grades 7 and 8 at Queen Elizabeth Junior High, Wetaskiwin (total 12 students). It should be noted that the EATP class in Hobbema was somewhat distinct in that its students were attending this alternative school program voluntarily, all having previously dropped out of the regular school system for a variety of reasons.

Teaching and Testing Materials

Prior to the study's commencement, a set of 25 LOGO lessons, directed to teachers, was developed (see chapter 3 for a description and discussion of these lessons).

The following tests were used for assessment purposes:

Computer use questionnaire (after Clark, 1984; see Appendix B);

Raven's Coloured Progressive Matrices (CPM), Sets A, Ab and B (Raven, 1956);

Raven's Standard Progressive Matrices (SPM), Sets C, D and E only (Raven, 1958);

Representational Stencil Design Test (RSDT1) (Feuerstein, 1973a, 1973b);

Learning Potential Assessment Device, Variations I (LPAD1) (Feuerstein, 1980b);

Learning Potential Assessment Device, Variations II (LPAD2) (Feuerstein, 1973c);

Representational Stencil Design Test, Parallel Form (RSDT2) (Feuerstein, 1973b, 1973d).

Reasons for selecting these tests and the appropriateness of their use with the subject group have been discussed in chapter 2.

Procedure

Experimental Design

Due to restrictions of geography and school administration it was necessary to use intact groups. Thus, it was not possible to randomly assign students to groups or to match groups on the basis of preliminary test results. The grade 7 and 8 classes at Queen Elizabeth Junior High School, Wetaskiwin, were designated as the Non-Intervention group, while the remaining classes comprised the Intervention group.

Consent

Permission to conduct the study was obtained from the following:

(1) the County of Ponoka Board of Education (through the Associate Superintendent of Education);

(2) the Department of Indian and Northern Affairs (through the Principal of Ermineskin Junior High School, Hobbema);

(3) the Ermineskin Education Trust Board;

(4) the County of Wetaskiwin Board of Education (through the Principal of Queen Elizabeth Junior High School, Wetaskiwin).

The teachers of the classes concerned were approached regarding participation, and all six consented. The four teachers of classes comprising the Intervention group, from whom a greater commitment was required, showed enthusiasm for the study. One of these teachers (of the EATP class) was Native Indian.

Letters were sent to parents or guardians of each student, informing them of the project and requesting their permission for students' participation in either the Intervention or Non-Intervention group, as appropriate (see Appendix C). Care was taken in these letters to explain that information collected during the project concerning individual students would be available to parents or guardians and to the student, on request. It was also made clear in these letters that test results of individual students would be strictly confidential and would not be made available to school authorities.

Computing Hardware and Software

For the purposes of this study, the special class at Ponoka Junior High School had access to the school's laboratory of Apple //e computers. Each student had individual access to a computer and his or her own initialized disk.

Classes 7B and 8B at Hobbema Junior High School and the EATP class shared a laboratory of 10 Apple //c computers, obtained through the Canadian Centre for Learning Systems and set up in the EATP building which is located next door to the Hobbema Junior High School main building. Class size sometimes meant that students worked in pairs on a computer, an uncontrolled variable the results of which are discussed in chapter 5 of this thesis.

Each computer laboratory was supplied with copies of the Apple System Master disk necessary for initializing student disks and a copy of Terrapin LOGO.

Teacher Training

Since the four teachers of classes comprising the Intervention group were unfamiliar with both computer use and the LOGO language they were invited to two, day-long inservice workshops, one held in early December, 1984, and one held in early January, 1985, in the EATP classroom at Hobbema.

On both days the workshop format was similar; approximately half of each workshop was devoted to discussion of the aims of the project and problems which teachers foresaw, and the other half was devoted to introduction of teachers to the operation of Apple //c computers and the LOGO language. Teachers were given a five-page 'cheat sheet' of LOGO commands and sample procedures at the first workshop and it was established that each teacher had access to an Apple //c or //e computer on which they could practice LOGO. At the second workshop, teachers were given the first set of LOGO-based lessons (lessons 1 to 9, see Lesson titles, Table 2 and sample lesson, Appendix A).

Testing

Pretesting of students was undertaken in the week of January 14 to 18, 1985. Students were tested at school in class groups and were given the Computer Use Questionnaire, Raven's CPM, Raven's SPM (sets

C, D and E only) and RSDT1, in that order. Due to school administrative constraints, it was necessary to spread the testing over two days and the RSDT1 was given on the second day. The Raven's tests were administered following standard procedure (Raven, Court, & Raven, 1986). The RSDT1 was introduced using a training sheet of examples (Feuerstein, 1973e).

Posttesting was conducted during the week of March 4 to 8, 1985. Students were given the LPAD1 and LPAD2 variations on the Raven's Progressive Matrices and RSDT2 (parallel form), in that order. Again, it was necessary to spread testing over two days and the RSDT2 was given on the second day. Each set of LPAD variations was introduced using the associated training item, in an approach analogous to the standard Raven's instructions. Again, the training sheet of examples was used to introduce the RSDT2 (Feuerstein, 1973e).

It is important to note here that the testing sessions were conducted according to normal practice for standardized psychometric testing, and not according to Feuerstein's within-task training approach outlined earlier. This accords with the design of this study which substitutes LOGO lessons for the training section of Feuerstein's testing-training-testing approach.

Psychologists' Reports

Two independent psychologists, familiar with the cognitive functions identified by Feuerstein (Table 1) and experienced in the analysis of Raven's CPM, SPM and RSDT test responses, were asked to identify which of the cognitive functions on Feuerstein's list were markedly deficient in the tested population. This analysis was performed on only the pretest responses.

Teaching

Teachers of the classes comprising the Intervention group undertook to conduct LOGO-based sessions of between 50 minutes and 90 minutes per day, during the regular school program, for the period of the study. Due to administrative constraints, the Ermineskin Junior High School 7B and 8B classes were restricted to sessions of 50 minutes in length, while it was possible for the special Ponoka Junior High school and EATP classes' sessions to extend up to 1½ hours. The Ermineskin Junior High School teachers partly compensated for this by encouraging students to arrive early for classes (which some students often did) or by covering some material in another lesson. Each teacher taught between 25 and 30 sessions over a period of 7 weeks. Overall, the Ponoka and EATP classes' total LOGO session time was 20% to 30% higher than that of the Ermineskin Junior High School classes. This discrepancy between classes had no effect, however, as discussed in chapter 5 of this thesis.

Students in classes comprising the Non-Intervention group followed their regular school program over this 7-week period. While aware that their students had been tested as part of a project investigating the development of thinking skills, teachers of these classes were not exposed to the training or LOGO lessons available to teachers of the Intervention group.

Teacher Support

At the close of the second training workshop, teachers were given the researcher's telephone number in Calgary, and encouraged to make contact with problems or questions concerning the study. Teachers were also encouraged to prepare posters of basic LOGO commands (primitives) for permanent classroom display, and the three teachers sharing the

EATP computer laboratory took up this suggestion.

A conscientious effort was made by the researcher to visit each class of the Intervention group at least once a week. These visits were usually of ½ to 1 hour's duration while classes were in progress, but occasionally a teacher was interviewed at lunch time, during a free lesson or after school (teachers were always very willing to participate in these interviews). Occasionally, bad weather or alternative school activities intervened in the schedule of visits. Teachers were often reminded that they could contact the researcher in Calgary by telephone, but in fact such contact was made only once during the study.

Two further sets of LOGO-based lessons (lessons 10 to 19, lessons 20 to 25) were delivered to teachers as they neared completion of preceding lesson sets. Throughout, it was left to teachers to decide whether to provide handouts or written exercises for students (resulting materials and activities are outlined in chapter 5).

Equipment maintenance was provided during weekly visits to classes by the researcher. The only major problems occurred with one computer and two monitors which malfunctioned at different times. Replacement equipment was delivered on the next visit. A number of disks also had to be replaced early in the study to ensure that each student had his or her own disk on which to save LOGO routines.

Anecdotal Reporting

Teachers were encouraged to keep a daily log of classes, in which they could comment upon such things as attendance, student motivation, problems, student questions and reactions to the lessons. Observational notes were made by the researcher concerning progress by classes, and teachers' and students' problems encountered or comments made on weekly visits to classrooms.

Confidence Level

The confidence level for all statistical tests to be reported was set at the five percent level ($p = .05$).

Chapter 5

RESULTS

Analyses of the tests outlined in chapter 4 are given below. As well, the teachers' and researcher's observations of the study are reported. Student attendance and dropout rates and supplementary materials used by teachers are also discussed.

