THE UNIVERSITY OF MANITOBA

COMPUTER ASSISTED LEARNING WITH THE PHYSICALLY HANDICAPPED

by

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ABSTRACT

This study researched the use of computer assisted learning in mathematics as a drill and practice program for elementary students who were physically handicapped. Two groups of randomly selected students were assigned to control and experimental situations. Both groups received regular classroom instruction, and the experimental group received additional computer assisted learning in mathematics for a period of three months at two days a week. The subjects were administered the Stanford Achievement Test in mathematics before (pretest 1, pretest 2), after (posttest), and three weeks after (retention test) the computer assisted learning sessions.

The results of this study showed that there were no significant differences between the two groups. However, there was a significant difference over time between the pretests and posttest and pretests and retention test. Although the results of the study did not show overall statistical significance, some educational relevance was apparent to teachers and administrators. There was a seven month gain for the experimental group during a four month period versus a three month gain for the control group during the same period of time.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Computer assisted learning (C.A.L.) has presently become a powerful ally in the improvement of educational opportunities for students. C.A.L. has been found to be a technologically feasible tool in the teaching process and is no longer a novelty on the educational scene. Much time and effort has been involved in its development and applied use. One of the main goals of education is to educate through the use of individualized instruction. Ideally, the characteristics of individualized instruction suggest that a means be developed to enable students to progress at their own pace by mastering learning materials tailored appropriately to their needs.

Electronic information sharing, specifically C.A.L., is a method which may be beneficial to teachers who attempt to individualize learning experiences. Programmed Instruction (P.I.) and more recently C.A.L., have been developed as methods of individualization at the elementary, secondary, and University levels. In the field of special education, P.I. and C.A.L. have shown potential in teaching the culturally disadvantaged, the mentally and emotionally handicapped, and the hearing and visually impaired. However, little attention has been paid to the development of C.A.L. as a useful means of individualization for the physically handicapped child or adolescent.

Physically handicapped students are often limited in the types of programmes in which they are able to participate.

Adaptations must be made to programs to suit the individual needs of the children and to eliminate frustration for them. The computer may provide intricate remediation procedures, a high motivation level, and a practical means of instruction for the physically handicapped student.

Practice in computational skills has tended to be overshadowed in recent years by advances in other areas of mathematics teaching. Nevertheless, computational skills are essential. By using C.A.L., the practice can be individualized in the sense of constructing the task to match the pupil's performance. Knowledge of results and corrections can be given immediately to the student as well as to the teacher.

In the development of a C.A.L. environment, however, many problems must be solved. Thus, the following questions have to be asked before instituting C.A.L. into an elementary school for physically handicapped:

1. Can physically handicapped students manipulate the controls on a computer terminal effectively and independently?
2. Can appropriate programs in mathematics be made available to a population of students from Grade one to Grade six?
3. Can skills achieved by drill and practice be transferred to classroom mathematics activities?
4. Can the skills be retained over a period of time after the experimental phase?

The present study was designed to answer such questions.

In the development of a C.A.L. environment for the physically handicapped, further insight can be gained by studying the types of children involved. In the development of a program, it seems appropriate to look at the educational needs of the population.

There have been numerous studies in the area of P.I. with the exceptional child. However, less research is available in the area of C.A.L. with exceptional children. Because of the learning characteristics of the physically handicapped student, implications can be drawn from previous studies and utilized as a frame of reference for the present investigation.

It is the thesis of this study that C.A.L. can be an effective and practical means of instruction for the orthopedically and neurologically handicapped student. The areas of instruction pertain to drill and practice in elementary mathematics.

CHAPTER 2

THE PHYSICALLY HANDICAPPED CHILD

CLASSIFICATION AND SURVEY OF EDUCATIONALLY RELEVANT HANDICAPS

Introduction

The purpose of this section is to identify the types of physically handicapped children in this study and to review the educational handicaps associated with the physically handicapped student. It should be noted that the children in this study are the more severely handicapped students in the Winnipeg area. Less handicapped students receive their education in regular school classrooms.

In order to determine the kind of curriculum to offer disabled children, it is important to know what these children are capable of accomplishing, and to become aware of factors which influence their emotional, social and educational adjustments.

In reviewing the research related to the education of disabled children, it is striking how few studies relate directly to their learning characteristics or to the best ways to accommodate their needs through the use of special teaching methods. Research has been directed primarily toward the study of incidence and causes of crippling, or toward the psychology of its after-effects.