Computer Use Questionnaire

This questionnaire (see Appendix B) was used to establish a base line of computer use among students. Summary data are presented in Table 4. From this it can be seen that all students but one had used a computer prior to the start of this project. By far the largest prior use of computers was for playing computer games, and over three-quarters of all students reported that they played these games at least once a week. (In fact, observation of the lunchtime behavior of project students from the computer laboratory in the EATP building revealed that most of these students played computer or arcade games daily.) Table 4 reveals that other uses of computers by students were low, although prior use of a typewriter was quite high with 63.7% of students using a typewriter at least once a month.

A comparison of questionnaire responses of the Intervention and Non-Intervention groups from Table 4 indicates that, while the Non-Intervention group undertook program writing and computer catalog use less often than the Intervention group and word processing not at all,

Table 4

Computer Use Questionnaire Response Summary

Q	% Over-all	% Int Group	% N-Int Group	
1	98.6 N=71	98.3 N=59	100 N=12	have used a computer before
2	94.2	96.6	81.8	play computer games at least once a month
	75.4 N=69	75.9 N=58	72.7 N=11	play computer games at least once a week
3	75.7 N=70	72.9 N=59	90.9 N=11	write programs once a year or never
4	82.4 N=68	79.3 N=58	100 N=10	use word processing once a year or never
5	68.7 N=67	70.7 N=58	55.6 N=9	taught by computer once a year or never
6	90.0 N=70	89.8 N=59	90.9 N=11	use online library catalogs once a year or never
7	79.1 N=67	82.1 N=56	63.6 N=11	use computers in other ways once a year or never
8	63.7	72.4	18.2	use a typewriter at least once a month
	50.7 N=69	58.6 N=58	9.1 N=11	use a typewriter at least once a week

Note: Int = Intervention; N-Int = Non-Intervention the Non-Intervention group undertook more computer-assisted instruction and made more use of computers in other ways. It can also be noted that the Non-Intervention group had used typewriters much less (18.2% at least once a month) than the Intervention group (72.4% at least once a month).

Psychologists' Reports

The psychologists reported that for each of the cognitive functions on Feuerstein's list (Table 1), there was evidence of deficiency among at least some students. All students showed some deficiency in at least one or two cognitive functions. These results were crucial to this study, in that the LOGO lessons had been designed to highlight and exercise all of these functions. The fact that different cognitive functions were deficient to varying degrees among different subgroups of students indicated that the whole group of students potentially could benefit from exposure to the LOGO lessons.

Dropouts

Table 5 shows the dropouts from the Intervention and Non-Intervention groups. The dropout rate was high in the first two weeks of the project. This was exacerbated by a decision made by the teacher of the EATP class that this class should be of limited size. Consequently 8 students were discouraged from further attendance during the initial period of the project. A further 3 students (mean attendance = 65%) dropped out later in the project for health or family reasons.

Class 7B at Hobbema Junior High School contained 7 poor attenders (mean attendance = 50%) who were not present for posttesting. Class 8B

Table 5

Dropouts

Group	N		
	Pretested	Posttested	Dropouts
Intervention	59	38	21
Non-Intervention	12	7	5
Total	71	45	26

contained 3 students (mean attendance = 75%) who were not present for posttesting. The Ponoka Junior High School special class had no dropouts.

A total of 5 students (mean attendance = 50%) dropped out of the grade 7 and 8 classes at Queen Elizabeth High School, Wetaskiwin, for unspecified reasons. These classes comprised the Non-Intervention group.

A comparison of means of dropouts compared with means of students who remained in the study showed that students who dropped out tended to be older, with higher scores on the pretest Raven's CPM and SPM measures. The mean scores of dropouts on these variables, however, were still within one standard deviation of the overall means for all pretested students. No marked differences were observed between dropouts and other students on the pretest RSDT1 measure or the computer use questionnaire.

Preliminary Analyses

No statistically significant effects due to gender or age were found in preliminary analyses. Therefore, these factors are not included in subsequent analyses.

Raw Scores

Table 6 is a table of means of raw scores on the tests of general cognitive development.

Measures

Three dependent variables, R-L1, R-L2 and Stencil Design, were

Table 6

Mean Raw Scores and Standard Deviations for Tests of General Cognitive Development

Group	Pretest				Posttest			
		Mean	s.d.	n		Mean	s.d.	n
Overall	Raven's CPM	31.89	3.28	71	LPAD1	20.40	5.62	45
Int		31.64	3.38	59		19.79	5.07	38
N-Int		33.08	2.54	12		23.71	6.18	7
Overall	Raven's SPM	19.91	4.84	71	LPAD2	25.38	7.76	45
Int		19.51	4.59	59		25.53	7.23	38
N-Int		21.92	5.73	12		24.57	7.72	7
Overall	RSDT1	25.51	14.40	71	RSDT2	33.11	11.68	45
Int		24.32	14.11	59		32.79	11.42	38
N-Int		37.33	15.01	12		34.86	14.71	7

Note: Int = Intervention; N-Int = Non-Intervention selected to assess the effects of the seven-week teaching intervention. These variables were each comprised of a pre- and posttest of general cognitive development. Identical pre- and posttests were not used, however, to avoid problems associated with repetition of identical measures. Instead, the posttests LPAD1, LPAD2 and RSDT2 were administered paralleling Raven's CPM and SPM and RSDT1 pretest measures, respectively. Thus, the corresponding pairs of scores used to establish measures on the three dependent variables were:

• R-L1	pretest Raven's CPM	posttest LPAD1;
• R-L2	pretest Raven's SPM	posttest LPAD2;
• Stencil Design	pretest RSDT1	posttest RSDT2.

Total scores on these pre- and posttest measures were analyzed and the results are discussed below. All scores analyzed were first converted to percentages, since pre- and posttest scores were based on tests with differing numbers of items (Table 7).

Significant correlations between dependent variables reported in Table 8 indicated that multivariate analysis of variance was appropriate. Two(Treatment) × 2(Occasion) mixed multivariate analyses of variance were performed on the three dependent variables R-L1, R-L2 and Stencil Design, with Treatment(Intervention vs Non-Intervention) as a between-subjects variable and Occasion(Pretest vs Posttest) as a within-subjects variable. These were followed by univariate analyses, using the same design, for each dependent variable taken separately. Analyses were carried out using the general-purpose analysis of variance and covariance program, BMDP4V (Dixon, 1983, pp. 388-412).

Findings

Both pre- and posttest scores were available for 45 of the 71

Table 7

Mean Percentage Scores and Standard Deviations for Overall Scores

Group	Pretest		Posttest	
	Mean	s.d.	Mean	s.d.
Intervention (n=37)				
R-L1	88.0	9.9	67.6	15.1
R-L2	54.0	12.1	44.7	13.1
Stencil Design	42.9	24.7	55.4	19.3
Non-Intervention (n=7)				
R-L1	92.1	5.4	79.0	20.6
R-L2	60.7	15.5	42.4	13.3
Stencil Design	61.4	25.6	59.1	24.9
Combined (n=44)				
R-L1	88.6	--	69.4	--
R-L2	55.1	--	44.3	--
Stencil Design	45.8	--	56.0	--

Table 8

Correlations Among Pre- and Posttest Measures

	Pretest		Posttest		
	R-L2	Stencil design	R-L1	R-L2	Stencil design
Overall					
R-L1	.50***	.38**	.53***	.46***	.29*
R-L2	—	.60***	.69***	.59***	.50***
Stencil design		—	.53***	.54***	.73***
R-L1			—	.60***	.35**
R-L2				—	.51***
Stencil design					—
Feuerstein's sets					
R-L1	-.06	.24	.54***	.46***	.04
R-L2	—	.29*	.21	.25*	.30*
Stencil design		—	.53***	.54***	.73***
R-L1			—	.60***	.35**
R-L2				—	.51***
Stencil design					—
Matched sets					
R-L1	-.22	.22	.41**	.15	.08
R-L2	—	.30*	.12	.27*	.30*
Stencil design		—	.46***	.24	.73***
R-L1			—	.29*	.27*
R-L2				—	.35**
Stencil design					—

*$p < .05$
**$p < .01$
***$p < .001$ (1-tailed)

subjects originally tested. This sample size of 45 was reduced to 44 with deletion of one within-cell outlier with a score on LPAD1 more than three standard deviations below the mean score on that measure. Evaluation of the assumptions of normality, homogeneity of variance-covariance matrices, and linearity of these data was satisfactory.

The 2 × 2 mixed multivariate analysis of variance outlined above revealed a significant effect of Occasion on the combined dependent variables, R-L1, R-L2 and Stencil Design ($F(3,40) = 22.96$, $p < .001$). No significant effects due to Treatment ($F(3,40) = 1.8$, $p > .05$) or the interaction of Treatment with Occasion ($F(3,40) = 2.75$, $p > .05$) were found.

Univariate analyses, with the same design, for each of the dependent variables taken separately showed significant effects of Occasion on R-L1 ($F(1,42) = 32.89$, $p < .001$) and R-L2 ($F(1,42) = 33.40$, $p < .001$). As can be seen in Table 7, this effect was due to *lower* posttest mean scores on both variables.