There is little reason to expect a close relationship between a child's learning characteristics and some physical condition which affects his mobility, unless that condition includes neurological damage. Recent research in this area has tended to focus on cerebral palsy, a handicapping condition which unquestionably presents educational problems. However, when focusing on other physically handicapped populations, there is little reason to expect a consistent difference from the non-handicapped in the amount they will learn, given the opportunity to learn. However, restriction of mobility may mean restriction of background experiences, or prolonged hospitalization may affect the child's normal development. Also, emotional adjustment to the handicapping condition may interfere with the child's learning.

Cerebral Palsy

The Spastics Society of London (1967, p. 4) defines cerebral palsy as "a medical term covering a whole group of neurological conditions varying one from another in the clinical features of spasticity, athetosis, ataxia, tremor, rigidity or atony, but having one feature in common - a disorder of motor control." All forms of cerebral palsy result from injury to, or developmental anomoly to the brain, which usually arises before or during, but sometimes after, birth. The physical handicap in any particular case may range from slight lack of control in one limb to complete physical helplessness.

Secondary Handicaps of Cerebral Palsy

Most children with cerebral palsy have other multiple handicapping conditions which complicate the educational problem.

Some conditions that cause damage to the brain and nervous system, and result in motor inco-ordination, may also impair sensory, receptive, and integrative functions.

Defective speech is the most common disorder of cerebral palsy children. Among the speech defects are dysarthria, an articulation defect caused by poor motor control, delayed speech due to mental retardation and cerebral dysfunction, and voice disorders, such as stuttering, and various forms of aphasia (Kirk, 1962).

In the areas of visual and hearing defects, various authors agree that over 50% of cerebral palsy children have oculomotor defects and 25% or more have subnormal vision (Denhoff and Robinault, 1960). Hearing problems are not as common as visual defects. Fish (1955) found that 20% of cerebral palsied children have hearing losses.

The intelligence of children with cerebral birth lesions varies from retardation to superior levels, and it may bear little relation to the degree of physical handicap. Most surveys report a figure of between 40% and 50% of cerebral palsied children to be of subnormal intelligence (approximately 25% severely subnormal) (Allen & Jefferson, 1962). As for those with higher intelligence, approximately 47% score within normal limits, leaving about 6% in the upper intellectual ranges (Bowley & Gardner, 1972).

Studies of intellectual abilities of cerebral palsied children, however, are open to innumerable criticisms. Scores on standardized tests, timed tests, and tests involving performance scores may not be applicable to a population of cerebral palsied children. Their delayed responses, motor disabilities and lack of general experiences may play havoc with standardized scores. Many cerebral palsied children show learning difficulties in the area of visual perception and distractibility. These children may show perceptual difficulties, the most common of which are constructional apraxia, apraxia of dressing, confusion between right and left, and inability to grasp the concept of number (Blencowe, 1969).

In the light of such multiple problems, it is important to evaluate, extensively and individually, both the educational and psychological aspects of performance of the cerebral palsied. The teacher will then be able to determine the child's potential to achieve scholastically, and plan educational programs accordingly.

Spina Bifida

Woodburn (1975) defines spina bifida as a congenital malformation of the spine which is visible at the moment of birth as a protruding sack in the midline of the back, containing cerebro-spinal fluid and usually covered by a thin membrane. The degree of handicap is determined by the location and severity of deformity. Usually the defect occurs in the lower back. The higher the lesion, the more involved, and, therefore, the more complex the presenting problem. Symptoms associated with it are: dislocation of the hip, club feet, partial or full paralysis in the lower extremities, changes in tactile and thermal sensations, and lack of bowel and bladder control.

Commonly associated with spina bifida is an obstruction of the flow of cerebral spinal fluid which results in hydrocephalus and probable brain damage. However, hydrocephalus can be controlled by the insertion of a drainage tube and valve.

Secondary Handicaps of Spina Bifida

Spina Bifida students may show perceptual difficulties in the area of figure-ground perception and form constancy (Langford, 1972). The most severely paralyzed and immobile children have the greatest difficulty; the partially mobile have varying degrees of perceptual difficulty. In common with many children with limited mobility, there may be difficulty in developing number concepts.

Very marked in spina bifida children is their passive attitude which may be due to brain damage or adult handling of the child.

It is apparent that there is often a marked difference between verbal and performance scores on I.Q. tests of spina bifida children (Langford, 1972). Perceptual difficulties may depress performance scores, but equally higher verbal scores can be due to early hospitalization, and consequently, overabundance of adult company. Not to be confused with genuine verbal skills is the tendency of spina bifida children to be verbally or expressively bright. Langford (1972) links with this "cocktail party syndrome," a pattern of illogical thinking and difficulty in learning sequential action. These children may find learning difficult and need careful vocabulary training.

The Muscular Dystrophies

Muscular Atrophy

Muscular atrophy is a disease of the spinal cord. It is characterized by signs and symptoms due to progressive degeneration of motor nerve cells of the anterior (motor) portion of the spinal cord and of the motor nuclei of the cranial nerves in the brain stem (Koehler, 1975).

This disease is characterized by progressive hypotonia and paralysis of voluntary muscles in infancy and usually terminates life at an early age. In a less severe form, symptoms generally appear in the second year of life or later. Weakness is acutely localized, and there may be close to normal life expectancy.

Muscular Dystrophy (Duchenne)

Muscular dystrophy is an obscure defect in muscle metabolism which causes a diffuse weakness of all muscle groups. It is characterized by a degeneration of muscle cells and their replacement by fat and fibrous tissue (Wershow, 1966). It is a slowly progressing illness, which often becomes apparent between the fourth to the seventh year of life, and is usually disabling enough to require wheelchair living around age eleven. Death occurs in the second decade, and is usually brought about by respiratory infection (Wershow, 1966, Bleck, 1975).

Secondary Handicaps of Muscular Atrophy & Dystrophy

Children with muscular atrophy generally have normal intellectual abilities (Koehler, 1975). Some children may be minimally involved and able to take part in normal classroom activities. The more severely involved will require special schooling. These children may need longer time to finish an assignment. An electric typewriter may be required. With diminished motor skills, the emphasis must be on non-motor skills.

Mental subnormality, manifested by slowness in learning, and demonstrated by psychometric testing, is present in about 70% of muscular dystrophy children (Allen, 1960, Worden, 1962, Zillweger, 1967). The I.Q. is usually in the 80 - 90 range.

Emotional adjustment may be difficult as the disease progresses. This may interfere with the child's academic progress. Both psychologically and physically, the child with muscular dystrophy benefits from remaining in school, and participating in normal activities.

Myotonic Dystrophy

Myotonia is an abnormal persistence of induced or voluntary muscular contraction. Myotonia may involve the face, jaw, eye, neck and distal limb muscles (Swaiman & Wright, 1970). The course of the disease is one of steady progression; within 15 - 20 years of symptoms, most patients are severely disabled and unable to walk. The majority die before normal life expectancy has been reached.

Secondary Handicaps of Myotonic Dystrophy

Mental retardation is not uncommon (Swaiman & Wright, 1970, Tachdjian, 1972), but little research has been done in this area.

The face is expressionless and the voice monotonous and nasal, owing to the involvement of the laryngeal muscles. Dysarthia is common and speech therapy is often required.

Because of the pattern of muscle weakness in the small muscles of the hand, the child tires easily. Teachers should encourage typing skills, and limit the amount of writing required.

Ataxia-Telangiectasia (Louis Barr syndrome)

Arledge (1968) describes Ataxia-Telangiectasia as a rare progressive neurological disease. The ataxia is a part of a progressive mental and neurological deterioration that begins in early childhood and progresses to complete incapacitation by early adolescence. Ataxia, the result of damage to the cerebellum, cerebral tract, or 8th cranial nerve, is characterized by a loss of balance, staggering gait, inco-ordination, and lack of voluntary muscles.

Secondary Handicaps of Louis Barr syndrome

As this disease progresses, drooling and cerebellar dysarthic speech develop with poor breath control. Speech is described as scanning, slurred, or slow in character.

The neurological pathology produces striking manifestations. Peculiar conjugate eye movements occur (Smith, 1959). A disturbance in gaze occurs as the child is unable to look to either side voluntarily without overturning the head. Usually vision is normal. The "Kephart" educational methodology described by Haring and Staples (1966) stresses activities and remediation in the development of rythmic movement patterns, ocular training, and eye-hand co-ordination.

Often the child has normal pre-school intelligence. General progressive mental deterioration first becomes evident between the fifth and tenth years. At this time, premature senility is suggested as a possible cause of memory loss (Rey, 1960).

School programs should not be overly demanding, and counselling should be available to parent and child. The teacher should realize that progressive mental retardation will occur.

Arthrogryposis Multiplex Congenita

Arthrogryposis is a congenital disease in which the children are born with stiff joints and weak muscles. Tachdjian (1972) describes the clinical picture as typical and present at birth. Involvement is primarily, and most noticeably, of the limbs and trunk. In general, these children will be deformed and stiff with very limited joint motion. They may, or may not, be able to walk. However, there are children who will be quite functional in a wheelchair.