Only one other univariate finding was significant for the effect of the Occasion by Treatment interaction on Stencil Design scores ($F(1,42) = 4.75$, $p < .05$). Simple main effects tests demonstrated that this effect can be attributed to the fact that posttest mean scores, shown in Table 7, were significantly higher for the Intervention group ($F(1,42) = 21.25$, $p < .001$), but not for the Non-Intervention group ($F(1,42) = 0.14$, $p > .05$). It should be kept in mind when interpreting this result that the multivariate statistic for the Treatment by Occasion interaction was not significant.

Alternative Measures

Correlations between scores obtained on pretest and posttest measures, reported in Table 8, revealed significant positive correlations between pre- and posttest pairs of scores for R-L1, R-L2 and Stencil Design (r = .53, .59 and .73, respectively; $p < .001$, one-tailed). However, the moderate levels of the correlations of the pre- and posttest scores for R-L1 and R-L2 led to questioning of the assumption that the Raven's measures and the LPAD variations are in fact parallel forms. In consequence, two alternative sets of measures for the dependent variables R-L1 and R-L2 were derived from the original measures. The basis for these new measures is described in the following two subsections.

Feuerstein's Sets

Feuerstein (1979, pp. 96-97) claims that his LPAD1 questions are all variations of a subset of the Raven's CPM items, namely, items B8 to B12, and he has used comparisons of percentage correct scores on LPAD1 and Raven's CPM items B8 to B12 in several analyses of intervention effects. Similarly, he claims that his LPAD2 questions are variations of the Raven's SPM items C7, C8, C12, D12 and E12 (p. 156).

Consequently, a second analysis of the data was carried out using only scores on Raven's items B8 to B12 and on items C7, C8, C12, D12 and E12 as pretest scores for R-L1 and R-L2, respectively. Posttest scores for these variables (LPAD1 and LPAD2 scores) were left unchanged. These measures were grouped with the previously used RSDT measure, and analysis of these scores is reported in the Secondary Findings subsection below, titled Feuerstein's Sets.

Matched Sets

Close inspection of Feuerstein's LPAD variations of Raven's items revealed that in fact very few items in each set of tests are directly analogous. Tables 9 to 12 permit comparison of Raven's CPM items B8 to B12 with LPAD1 items according to the cognitive operations necessary to solve each item. (These tables were developed in part from information given in the manual accompanying the Raven's test (Raven, Court, & Raven, 1986).) The tables show that only LPAD1 variations A1 to A6, D1 and C1 require the same operations for solution as Raven's CPM items B8 to B11. Item B12 has no analogous LPAD item.

Similarly, Tables 13 to 16 compare LPAD2 items with Raven's SPM items C7, C8, C12, D12 and E12. The tables show that LPAD2 variations A1 to A3, B1, B4, B6, C10 and D1 to D3 are comparable to Raven's SPM items C7, C8, C12, D12 and E12. The remaining LPAD2 items require cognitive operations not needed in the solution of the Raven's SPM items. (Note that the LPAD2 set of variations E was based upon a Raven's item not used in this study, and therefore is not considered in Tables 13 to 16.)

On the basis of the foregoing comparisons, a third analysis of the data was carried out using scores on Raven's items B8 to B11 and on items C7, C8, C12, D12 and E12 as pretest scores for R-L1 and R-L2. Posttest scores were based on LPAD1 items A1 to A6, D1 and C1 and on LPAD2 items A1 to A3, B1, B4, B6, C10 and D1 to D3. These new measures were grouped with the previously used RSDT measure, and analysis of these scores is reported in the Secondary Findings subsection below, titled Matched Sets.

Table 9

Cognitive Operations Required for Solution of Raven's Items B8 and B9 and Corresponding LPAD1 Variations

	Modified figure	Asymmetrical change within figure	Orientation of figure
Raven B8	x	x	
LPAD1 Tr	x	x	
A1	x	x	
A2	x	x	
A3	x	x	
A4	x	x	
A5	x	x	
A6	x	x	
Raven B9	x	x	
LPAD1 Tr	x	x	x
B1	x	x	x
B2	x	x	x
B3	x	x	x
B4	x	x	x
B5	x	x	x
B6	x	x	x

Conclusion:
1. Raven's B8 and B9 require same operations as LPAD1 A1 to A6.
2. LPAD1 B1 to B6 combine skills required in Raven's B6, B7, B8 and B9. No directly analogous Raven's items.

Table 10

Cognitive Operations Required for Solution of Raven's Item B10 and Corresponding LPAD1 Variations

	Modified figure	Orientation of figure	Subtraction of figure	Addition of character	Subtraction of character	Orientation of character
Raven B10	x			x		
LPAD1 Tr	x					x
D1	x			x		
D2	x			xx		
D3	x				x	x
D4	x	x		x		
D5	x	x		x		
D6	x		x	x		x

Conclusion: Raven's B10 requires same operations as LPAD1 D1.

Table 11

Cognitive Operations Required for Solution of Raven's Item B11 and Corresponding LPAD1 Variations

	Modified figure	Orientation of figure	Subtraction of figure	Addition of character	Subtraction of character	Orientation of character
Raven B11	x				x	
LPAD1 Tr	x	x			x	
C1	x				x	
C2	x	x		x		
C3	x				xx	
C4	x	x		x		
C5	x		x	x	x	
C6	x				x	x

Conclusion: Raven's B11 requires same operations as LPAD1 C1.

Table 12

Cognitive Operations Required for Solution of Raven's Item B12 and Corresponding LPAD1 Variations

	Addition of character	Subtraction of character	Similarity, asymmetry and orientation
Raven B12		xx	
LPAD1 Tr		xx	x
E1	x	x	x
E2	x	x	x
E3		xx	x
E4	xx		x
E5	x	x	x
E6	xx		x

Conclusion: LPAD1 items combine skills required in Raven's B3 and B5, B10 and B12. No directly analogous Raven's items.

Table 13

Cognitive Operations Required for Solution of Raven's Item C7 and Corresponding LPAD2 Variations

		Position of character on 2 dimensions	Overall symmetry	Overall asymmetry	Position of character on 2 dimensions at once
Raven C7		x	x		
LPAD2	Tr	x	x		
	A1	x	x		
	A2	x	x		
	A3	x	x		
	A4	x		x	
	A5	x		x	
	A6	x		x	
	A7	x		x	
	A8		x		x
	A9		x		x
	A10		x		x
	A11		x		x
	A12			x	x
	A13			x	x

Conclusion: Raven's C7 requires same operations as LPAD2 A1 to A3.

Table 14

Cognitive Operations Required for Solution of Raven's Items C8 and C12 and Corresponding LPAD2 Variations

		Asymmetrical change within figure on 2D			Symmetrical change within figure on 2D	Asymmetrical change within figure on 1D			
		($\frac{1}{2}$ & whole)	($\frac{1}{4}$ & $\frac{1}{2}$)	($\frac{1}{3}$ & $\frac{2}{3}$)	($\frac{1}{4}$ & $\frac{1}{2}$)	($\frac{1}{2}$ & whole)	($\frac{1}{4}$ & $\frac{1}{2}$)	($\frac{1}{8}$ & $\frac{1}{4}$)	Other
Raven	C8	x							
	C12		x						
LPAD2	Tr	x							
	B1	x							
	B2					x	x		xx
	B3					x			
	B4		x						
	B5		x						x
	B6		x						
	B7						x	x	
	B8				x				
	B9			x					
	B10		x						x
	B11		x						x
	B12			x					
	B13			x					
	B14			x					
	B15								xx

Conclusion:
1. Raven's C8 requires same operations as LPAD2 B1.
2. Raven's C12 requires same operations as LPAD2 B4 and B6.

Table 15

Cognitive Operations Required for Solution of Raven's Item D12 and Corresponding LPAD2 Variations

		Permutation of numerical progression	Permutation of shape	Modification of shape	Orientation of shape	Asymmetrical change within figure	Modified figure	Other
Raven D12		x	x	x	x			
LPAD2	Tr	x	x	x	xx			
	C1	x		x		x		
	C2	x	x	x			x	
	C3	x				x	x	x
	C4				x		x	x
	C5					x	x	x
	C6	x		x		x		
	C7	x		x			x	
	C8						x	x
	C9	x						xx
	C10	x	x	x	x			

Conclusion: Raven's D12 requires same operations as LPAD2 C10.

Table 16

Cognitive Operations Required for Solution of Raven's Item E12 and Corresponding LPAD2 Variations

		Addition/Subtraction Summative	Asymmetrical change within character	Modified figure	Orientation of character
Raven E12		x			
LPAD2	Tr	x			
	D1	x			
	D2	x			
	D3	x			
	D4	x	x		
	D5	x	x		
	D6	x		x	
	D7	x			x
	D8	x			x
	D9	x			x
	D10	x			x

Conclusion: Raven's E12 requires same operations as LPAD2 D1 to D3.