Secondary Handicaps of Arthrogryposis

Because these children usually have normal intelligence and speech (Bleck, 1975), educational goals should follow the usual acadamic pattern. It would seem important to emphasize and encourage academic achievement in such children and direct them toward goals that do not involve hand skills or general mobility.

Osteogenesis Imperfecta

Sharrard (1971) describes osteogenesis imperfecta as a rare connective tissue disorder that primarily affects the bones. However, the inner ear, schlera, tendons, fascia, ligaments, and skin are often involved as well. Fragility of the bones is the most outstanding feature of the disease, with fractures occurring on the slightest injury.

Secondary Handicaps of Osteogenesis

Vision is usually normal, but deafness may occur. Hearing loss may be the conductive type, due to otosclerosis, or a nerve type, caused by pressure on the auditory nerve (Bleck, 1975). Teachers should be aware of a possible hearing loss. Because of the proneness to fractures, the child may be overprotective of the body and fearful of new experiences. O.I. children usually have normal intellectual functions.

The Limb Deficient Child

Phocomelia

Phocomelia is a shortening of one or more of the limbs. The limbs are described as "seal-like"; there may be an absence of one or more digits.

Thalidomide Syndrome

The Thalidomide syndrome is a massive retardation of limb development bilaterally or in all four limbs. Wide set eyes, low set, and occasionally deformed ears, and depressed bridge of the nose are characteristic. A wide variety of associated anomolies including malformation of digestive system and heart are occasionally found (Blakeslee, 1963).

Secondary Handicaps of Limb Deficiency

Limb deficient children usually exhibit a normal mental function (Blakeslee, 1963). However, problems of mobility, limited experiences, and lack of reach may prove an educational handicap to the child.

Summary

The preceding information delineates the varied physical and educational capabilities of the children in this research. It is apparent from this material that each child is different in his needs. These needs are best met through an individualized programme. The computer may be one means of providing this instruction on an individualized basis.

CHAPTER 3

A REVIEW OF INDIVIDUALIZED INSTRUCTIONAL TECHNIQUES WITH EXCEPTIONAL CHILDREN

Introduction to Programmed Instruction and C.A.L.

Programmed Instruction (P.I.) and Computer Assisted Learning (C.A.L.) have become influential in teaching children in the mainstream as well as exceptional children. Because of the individual needs of exceptional children, unique curriculum considerations and programs are necessary to facilitate learning.

Programmed Instruction has been the forerunner to C.A.L. and the implications of P.I. with exceptional children should be discussed, as it is closely related to C.A.L..

Pressey (1967), "the father of teaching machines," defines P.I. simply as planned instruction. Since the early devices of Pressey's (1926, 1927), and especially during the last two decades, P.I. has been used to facilitate learning in the fields of education, industry, the military, and special education.

The identifying characteristic of programmed instruction, whether presented by a book or teaching machine, is the active role assigned to the student. Other characteristics include logical sequencing of small steps, immediate feedback, and self-pacing.

C.A.L. has mushroomed in the past decade. It has resulted from a number of converging technologies, including programmed instruction learning, audiovisual communications, the data processing field, and data communications. Atkinson and Wilson, from the Stanford C.A.L. Centre, attribute the rapid growth of C.A.L. to the "rich and intriguing potential of C.A.L. for answering today's most pressing need in education - the individualization of instruction" (Atkinson & Wilson, 1968, p. 73).

There are various applications of computers in education. C.A.L. is however, the most significant of the instructional applications and is defined as: "A man-made interaction in which the teaching function is accomplished by a computer system without intervention by a human instructor. Both training material and instructional logic are stored in computer memory" (Salisbury, 1971, p. 48).

There are three basic modes included in C.A.L. and are defined by Taylor (1974) as:

1. Drill and Practice

The drill and practice mode of C.A.L. involves the use of the computer to drill students in facts or to assist the student in practicing skills. With drill and practice, facts or skills are taught through some other mode or means. The students then use C.A.L. drill and practice to memorize those facts or to practice those skills.

2. Tutorial

The tutorial mode of C.A.L. is intended to approximate the interaction which would occur between a skilled, patient tutor and an individual pupil. A tutorial system is used to initially present a concept and to develop a student's skill in using the concept.