Secondary Findings

Unfortunately the two alternative analyses involved *post hoc* regroupings of the data, as explained above, and this influences statistical confidence levels in a manner which is difficult to determine. It could be argued that a solution to this problem would be to adopt the more stringent confidence level of $\underline{p} = .05/3$ (since three groupings of the original scores were used). Here, however, each grouping of the data was treated as independent, and thus it should be kept in mind that the likelihood of making a Type I error is possibly higher than the reported level of confidence indicates.

Feuerstein's Sets

As discussed above, these sets were selected on the basis of Feuerstein's claim that the posttest items are variations of only a small set of the pretest items measured in this study. To the extent that Feuerstein's variations do reflect similar cognitive operations to those necessary in the solution of this subset of pretest items, it could be reasonably expected that pre- and posttest scores would correlate highly, at least more highly than for the overall test scores comprising a greater diversity of cognitive operations. The correlations in Table 8 indicate that this was not the case, although the correlation did increase fractionally for pre- and posttest R-L1 scores.

Analyses of these data exactly parallel those reported under Measures. The multivariate analysis identified no significant effects. Mean percentage scores for these data are presented in Table 17.

The only significant univariate effect identified was the Treatment by Occasion interaction for the Stencil Design test. This was expected, however, since the Stencil Design data analyzed here was the same as

Table 17

Mean Percentage Scores and Standard Deviations for Feuerstein's Sets

Group	Pretest		Posttest	
	Mean	s.d.	Mean	s.d.
Intervention (n=37)				
R-L1	60.0	36.2	67.6	15.1
R-L2	37.3	16.4	44.7	13.1
Stencil Design	42.9	24.7	55.4	19.3
Non-Intervention (n=7)				
R-L1	77.1	18.0	79.0	20.6
R-L2	37.1	7.6	42.4	13.3
Stencil Design	61.4	25.6	59.1	24.9
Combined (n=44)				
R-L1	62.7	--	69.4	--
R-L2	37.3	--	44.3	--
Stencil Design	45.8	--	56.0	--

that used in the analyses of overall scores, and thus requires no further interpretation.

Matched Sets

It will be recalled that these sets were selected so that the same cognitive operations were required for solution both pre- and posttest. It was anticipated that items matched in this manner would result in higher correlations between altered tests than were found originally when pre- and posttests did not involve identical operations. This expectation, however, was not confirmed, as can be seen in Table 8. Unfortunately, there were substantially fewer items in these regrouped sets of items and this may explain why only moderate to low correlations were obtained with this regrouped data. This artifact may also account for the failure above to find substantial improvement in the strength of correlations using Feuerstein's sets. If this is not the explanation, it is difficult to understand why higher correlations were not obtained with more precise matching of pre- and posttest items.

Multivariate tests showed a significant effect for Occasion, indicating that pre- and posttests could be differentiated on the basis of some linear combination of dependent variable scores ($F(3,40) = 3.22$, $p < .05$). Neither Treatment nor the Treatment by Occasion interaction were significant.

Table 18 reports cell means for each of the three dependent variables. Univariate tests showed that these means increased significantly for R-L2 scores from pre- to posttesting ($F(1,42) = 4.92$, $p < .05$) and, again, the Treatment by Occasion interaction was confirmed for the repeated Stencil Design scores.

Table 18

Mean Percentage Scores and Standard Deviations for Matched Sets

Group	Pretest		Posttest	
	Mean	s.d.	Mean	s.d.
Intervention (n=37)				
R-L1	66.9	38.2	79.7	18.5
R-L2	37.3	16.4	49.5	15.4
Stencil Design	42.9	24.7	55.4	19.3
Non-Intervention (n=7)				
R-L1	78.6	17.2	84.0	26.7
R-L2	37.1	7.6	41.4	9.0
Stencil Design	61.4	25.6	59.1	24.9
Combined (n=44)				
R-L1	68.8	--	80.4	--
R-L2	37.3	--	48.2	--
Stencil Design	45.8	--	56.0	--

Observations and Teachers' Reports

Class Progress

Progress through LOGO lessons 1 to 25 reflected the estimated 20% to 30% differential in total LOGO lesson time between the Ponoka and EATP classes and the Ermineskin Junior High School classes.

The Ponoka and EATP class teachers reported that they moved fairly rapidly through the early lessons, and had reached lesson 20 by the end of the fifth week. Both then decided to spend several lessons reviewing earlier material and spent less than one week on lessons 21 to 25 (the design exercise). The Ermineskin Junior High School teachers made somewhat slower progress through the lessons. They reported that, while they allowed some time for free drawing, no time was spent on lessons 21 to 25.

Anecdotal Reports

All teachers reported initial difficulty in establishing discussion sessions. It was common experience that once students had begun working at a computer they often did not cooperate if they were interrupted to participate in a group discussion. Consequently, group discussion of the principles involved in each lesson was introduced along with the initial instruction at the beginning of each session. The principles were then pointed out by the teacher whenever the opportunity arose during the remainder of the session.

Group discussions were slow to build up and never lasted longer than 10 minutes. Contrary to the instructions given in each lesson, teachers did not always incorporate discussion sessions into every lesson and it was observed that this was particularly so when teachers had limited classroom time.

From the earliest sessions all teachers reported that student time spent on task was considerably higher than they had expected, based on previous experience with the same students. All teachers observed a lack of willingness to experiment among some students in early lessons and a dependence on the teachers which made teaching particularly tiring due to the walking necessary between computers and the constant demands from different students.

However, by the end of week 5, all teachers reported an increased willingness to experiment among previously timid students. In the final week of teaching, three teachers observed that their students had become much more independent and sophisticated in their computer use and LOGO programming, were attempting to solve their own problems before asking for help, and were spending even more time on task than initially reported. The remaining teacher reported increased time on task, but felt that disruptive elements in the class had interfered with this to some extent.

The above paragraphs are a summary of several concerns reflected in the teachers' daily logs. Throughout the seven-week period of the project the logs recorded the daily vicissitudes of classroom life. For example, early in week 4 a teacher wrote:

> I don't know if students understood the lesson today. They did work steadily and consistently, copying instructions off the board. Yet when I asked them to practise and recreate what they learned they wouldn't do it. Not a very good day for discussion. I couldn't get one word out of the students.

Two days later the same teacher wrote:

> Students are extremely motivated! They are working very steadily and hard! Engaging in planning behavior rather than trial and error. . . . A very productive class today as far as discussion of principles was concerned.

Criticisms of Lessons and Teachers' Suggestions

Two typing errors and one error of arrangement in the lessons were pointed out by all teachers. Lesson 5 was criticized as requiring rather more teaching time than other lessons.

Teachers had been left to their own devices regarding handouts and written exercises for students. Three teachers repeatedly suggested that students in fact needed materials to refer back to in later lessons, and prepared handouts (see Supplementary Materials Used by Teachers below) for particular lessons.

Two teachers independently suggested the need for students to keep ongoing workbooks in which they recorded session activities. This contradicted the opinion expressed by all teachers in the initial stages of the project that workbooks were undesirable since many students would mislay or mistreat them.

Throughout the project one teacher strongly felt that pairing of students on a computer was unsuccessful. This teacher also suggested that individualized instruction be prepared to allow students to progress at their own rate. Another teacher reported that pairing of weak and strong students was particularly helpful in keeping slower students up with the rest of the class.

Student Attendance

Throughout the project teachers of the Intervention group consistently reported that student attendance was well above that expected. A *post hoc* examination of attendance records revealed that the students in the Intervention group attended approximately 85% of classes, while those in the Non-Intervention group attended approximately 80% of classes.

Supplementary Materials Used by Teachers

Teachers were initially encouraged to make posters of LOGO primitives or simple designs for display in their classrooms as they judged necessary. The computer laboratory in the EATP building, used by three classes, gradually showed evidence of this. By the end of the project, posters showing a number of primitives, three simple procedures, and two complex geometric designs based on Native Indian motifs were displayed.

By the middle of the project, commercially-produced adventure or logic games had been acquired by all teachers. These were often, but not always, used towards the end of sessions to reward students who had applied themselves during the sessions. They also served to reinforce cognitive functions taught during lessons, albeit in a somewhat random fashion. No record was kept of the extent of student use of these games.

Three teachers prepared occasional handouts for students to use in particular lessons. These handouts either listed a LOGO procedure which students could then copy/type on the computer, or challenged students to write their own procedure to replicate a particular design (e.g., an arrowhead). These handouts were not cumulative and not intended for use in subsequent lessons.

One teacher also prepared short written questions to follow a number of sessions as homework, and prepared a course overview with accompanying short-answer test questions on completion of lesson 12. The written work resulting from this form of homework and testing was very pleasing to the teacher concerned.

Summary

A high baseline of students' prior computer use was found. Psychologists' reports based on pretests indicated deficiencies in the student group on all specified cognitive functions, and all students showed deficiency in at least one or two cognitive functions.

The dropout rate was high early in the study, but comparable across both Intervention and Non-Intervention groups. No statistically significant effects due to gender or age were found. A multivariate analysis of variance on the three dependent measures, R-L1, R-L2 and Stencil Design, revealed significantly lower posttest scores on R-L1 and R-L2 for both Intervention and Non-Intervention groups. Encouragingly, however, a univariate analysis revealed a significantly higher posttest score for the Intervention group on the Representational Stencil Design Test. It should be noted that pretest-posttest correlations revealed that Feuerstein's posttest forms of the Raven's Coloured and Standard Progressive Matrices were in fact not parallel forms. *Post hoc* selection of subsets of these tests did not improve correlations and subsequent analyses.

A 20% to 30% differential in total LOGO lesson time between classes was reported. Teachers also reported having difficulty in establishing discussion sessions while classes progressed. However, improvement in skills such as time spent on task, willingness to experiment, and independence in problem solving by a number of students was reported. Student attendance also improved.

The pairing of students on computers provoked a mixed reaction from teachers. As a supplementary activity, teachers suggested the use by students of workbooks for recording session activities. They also produced wall posters and handouts, and acquired commercially produced adventure and logic games for use as supplementary class activities.

Chapter 6

DISCUSSION

The results presented in the previous chapter should be interpreted in the context of the students' prior familiarity with computers. The computer use questionnaire indicated a high base line of prior computer use among all students, particularly for game playing (Table 4). It seems reasonable to assume, therefore, that any differences between the Intervention and Non-Intervention groups cannot be accounted for in terms of a novelty effect of computer use among students in the Intervention group.

On the other hand, such an effect may have occurred between *teachers* of the groups. Since initially the teachers of the Intervention group were unfamiliar with both computer use and LOGO, involvement in teaching LOGO may have affected their treatment of this group in unpredictable ways. It seems most likely that they would each have reacted idiosyncratically to this new subject content and the novel approach to teaching, and to the extra attention being drawn to their work. These factors may, in their turn, have affected their teaching and altered the likelihood of improvements in cognitive functioning being found among students.

The second contextual factor against which the results of this study should be interpreted is the prior level of students' cognitive functioning. The psychologists' reports indicated that there was evidence of deficient cognitive functioning among the subject group in all areas listed by Feuerstein (Table 1).

Disappointingly, however, no support was found for hypotheses 1 and 2 that the teaching intervention (LOGO lessons) would improve cognitive development as measured by parallel forms of Raven's CPM and SPM. In fact, as reported in the previous chapter, multivariate analyses of variance performed on pre- and posttest percentage scores of the three measures of general cognitive development revealed a significant decrease for both Intervention and Non-Intervention groups on two of these measures, R-L1 and R-L2. Since these two measures were composed of the pretests Raven's CPM and SPM, respectively, and the posttests LPAD1 and LPAD2, respectively, this indicates that all students in fact found the LPAD1 and LPAD2 tests more difficult than the comparable Raven's CPM and SPM tests. This brings into question Feuerstein's assumption that the LPAD variations, which he developed, are in fact parallel forms of the Raven's CPM and SPM. As pointed out in chapter 5, this assumption was also seriously brought into question by the moderate levels of correlation found between pre- and posttest scores on the measures R-L1 and R-L2, as reported in Table 8.

More encouraging was a univariate analysis which revealed significantly higher posttest percentage scores for the Intervention group on the Stencil Design variable. This result offers support for hypothesis 3, suggesting that the LOGO lessons were indeed effective in developing students' cognitive functioning as measured by parallel forms of the RSDT. The correlation between the pre- and posttest scores of the Stencil Design variable is also reassuringly high, suggesting that the test RSDT2 is indeed a parallel form of RSDT1. However, it should be kept in mind that this encouraging result is open to question since it is based on a univariate analysis, the multivariate statistic for the Treatment by Occasion interaction not being significant.

As outlined in the previous chapter, the analyses were repeated twice for scores based on subsets of items from the R-L1 and R-L2 measures. These subsets were selected on the basis of closer analogy between the cognitive functions required in both pre- and posttests (as illustrated in Tables 9-16). For the subsets identified as Feuerstein's Sets, this had the effect of eliminating the significant decrease discussed above between pre- and posttests on R-L1 and R-L2. However, the correlations between pre- and posttest scores (Table 8) still do not indicate that these subsets are in fact parallel forms of the Raven's CPM and SPM. For the subsets called Matched Sets, a significant increase was found for both Intervention and Non-Intervention groups between pre- and posttests on R-L1 and R-L2. This indicates that all students found these subsets of the LPAD1 and LPAD2 variations easier than the comparable Raven's CPM and SPM. Again, low correlations (Table 8) between scores on pre- and posttests do not indicate that these sets are parallel forms of the Raven's CPM and SPM, although in this case this may be due to substantially fewer items in the sets.

Measurement of Cognitive Development

The results discussed above raise the question as to whether the testing methods were appropriate for measuring the generalizability of problem-solving skills from a LOGO environment. The lack of correlation between pre- and posttest scores on the measures R-L1 and R-L2 has been mentioned above. This was not overcome when subsets of the tests were selected on the basis of closer analogy of skills required to solve items. This indicates that the pre- and posttests were not in fact appropriate parallel forms. Only the tests RSDT1 and RSDT2, which comprised the Stencil Design measure, were suitable parallel forms.

A univariate analysis of posttest percentage scores on the Stencil Design measure revealed significantly higher scores for the Intervention group, indicating limited generalization of problem-solving skills by students who undertook LOGO classes, as measured by the RSDT parallel forms (see p. 67).

The comparison of test results with Feuerstein's (Table 19) and other normative data is also of interest, since the use of Feuerstein's testing methods had here been extended to a cultural group quite different from that with which Feuerstein has worked. Unfortunately, however, Feuerstein's results have been based on relatively small sample sizes. On the Raven's CPM, Feuerstein has found mean scores of 22.06 (s.d. = 6.50, n = 69 "retarded performers") (Feuerstein, 1979, p. 153) and 27.76 (s.d. = 4.08, n = 55 culturally deprived adolescents) (p. 175). These scores are lower than those obtained in the present study. In the same studies, Feuerstein found LPAD1 mean scores of 18.30 (s.d. = 7.95) and 29.67 (s.d. = 3.28), respectively. He has also obtained a mean LPAD1 score of 28.47 (s.d. = 7.69, n = 34 disadvantaged adolescents) and a mean LPAD2 score of 41.53 (s.d. = 8.37) in the same study. These scores tend to be higher than those found in the present study and reinforce the finding discussed in chapter 5 (p. 67) that the Native Indian students in the present study found the LPAD variations particularly difficult.

It should be noted that the results obtained on the Raven's CPM in this study (overall mean = 31.89, mean age = 14.92 years) indicate

Table 19

Comparison with Feuerstein's Data

Test	Study	Mean	s.d.	n
Raven's CPM	Feuerstein, 1979	22.06	6.50	69 retarded performers
	Feuerstein, 1979	27.76	4.08	55 culturally deprived adolescents
	Present study	31.89	3.28	71 Native Indian adolescents
LPAD1	Feuerstein, 1979	18.30	7.95	69 retarded performers
	Feuerstein, 1979	29.67	3.28	55 culturally deprived adolescents
	Feuerstein, 1979	28.47	7.69	34 disadvantages adolescents
	Present study	20.40	5.62	45 Native Indian adolescents
LPAD2	Feuerstein, 1979	41.53	8.37	34 disadvantaged adolescents
	Present study	25.38	7.76	45 disadvantaged adolescents

retarded performance in comparison with norms for European cultural groups (Raven, Court, & Raven, 1986), which set a score of 32 at the 75th percentile for 11 years of age (p. CPM32) and at the 57th percentile for 11.50 years of age (p. CPM36).

It is not possible to make comparisons with Feuerstein's results using Raven's SPM since he reports these figures in combination with scores on the Raven's CPM tests. It is also difficult to make comparisons with Feuerstein's reported RSDT results because it is not clear which form of the RSDT he used, and his results are presented as out of a maximum score of 20 (in the present study RSDT1 maximum score = 57 and RSDT2 maximum score = 59). However, the following percentage scores can be calculated for comparison purposes: In the present study the mean percentage correct score on RSDT1 was 45.8%, while on the RSDT2 it was 56.0% (Table 7); Feuerstein (1979, p. 191) suggests an average of 55 to 60% correct score on the RSDT (unspecified version) for "regular middle class children" and found a score of 52.25% in a study of 55 culturally deprived children (p. 195).