3. Simulation

In this mode of computer use, the learner is led by the computer through a learning situation similar to actual on-the-spot learning, as if the learner were in the real-life situation. The model of reality may represent an economic system, a social system, a set

> of physical relationships etc. In using the simulation the students learn the structure of the system, the relationships and assumptions operating, and have an opportunity to test and refine decision strategies (Taylor, 1974, p. 48).

The use of instructional technology has tremendous potential in the area of special education. There has been little research available, to the knowledge of this author, using P.I. or C.A.L. with physically handicapped populations. Thus, it is necessary to review the literature associated with instructional technology and other groups of exceptional children. As mentioned in Chapter 2, physically disabled students tend to display handicaps not unlike many of the areas to be discussed in the following review (i.e. developmental handicaps, underachievement, auditory disorders).

Instructional Technology and the Culturally Different Child

Language Arts in the Kindergarten

Steg (1968) and Bender (1968) compared various teaching machines used to instruct reading and language skills to disadvantaged pre-kindergarten children. The machines used were the Edison Responsive Talking Typewriter and the Story Telling Automated Reading Tutor. Results showed that the automated methods were generally more efficient than regular classroom methods.

At Tulane University in Louisiana (1968), P.I. was set up to teach reading to Headstart children. The Sullivan Associates Readiness in Language Arts was used with 15 children in each of

5 head start classes. Equal numbers were used as controls. It was found that the experimental group had greater achievement in 1) recognition and identification of letters and 2) familiarity with numbers and letters. The control group made greater advances in 1) familiarities and differences in word formations and 2) understanding oral instructions and sensitivity toward sounds. Significant results were shown in some areas.

Leslie Malpass (1966) used P.I. in reading as a teaching method for slow learning, culturally different young children. 45 children were divided into control group (traditional teaching), and experimental group (machine teaching and programmed workbooks).

Results showed a significant improvement in vocabulary gain for machine taught over control, and workbook taught over control. There was no significant difference between machine taught and workbook taught methods.

Green (1968) used slides, a teletype, and tape recorder to teach disadvantaged four year olds to recognize words and letters. C.A.L. was tested with disadvantaged and middle class children. Programs were found to be more suitable for the middle class. However, the author felt that a C.A.L. approach, which provided for gross motor responses in lieu of verbal ones, was well suited to disadvantaged children, especially boys.

Mathematics Studies in Elementary Schools

Jacobs (1968) taught culturally different Israeli children mathematics through presentation of P.I.. Results showed that P.I. was effective in eliminating the difference between high and low ability students.

A non-verbal program of instruction in Math was designed and tested with first grade children from a disadvantaged area in New York City (Kaplan, 1969). Only six children participated in the testing phase and, therefore, results are only indicative. Pretest, posttest results show a 45% increase. Whereas a certain degree of success was demonstrated, it was not possible to project the use of P.I. for full classroom use.

Results of a two year study by Prince (1969) showed some interesting results with disadvantaged children. Computer assisted drill and practice in Math was used in 17 elementary schools. After the first year a significant educational difference existed between the groups on C.A.L. versus the control groups. A more detailed study the second year revealed that there was little significance between groups of high income, high I.Q., and children on C.A.L. and regular instruction, but startling results were obtained in favour of C.A.L. in Negro and low income groups.

Gayden Stovel (1969), Gipson (1971) and Jamison (1971) show similar research studies with elementary school children in disadvantaged areas. In comparing C.A.L. to conventional teaching techniques, C.A.L. groups showed significantly greater gains than the control groups.

Street (1972) studied the use of C.A.L. to improve Math skills of disadvantaged elementary students. Results indicated no increase in C.A.L. versus non-C.A.L. scores on the basis of standardized scores. In some instances a slight increase was noted. The lack of significant gain was attributed to 1) frequent computer "crashes", 2) inappropriate programs and 3) lack of supervision of students and related programs.

Drill and practice programs, tutorial, and problem solving programs are offering the teacher varied ways of preparing materials to aid the disadvantaged learner. The characteristics of the disadvantaged student's family structure, home environment, and neighbourhood all affect his learning potential.

Gipson comments on C.A.L. and the disadvantaged.

> The special needs of the disadvantaged student suggests that modern electronic technology could be helpful. C.A.L. can be useful in overcoming negative teacher attitudes toward disadvantaged students, in teaching students to follow instructions, and in stimulating student interest. (Gipson, 1971, p. 1).

Selection of P.I. and C.A.L. Materials for the Developmentally Handicapped

Malpass (1963) evaluated the usefulness of automated teaching procedures with E.M.H. (Educable Mentally Handicapped) and T.M.H. (Trainable Mentally Handicapped) institutionalized children. Results showed that the automated instructional procedures were effective in teaching word recognition, spelling, and reading skills. This procedure was more effective than conventional classroom instruction. Retention levels using automated instruction were significantly higher after a 60 day period.