Overall, it would seem that while the LPAD variations devised by Feuerstein did not provide appropriate parallel forms of the Raven's CPM and SPM tests and were particularly difficult for the Native Indian student group used in this study, the RSDT parallel forms provided results comparable with Feuerstein's. Some improvement in general cognitive development was noticed on this test after the teaching intervention (LOGO lessons).

Teaching Techniques

As reported in the previous chapter, a marked differential in class progress through the LOGO lessons was observed between classes. This reflected the 20% to 30% differential in total class time available. This difference between classes was tolerated, and indeed could not be avoided, because of schools' timetabling demands. While this was a disconcerting situation, it was beyond control in this field study, and was accepted as reflecting similar situations which would arise if the teaching materials developed for the study were given wider distribution.

This difference in LOGO lesson time in turn affected the amount of time devoted to group discussion sessions, which are crucial to the use of mediation and discussion for insight as teaching techniques. However, since no significant differences were noticed between classes on posttest scores it is not known whether this reduced class discussion time had no effect on the efficacy of the teaching techniques or whether the teaching techniques were simply ineffective.

Overall, it was observed that there was a differential between classes in the amount of time devoted to group discussion, and that discussions were difficult to start and brief, never lasting longer than 10 minutes. A concerted effort on the part of teachers to incorporate longer, regular discussion sessions may yield beneficial results.

Teaching of LOGO

The lack of significant improvement in posttest scores of general cognitive development (except for the univariate analysis of the RSDT scores) in this study was disappointing. Some problems associated with the testing and teaching techniques have been discussed above. However, the content which was taught should also be considered. It may be that the LOGO lessons developed useful skills, but that these skills were not adequately measured by the posttests used.

As reported in chapter 5, particular benefits of the project recognized by teachers included increased time on task by students during LOGO lessons and increased willingness by timid students to experiment in later lessons. Increased independence in problem solving by students and a marginal increase in student attendance were also noticed. These benefits suggest that students developed problem-solving, social and life skills of a more general nature, which were not measured on the posttests used. Thus Feuerstein's method of testing-training-testing, or dynamic testing, would not in this case serve as a useful way of evaluating the efficacy of the training program based on LOGO. The fault here lies with the testing methods used.

An alternative explanation is that the skills learned in the LOGO environment were not generalized by the students and applied in other problem-solving situations, i.e., the testing situation. Perhaps the fault here lies not so much with the LOGO lessons themselves as with the teaching techniques designed to be used in conjunction with them to encourage generalization of acquired skills into other problem-solving areas. The literature reviewed in chapter 2 strongly suggests that a mediated approach should be used to encourage generalization of problem-solving strategies. The suspicion occurs that skills developed in the LOGO environment were not being generalized and used on the posttests due to inadequate mediated teaching.

Students' level of current cognitive functioning should also be considered. The reviewed literature indicates that most benefit from LOGO, in terms of problem-solving skills, will be derived by students at least 12 years old and capable of formal operational thinking. While all students in this study were 12 years or over, some were undoubtedly not capable of formal operational thinking, although the LOGO lessons may have encouraged formal operational thinking among concrete operational thinkers in the group under study.

Overall, it would seem that several explanations are possible for the failure to find significant effects in this study. It may in fact be the case that skills were developed in the LOGO environment which were either not tapped by the testing methods used, or not generalized into the testing situation due to inadequate mediated teaching. Students' level of cognitive functioning should have allowed for maximum benefit to be gained from the LOGO environment, with adequate mediated teaching.

Teaching Materials

This project served as a formative evaluation of the teaching materials developed (chapter 3). The lack of significant gains observed on the posttests used may in fact be indirectly due to inadequacies in the lessons themselves. These lessons were written for teachers to enable them to teach LOGO to their classes using the lessons as a model. The lessons may not have provided enough guidance in the teaching of particular problem-solving strategies, or may not have communicated successfully to teachers the need for, and techniques of, mediation and discussion for insight.

In light of the uncertainty about student gains from the LOGO intervention, it is difficult to evaluate the usefulness of the incorporation of Native Indian design motifs into the lessons as a cultural bridge. However, it was observed that students seemed comfortable with these motifs, and teachers adopted similar motifs for posters displayed in the EATP building.

As well, all teachers indicated a need for support materials to be used with their classes. These were introduced by teachers themselves in the form of wall posters, teacher-prepared handouts and/or computer games. One teacher sometimes set written homework, and ongoing student workbooks were also suggested as potentially useful. The continuing requirement by teachers for more varied computer activities is perhaps not surprising, but requests for written materials and suggestions for written workbooks were surprising; these materials had been deliberately avoided in light of the students' history of failure in written expression. It now appears that students' involvement in the LOGO environment may be capitalized upon in the development of other computer skills and also written skills, in a way not previously predicted.

Overall, there were indications that, while the lessons supported teachers throughout this two-month project and that students readily accepted the use of Native Indian design motifs, the lessons may not have been detailed enough regarding problem-solving strategies or in the use of appropriate teaching techniques. As well, more support materials to be used by students, involving both computer and written activities, were requested by teachers throughout the project.

Further Research

In light of the above discussion, several avenues of research present themselves. In light of the advocacy of the use of Raven's

CPM and SPM with Native Indian students by MacArthur (1968), it would seem that the use of those tests in situations comparable with Feuerstein's testing-training-testing situation should be pursued with these students, but only if suitable parallel forms can be developed. The encouraging results on Feuerstein's RSDT parallel forms indicate that this test may be particularly suited to evaluation of the problem-solving skills developed in the LOGO environment by Native Indian students. This supposition could be further investigated, perhaps over a longer period of LOGO lessons or with different student and cultural groups.

Students' level of cognitive functioning could also be considered in detail. It may be of interest to compare the performance on various tests, after training, of students who are concrete operational thinkers with those already capable of formal operational thought.

The problem of the lack of classroom control, characteristic of the field study situation, needs to be overcome. A longer course of training for teachers in Feuerstein's methods of mediation and discussion for insight may better equip teachers to encourage the generalization of skills which is necessary if the full benefit of problem-solving skills learned in the LOGO environment is to be obtained. Such a course may also overcome any novelty effect resulting from teachers' lack of experience with computers in general, or LOGO in particular. As well, more detailed observations of factors such as students' time on task, confidence and independence in problem solving, and attendance should be made, comparing an intervention group with a control group on these variables.

It should be stressed that the lessons (chapter 3) developed for this project were at the stage of formative evaluation; a number of modifications may make them more useful. More direct and repetitious teaching of particular cognitive strategies would require a fundamental change in the lesson structure, but may be useful in establishing particular strategies (this is akin to the repetitious techniques used in Feuerstein's program of Instrumental Enrichment). As well, more detailed checklists for teachers could be incorporated into each lesson, listing lesson objectives and requiring teachers to spend more lesson time on objectives not yet attained, rather than feeling obliged to continue with the next lesson despite unsatisfactory progress through earlier lessons. Ongoing workbook activities could also be incorporated into the lessons, to exercise written skills and encourage revision of earlier material. As well, a variety of support materials could be supplied for student use, including handouts, other computer activities and written exercises. The above lesson modifications can be categorized as providing either increased teacher direction, or supplementary student activity. Each category needs to be investigated. The individualization of instruction and use of peer teaching also need to be considered in a revised lesson design. While the individualization of instruction would require quite a different type of lesson design from that used here, suggestions of the occasional use of peer teaching, the pairing of a strong student with a weaker one, may easily be integrated into the present lesson design and may result in benefit to both students. This could readily be investigated.

Conclusion

Cohen (1977) suggests that, in studies of cognitive development, higher scores on measures of general cognitive development may be "only a proxy for other things learned during the experiment, such as academic persistence, good behavior," and asks "whether cognitive change produces any change on other measures of educational success such as grades or years of school completed" (p. 461). Walker and Schaffarzick (1977) urge that

> ways of relating end-of-course measures to more long-term and far-reaching outcomes are . . . needed . . . an attempt should be made to measure two sets of extended outcomes: lasting changes in ability and inclination to study and learn additional school subject matter or skills, and long-term life consequences of school learnings. (p. 436)

The present study should be reviewed in light of these suggestions. While student gains from the LOGO intervention were not as obvious as hypothesized and only obtained on a univariate analysis of pre- and posttest scores on one measure, it should be kept in mind that students may have made a number of gains not detected by the tests of cognitive development used; these changes may also not be obvious except in the longer term. The measurement techniques used in this study need to be carefully reviewed.

Similarly, Dahllof (1977) warns against "taking for granted that what is expected from the instruction is also taking place among all participants" (p. 397); he argues for more careful examination of the educational process that is actually taking place in a teaching/learning situation. The present study represents a formative evaluation of the teaching materials used, and they should be carefully reviewed in terms of what they actually achieved, according to factors such as their effectiveness in modifying teachers' techniques, their efficiency in teaching the required content, and their suitability for the student and teacher population with which they were used.