Santin (1971) and Nelon (1972) discussed the effectiveness of P.I, and C.A.L. with the mentally handicapped. Both authors reviewed the merits of using instructional technology in vocabulary training.

Sandals (1973) studied the use of C.A.L. as a means of teaching banking concepts to developmentally handicapped young adults. The programs presented materials not only through the teletype, but also through the use of colored slides. Concepts such as budget, deposits, and withdrawals were taught. Significant differences were shown between pre and posttest, and pretest and retention test administrations. It was concluded from this study that the computer was an effective means of instructing social skills to retarded learners.

At the University of Texas, Knutson (1970) established a C.A.L. program to teach money skills to T.M.H. students. A metal overlay keyboard was designed with 10 oversized keys, allowing actual coins to be placed on the keys. C.A.L. was effective in improving the money skills for a large proportion of students. It was felt to be a successful method of teaching a set of specified skills to the T.M.H..

Studies by Dezelle (1971) and Thibodeau (1974) used P.I. to teach math to E.M.H. students. Neither author attained significant gains when comparing control and experimental groups in pretest - posttest situations.

Fricklas & Rusch (1974) evaluated the teaching effectiveness of Trimodal Programmed Instruction in Reading with Pseudo-dyslexic children. Nine subjects interacted with a Teledesk, which utilized the child's kinesthetic, auditory and visual modalities. Word recognition and comprehension skills showed a dramatic increase when posttested.

Warner (1967) studied the effects of P.I. in phonics with three groups of exceptional children - seven emotionally disturbed, five neurologically impaired, and seven mentally retarded. Results showed that the emotionally disturbed and mentally retarded groups made significant progress between initial and terminal performance. Girls, and younger children below the age mean of eight, made more significant progress than those that exceeded the mean.

C.A.L. with Underachieving Students

Crawford (1970) studied the role of C.A.L. as a remedial math technique for underachieving students. Both experimental and control groups received classroom instruction. The experimental group also received C.A.L.. A significant gain was shown by the experimental group. However, a lack of significant difference between posttest scores was noted. Major weaknesses included frequent equipment breakdowns, insufficient staff inservice, absenteeism of students, and an insufficient period (8 weeks) of evaluation.

Berthold (1974) compared the effectiveness of the teacher, computer alone, and computer and teacher combination in teaching math and spelling to eleven minimally brain damaged children. During three randomly ordered two week blocks, tutorials were presented by 1) teacher, 2) computer, 3) teacher and computer. Gains in performance followed instruction by teacher and teacher-computer combination. Both methods were superior ($p < 0.05$) to C.A.L. alone.

Reasons for inferiority of computer alone were 1) the teacher had available more modes of instruction than the teletype, and 2) the full adaptability of the program was not utilized between sessions to meet the needs of the students.

In Chicago, Litman (1973) implemented a C.A.L. system for underachieving elementary students. Greater gains were made in language arts and math than in the reading program. Especially high gains were noted for students who completed more than 100 sessions.

<u>Programmed Instruction and Children with Auditory Disorders</u>

There have been more than 40 investigations since 1959 in which P.I. was used with children with auditory disorders (Pfau, 1969). Research findings in the area of linguistic retardation have provided an impetus for the educator's search for more productive instructional materials, better methods of presentation, and modes of instruction that will meet the needs of the deaf student.

Birch and Stuckless (1963) studied the feasibility of programmed written language with a group of 10 year old deaf children. They found that 1) students learned the same content under either P.I. or the teacher-instructional approach, 2) P.I. was more efficient than conventional teaching, and 3) generally, teachers were favourably disposed to P.I.. Birch and Stuckless concluded that programmed written language for deaf students is very feasible and that P.I. required less than half the time assigned to teacher instruction.

In contrary findings, however, Bornstein (1964) revealed that P.I. was no more effective than the lecture method in teaching high school math to deaf students. Furthermore, P.I. required as much and often more time than the lecture method.

Roy et al (1964) and Grigonis (1970) found similar results using P.I. with deaf students. Significant gains in language and verb vocabulary occurred with the use of P.I..

Karlsen (1966) developed an automated instructional system to teach reading using a non-oral method (a visual presentation via P.I.) to five year old hearing impaired children. Karlsen found 1) an automated system of non-oral reading instruction could be developed successfully for use with young deaf students, 2) the development of reading skills and the necessary language concepts to accompany these skills would require an enormous amount of programming, 3) the teaching machine, as used in teaching reading had a place in every classroom for deaf children.

Possibly the largest and most comprehensive P.I. endeavour for the handicapped child is Project LIFE - Language Improvement to Facilitate Education of hearing impaired children. The nucleus of the project is a linear approach to P.I., with the majority of materials in filmstrip form. The machine provides immediate feedback to the learner by means of a green confirmation light.

Instructional materials available include over 400 filmstrips on perceptual training, perceptual thinking and language reading. Pfau states that:

> ....the GE/Life Program is being well received by nearly every population of the handicapped, as well as non-handicapped programs because of the learning/motivational features of the program. (Pfau, 1974, p. 551).

Field testing has included over 100 centers. All demographic and student performance data are compiled and analyzed by the Project Life Research Department. However, no statistical evaluation is yet available. The future success of the program appears to be contingent upon continued validation before commercial dissemination is begun.

Computer Assisted Learning in Deaf Education

Probably the largest C.A.L. program for the handicapped has evolved from the Institute for Mathematics Studies in Social Sciences at Stanford University. A three year study included 5,000 students in 15 schools for the deaf. Language arts and elementary mathematics were evaluated (Suppes and Fletcher, 1974, pp. 129 - 131).

I Mathematics strands experiment - The results of this program indicated that C.A.L. math strands 1) lead to substantial increases in mathematics computation Grade Points when used by hearing impaired students, 2) gains can be achieved by students working intensely for six to ten minutes a day on drill and practice, 3) gains were two to three times greater than regular classroom instruction.

II Language Arts Experiment - This experiment, analagous to the maths strands experiment, indicated that the program was of significant value for those students who completed many of the sessions attempted, but of much less value for those students who completed few of the sessions attempted.

Research studies from the Kendall School for the Deaf (Behrens, 1969) and the Texas School for the Deaf (Culbertson, 1974) describe results similar to Suppes and Fletcher. The students' motivation has been shown as consistently high and students are described as showing an increased maturity towards learning. The growth of C.A.L. in schools for deaf is expected to continue as a proven effective teaching tool for the deaf.

C.A.L. with the Visually Impaired

A pilot study at Overbrook School for the Blind in

Philadelphia (Evans, 1972) described the use of the computer to provide remedial instruction in mathematics to blind students. Braille characters were printed on paper and emitted from a Braille adapter.

Difficulties in C.A.L. were in its adaptation for the visually impaired. The adapter printed only grade one Braille as opposed to grade two Braille. It was found that the children were accustomed to reading a word in contracted or grade two Braille and the loss of time was involved until recognition in grade one form was comprehended. However, teachers felt that C.A.L. with the blind has a promising future. Systems are now being developed which will use grade two Braille.

Programmed Instruction and the Physically Handicapped

Coss (1966) studied the effectiveness of P.I. to teach fractions and decimals to a group of 28 severely physically handicapped secondary students. Subjects were divided into four groups matched in terms of reading level and intelligence. Four treatment modes were used. Two groups alternated between a teaching machine (TM) and the classroom (C). One group remained continuously with the teacher and one continuously with the machines. The machine controls were adapted to the disabilities.

Three main effects were found to be significant ($p < .05$) - the sequence of instruction, the complexity of instruction, and the level of intelligence of the student.

The results of the treatment groups were reported as follows:

1) TM mode of instruction was about 2/3 more efficient in time

2) TM mode was most effective in tandem with C mode

3) TM mode was most effective for students with lower intelligence

4) C instruction mode became more effective as instruction material became more complex

5) TM followed by C was the most effective sequence

6) Operation of machines could be adapted to the various disabilities

Coss (1966, p. 29) described the effectiveness of automated visual instruction in four problem areas for the physically handicapped population.

1 - Time for Instruction. Teaching machine instruction is more efficient than conventional instruction with this population. In a situation where time for instruction is reduced due to medical and surgical priorities, the teaching machine mode is effective in maintaining educational progress.

2 - Compensation for Interruptions of Learning Continuity. Automated instruction is under control of the student. Where interruptions of learning are caused by fatigue, pain, illness, surgery, or therapy, the student may review or proceed with the subsequent task without educational content loss upon returning to the learning situation. Teacher absence has little effect on continuity.

3 - Provision for Meeting the Multi-grade Levels in Each Classroom. Small classes require combinations of several grades with achievement spans of several years. Automated programs can permit individual students to work independently at their appropriate grade levels.