REFERENCES

Anastasi, A. (1976). *Psychological testing* (4th ed.). New York: Macmillan.

Arthur, G.A. (1930). *A point scale of performance tests: Vol. 1. Clinical manual.* New York: Commonwealth Fund.

Arthur, G.A. (1941). An experience in testing Indian school children. *Mental Hygiene*, 25, 188-195.

Arthur, G.A. (1943). *A Stencil Design Test.* New York: Psychological Corporation.

Arthur, G.A. (1944). A non-verbal test of logical thinking. *Journal of Consulting Psychology*, 8, 33-34.

Atkinson, C. (1983). *Making sense of Piaget: The philosophical roots.* London: Routledge and Kegan Paul.

Boulger, C., & Arthur, G. (1944). An unpublished design test. *Journal of Consulting Psychology*, 8, 31-32.

Bowd, A.D. (1973). A cross-cultural study of the factorial composition of mechanical aptitude. *Canadian Journal of Behavioural Science*, 5, 13-23.

Bowd, A.D. (1977). Ten years after the Hawthorn report: Changing psychological implications for the education of Canadian Native peoples. *Canadian Psychological Review*, 18(4), 332-345.

Chait, S. (1978). *An analysis of children's problem solving in a graphics oriented computer programming environment.* Unpublished master's thesis, McGill University, Montreal.

Chambers, S. (1985, August). *Cognitive components and mechanisms underlying children's acquisition and transfer of LOGO programming skills.* Paper presented at LOGO in Australia, 10 years on, Clayton, Victoria, Australia.

Clark, W.B. (1984). *Designing a user interface employing supplantation of cognitive processes as an instructional device: A feasibility study.* Unpublished doctoral dissertation, Syracuse University.

Cohen, D.K. (1977). Politics and research: Evaluation of social action programs in education. In A.A. Bellack & H.M. Kliebard (Eds.), *Curriculum and evaluation* (pp. 442-467). Berkeley: McCutchan.

Dahllof, U. (1977). Trends in process-related research on curriculum and teaching at different problem levels in educational sciences. In A.A. Bellack & H.M. Kliebard (Eds.), *Curriculum and evaluation* (pp. 442-467). Berkeley: McCutchan.

Das, J.P., Kirby, J., & Jarmon, R.F. (1979). *Simultaneous and successive cognitive processes.* New York: Academic.

Delclos, V.R., Littlefield, J., & Bransford, J.D. (1985). Update on microcomputer use in instruction. Teaching thinking through LOGO: The importance of method. *Roeper Review*, 7(3), 153-156.

Dick, W., & Carey, L. (1978). *The systematic design of instruction.* Glenview, Illinois: Scott, Foresman.

Dixon, W.J. (Ed.). (1983). *BMDP statistical software.* Berkeley: University of California Press.

Dog, P.S. (1985). Exciting effects of LOGO in an urban public school system. *Educational Leadership*, 43(1), 45-47.

Feuerstein, R. (1973a). *L.P.A.D.: R.S.D.T. test.* Jerusalem: Hadassah-Wizo-Canada-Research Institute.

Feuerstein, R. (1973b). *L.P.A.D.: R.S.D.T. Arthur stencil design test, Form 1.* Jerusalem: Hadassah-Wizo-Canada-Research Institute. (N.Y.: Psychological Corporation, c1947; reproduced by special permission).

Feuerstein, R. (1973c). *L.P.A.D. set-variations II.* Jerusalem: Hadassah-Wizo-Canada-Research Institute.

Feuerstein, R. (1973d). *L.P.A.D.: R.S.D.T. parallel test.* Jerusalem: Hadassah-Wizo-Canada-Research Institute.

Feuerstein, R. (1973e). *L.P.A.D.: R.S.D.T. training.* Jerusalem: Hadassah-Wizo-Canada-Research Institute.

Feuerstein, R. (1979). *The dynamic assessment of retarded performers: The learning potential assessment device, theory, instruments, and techniques.* Baltimore: University Park Press.

Feuerstein, R. (1980a). *Instrumental enrichment: An intervention program for cognitive modifiability.* Baltimore: University Park Press.

Feuerstein, R. (1980b). *L.P.A.D. set-variations I.* Jerusalem: Hadassah-Wizo-Canada-Research Institute.

Feuerstein, R., Rand, Y., Hoffman, M., Hoffman, M., & Miller, R. (1979). Cognitive modifiability in retarded adolescents: Effects of Instrumental Enrichment. *American Journal of Mental Deficiency*, 83(6), 539-550.

Folk, M. (1972). *Influences of developmental level on a child's ability to learn concepts of computer programming.* Unpublished doctoral dissertation, Syracuse University.

Gagne, R.M. (1974). Educational technology as technique. In E.W. Eisner & E. Vallence (Eds.), *Conflicting conceptions of curriculum* (pp. 50-63). Berkeley: McCutchan.

Gallini, J.K. (1985). Instructional conditions for computer-based problem-solving environments. *Educational Technology*, 25(2), 7-11.

Havighurst, R.J., & Hilkevitch, R.R. (1944). The intelligence of

Indian children as measured by a performance scale. *Journal of Abnormal and Social Psychology*, 39, 419-433.

Hawthorn, H.B. (Ed.). (1966). *A survey of the contemporary Indians of Canada* (Vol. 2). Ottawa: Indian Affairs Branch.

Jensen, A.R. (1969). How much can we boost IQ and scholastic achievement? *Harvard Educational Review*, 39, 1-123.

Kaufman, D. (1978). *The relation of academic performance to strategy training and remedial techniques: An information processing approach.* Unpublished doctoral dissertation, University of Alberta, Edmonton.

Krasnor, L.R., & Mitterer, J.O. (1984). LOGO and the development of general problem-solving skills. *Alberta Journal of Education Research*, 30, 133-145.

Krywaniuk, L.W. (1974). *Patterns of cognitive abilities of high and low achieving school children.* Unpublished doctoral dissertation, University of Alberta, Edmonton.

Lazure, D. (1973). Indian children of Canada: Educational services and mental health. *Child Psychiatry and Human Development*, 4, 44-52.

Lepper, M.R. (1985). Microcomputers in education: Motivational and social issues. *American Psychologist*, 40(1), 1-18.

MacArthur, R.S. (1962). *Assessing the intellectual ability of Indian and Metis pupils at Fort Simpson.* Ottawa: Department of Northern Affairs and National Resources.

MacArthur, R.S. (1965). *Mackenzie norming project.* Ottawa: Department of Northern Affairs and National Resources.

MacArthur, R.S. (1968). Assessing intellectual potential of Native Canadian pupils: A summary. *Alberta Journal of Educational Research*, 14(2), 115-122.

MacArthur, R.S. (1969). Some cognitive abilities of Eskimo, White, and Indian-Metis pupils aged 9 to 12 years. *Canadian Journal of Behavioural Science*, 1, 50-59.

Michayluk, J.O., & Yackulic, R.A. (1984). Impact of a LOGO program on Native adults. *Canadian Journal of Educational Communication*, 13(3), 4-6, 15.

Narrol, H., & Bachor, D.G. (1975). An introduction to Feuerstein's approach to assessing and developing cognitive potential. *Interchange*, 6, 2-26.

Papert, S. (1980). *Mindstorms: Children, computers and powerful ideas.* New York: Basic Books.

Rand, Y., Tannenbaum, A.J., & Feuerstein, R. (1979). Effects of Instrumental Enrichment on the psychoeducational development of low-functioning adolescents. *Journal of Educational Psychology*, 71(61), 751-763.

Rattan, M.S., & MacArthur, R.S. (1968). Longitudinal predictions of school achievement for Metis and Eskimo pupils. *Alberta Journal of Educational Research*, 14(1), 37-41.

Raven, J.C. (1956). *Coloured progressive matrices: Sets A, Ab, B.* London: H.K. Lewis.

Raven, J.C. (1958). *Standard progressive matrices: Sets A, B, C, D, and E.* London: H.K. Lewis.

Raven, J.C., Court, J.H., & Raven, J. (1977). *Manual for Raven's progressive matrices and vocabulary scales.* London: H.K. Lewis.

Rey, A. (1934). D'un procede pour evaluer l'educabilite: Quelques applications en psychopathologie. *Archives de Psychologie*, 24, 287-337.

Rey, A., & Dupont, J.B. (1953). Organization de groupes de points en figures geometriques simples. *Archives de Psychologie, Geneve*, 34, 39-65.

Skinner, B.F. (1968). *The technology of teaching.* New York: Appleton-Century-Crofts.

Statz, J. (1973). *The development of computer programming concepts and problem solving abilities among ten-year-olds learning LOGO.* Unpublished doctoral dissertation, Syracuse University.

Stowbridge, M.D., & Kugel, P. (1983). Learning to learn by learning to play. *Creative Computing*, 9(4), 180, 183-184, 186, 188.

Taylor, R. (Ed.). (1980). *The computer in the school: Tutor, tool, tutee.* New York: Teacher's College Press.

Tetenbaum, T.J., & Mulkeen, T.A. (1984). LOGO and the teaching of problem solving: A call for a moratorium. *Educational Technology*, 24(11), 16-19.

Vernon, P.E. (1969). *Intelligence and cultural environment.* London: Methuen.

Walker, D.F., & Schaffarzick, J. (1977). Comparing curricula. In A.A. Bellack & H.M. Kliebard (Eds.), *Curriculum and evaluation* (pp. 442-467). Berkeley: McCutchan.

West, L.W., & MacArthur, R.S. (1964). An evaluation of selected intelligence tests for two samples of Metis and Indian children. *Alberta Journal of Educational Research*, 10(1), 17-27.

Willis, S.L., Blieszner, R., & Baltes, P.B. (1981). Intellectual training research in aging: Modification of performance on the fluid ability of figural relations. *Journal of Educational Psychology*, 73, 41-50.

APPENDIX A

LESSON 3

(Reduced to 83% of original size)

3.1

LESSON 3 (1-1½ hrs)

CLASS ACTIVITY: Review Keyboard/PRINT/DRAW, LOGO Primitives

PRIMARY GOALS: To encourage: adequate verbal tools;

precision and accuracy in communication;

ability to perceive and define problems.

SUBGOALS: To encourage making of comparisons

MOTIVATION: Tell students that today they will be learning some LOGO language which will enable them to tell the computer to do certain things. They will learn to command the computer to write messages for them on the monitor screen and they will be able to draw some designs on the screen as well.

PRESENTING CLASS ACTIVITY: Check students' homework assignment. Remind students of the principles involved.

Review Keyboard

*Make sure that each student has the CAPS LOCK key on their keyboard down.

Discuss the use of RETURN key (tells LOGO to do what has just been typed in)

Number keys

Symbol keys

Shift key

Space bar

Adequate verbal tools

Don't forget to draw parallels between this and other keyboards with which students are familiar, and to remind students that they need to know what all the keys do to communicate properly with the computer.

LESSON 3 (cont'd)

PRINT

To focus students' typing activity, introduce the PRINT command. Ask students to type their name and press the RETURN key. What happens? The computer needs to be told what to do; it needs a 'command'. Tell students to type

PRINT [their name] and press RETURN

Precision and accuracy in communicating

Did the computer do what they told it to? If not, check that they can type square brackets correctly and leave a space after PRINT. Point out that the <u>exact</u> pattern must be followed for the computer to understand a command.

Review the use of the

ARROW keys	(move cursor)
CONTROL key	(used in combination with other keys)
ESC key	(deletes the last character typed)
CONTROL-D	(deletes the character under the cursor)
CONTROL-K	(deletes the rest of the line from cursor to end)

Making of comparisons

Encourage students to experiment by printing other messages, deleting their mistakes as they go. If they are working in pairs, encourage students to help each other in finding mistakes and correcting them.

As mediator, ask students about other machines that print (e.g., typewriters), or about video games. Can you easily erase a mistake on such machines?

DRAW, LOGO Primitives

Tell students that until now they have been working in the 'text' mode of LOGO.

If they want to draw a design they should go into the 'graphics' mode. To do this, they type the command DRAW and press RETURN.

LESSON 3 (cont'd)

The triangle in the middle of the screen is called a turtle and it is waiting for them to tell it what to do.

Introduce the LOGO commands (primitives)

FORWARD

BACK

LEFT

RIGHT

PENUP

PENDOWN

Point out that these can be abbreviated to FD, BK, LT, RT, PU, PD to save typing.

Suggest that students experiment with these commands, telling the turtle how many steps to go or what angle to turn. (Make sure that students leave a space between the command and the number, e.g., FT 50.) If they want to start over again, they can just type DRAW and press RETURN to start again.

Suggest that students pick a spot on the screen and see if they can take the turtle to it. If students are working in pairs, suggest that one picks the spot and the other directs the turtle.

Precision and accuracy in communicating

Ability to perceive and define problems

If students make mistakes in typing commands, point out that the <u>exact</u> pattern must be followed for the computer to understand a command. If the turtle doesn't go where students expect, challenge them to work out why. Should they turn it more? Less? How can they tell which way it will go? Can they get where they want to in a straight line?

STUDENT PARTICIPATION

Encourage students to test each key on the keyboard and some of the CONTROL-key combinations.

Make sure students can control the cursor and erase characters.

LESSON 3 (cont'd)

Ask each student to print a message for you.

Ask students to direct the turtle to a spot on the screen chosen by you or their partners.

DISCUSSION FOR INSIGHT

This is the most important part of this lesson. Try to draw out from students the principles on which this lesson is based (these are closely related to the above listed goals of the lesson).

Principles to be identified in this discussion are:

1. It is necessary to know the appropriate language (keys or key combinations) to communicate.
2. Precision and accuracy are necessary to clear communication.
3. If what students want or expect to happen doesn't, there may be a problem in communicating which students can discover for themselves.
4. Comparisons might be useful in this process.

Remember to be enthusiastic when students identify one of the above principles, and if they are analytic about their own problem-solving behaviour.

Assignment

Set an exercise related to the principles underlying this lesson. For example, ask students to think of an example where something unexpected happened to them because the instructions they were following were not clear. They must also explain in what way the instructions were not clear.

APPENDIX B

COMPUTER USE QUESTIONNAIRE

(Reduced to 83% of original size)

(1) Code: ________

(2) Age: ______ (3) Grade: ____ (4) Sex: M F

Familiarity with Computers

(5) Have you ever used a computer before? NO YES

IF YES, how have you used them and how often?

			1	2	3	4
	∅					
(6) Playing computer games	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily
(7) Writing computer programs	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily
(8) Writing essays, letters, etc.	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily
(9) Being taught by computer	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily
(10) Looking for books in a library	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily
(11) Other: ______________	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily

Familiarity with Typewriters

(12) Have you used a typewriter?	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily

APPENDIX C

LETTERS OF CONSENT

January 7, 1985

During this term our school will be offering a 5-month program for a number of students involving approximately one hour a day. Your son/daughter is one of the students chosen for this program.

We wish to identify particular problems which students may be having with school learning and provide them with some help in overcoming these difficulties. At the same time we would like to help the students to develop a positive attitude toward learning the various school subjects.

This program will be part of the regular school program. The first part will be designed to help the students to further develop thinking skills which are needed for effective learning in junior high school. The second part will help the students apply these skills to the learning of mathematics and English.

To carry out this program we need to administer a small set of paper and pencil tests to each student. Some of the tests will help us to identify problems the students may be having with thinking skills. We will also need to find out their level of ability in mathematics and language at the start of the program. Another test will help us to identify the students' attitude towards learning school subjects. We will ask students to take similar tests part-way through the program and again at the end of the program to see how effective it has been.

We will be careful about making sure confidential information about your son or daughter is protected. Because of this we will identify each student by a number only. At no time will students' names be used in any report about the program. At the end of the program all information traceable to individual students will be destroyed.

Because we feel it is important that parents be provided with as much information as possible about their children, we will be pleased to discuss the project with you at any time. The people from the University of Calgary who are helping with the project have agreed to make themselves available at the end of the project to give you as much information as they can about your son or daughter. They may be able to make suggestions of further help to your child.

I grant my permission for ______________________________ to participate in the program and be given the tests described above.

Signed: ______________________________

January 7, 1985

During this term a pilot program for Native junior high school students is taking place in some of the schools in our district. This program is designed to help students further develop thinking skills which are needed for effective learning in junior high school and to apply these skills to the learning of mathematics and English.

To carry out this program a small number of paper and pencil tests are being administered to the participating students. Some of the tests will help identify problems students may be having with thinking skills. Two others will help identify their level of ability in mathematics and language. Another will help identify the students' attitudes twoards learning school subjects. The students will be asked to take similar tests part-way through the program and again at its end in order to tests the effectivness of the program.

This program is not being conducted in our school this term. However, in order to evaluate the effectiveness of the pilot program it is necessary to administer the tests to students who are not taking part. Our school has volunteered to participate in this way and to administer these tests to students for whom their parents/guardians grant permission. (No student will be forced to participate against his will.)

We will be careful about making sure confidential information about your son or daughter is protected. Because of this we will identify each student by a number only. At no time will students' names be used in any report about the program. At the end of the program all information traceable to individual students will be destroyed.

Because we feel it is important that parents be provided with as much information as possible about their children, we will be pleased to discuss the project with you at any time. The people from the University of Calgary who are helping with the project have agreed to make themselves available at the end of the project to give you as much information as they can about your son or daughter. They may be able to make suggestions of further help to your child.

I grant my permission for ______________________________ to be given the tests described above.

Signed: ______________________________