4 - Provision for Multi-Level Content. Teaching machines have the capability of providing a variety of subject content to suit curriculum or individual needs. Adequate automated instruction can also be offered to a student in a subject in which the instructor lacks competence.

Summary

In the review of the literature, it is apparent that P.I. and C.A.L. are credible means of instruction for the exceptional child. As little research has been recorded in the area of the physically handicapped, it is realistic to study the programs that have been made available to other exceptional children.

Pertinent to this study, it is necessary to discuss the advantages and merits of the following: 1) C.A.L. as a means of drill and practice in mathematics, and 2) C.A.L. as an appropriate teaching aid with the physically handicapped.

1) C.A.L. in mathematics - C.A.L. is a technological innovation which has various uses in presenting materials to students. The computer goes beyond the approach of the regular

mathematics textbook, i.e. the traditional approach. Joella Gipson (1971), who has studied C.A.L. for teaching mathematics to the disadvantaged, outlines some advantages of using C.A.L. mathematics programs. The C.A.L. system can 1) provide highly individualized mathematical instruction to a large number of pupils daily, 2) perform an immediate analysis of the accuracy of pupil's mathematical responses, making possible individualized instruction, 3) keep each pupil and his teacher informed of the individual pupil progress, 4) provide reports to the teachers on class performance and item reliability for use in daily planning, 5) can be easily revised in program content to meet the needs of the students, and 6) present materials on many levels of difficulty (unlike mathematics textbooks) allowing pupils to progress at their own pace.

C.A.L. can be useful in overcoming negative attitudes of the student to teachers and to mathematic drills. The computer has no preconceived notions of the pupil's performance. C.A.L. tends to accept children where they are and there is no pressure to keep up with the rest of the class. The child is able to progress at his own rate. In the drill and practice C.A.L. program, each step is carefully spaced so the child can master one level before he approaches the next step in the mathematical process. The student's weaknesses can be isolated so that the teacher can provide additional materials for problem areas.

2) C.A.L. with the physically handicapped - The educational characteristics of physically handicapped, as discussed in Chapter 2, suggest several advantages for utilizing the computer in presenting and planning instruction. An instructional system using computers provides a learning environment which accommodates an exceptional child's needs in the following areas: 1) active learning with a high student response rate, 2) immediate feedback and reinforcement, 3) maintenance of attention, 4) individual pacing of instruction, 5) infinite patience with sufficient repetition to insure learning and 6) possibilities of modifying content of instruction to meet the needs of individual exceptional children (Faford, 1973, IX7).

The objectives of education for all children are usually modified to meet individual needs. Educators working with severely disabled children in hospitals and schools are cognizant of the special needs of the population and attempt to meet them.

The students in the school under study are average in reading, compared to a non-handicapped population, but show a general weakness in mathematics. The students have difficulty remembering basic facts and applying mathematical concepts. Some of the problems are due to lack of experience with money, as they do not have the opportunity to handle money as their peer groups do. The children are bussed to school and are generally dependent on their parents to tell time for bus pick-up etc.. Some of the children are not able to handle objects and find bridging the gap between the concrete and abstract very difficult. The transfer of learning is difficult to maintain.

Teaching aids in mathematics, such as drill work sheets, are inappropriate for many of the children at Ellen Douglass School, which is the school under study. Because pencil work is tedious and slow for the children, work sheets must be used in the typewriter. Doing mathematics on a regular typewriter is difficult because the computational problems require the use of the backspace key to move from the 1's, 10's, and 100's columns. The computer eliminates this frustration as it automatically sets up the columns, and spacing is correct for receiving the answer.

A large percentage of the students use electric typewriters for language arts and spelling. They are familiar with the computer teletype terminal. Also, the keyboard characters are raised and widely spaced, which facilitates typing for the cerebral palsied or severely handicapped child.

Because of the problems in the area of mathematics, there is a need for assistance, such as C.A.L., in order for the children to complete an elementary mathematics course. The use of C.A.L. enables the child to interact on a one to one basis with the computer. The student is able to carry on a dialogue of questions, answers, and immediate reinforcement with the computer. C.A.L. seems an appropriate method by which to teach mathematics to the physically handicapped.

CHAPTER 4

INVESTIGATION

The Problem

The underlying problem represented in this study is the following: Can drill and practice skills in mathematics be taught to physically handicapped children via a computer terminal? As previously mentioned in Chapter 1, questions to be answered in the study are:

1. Can physically handicapped students manipulate the controls on a computer terminal effectively and independently?
2. Can appropriate programs in mathematics be made available to a population of students from grade one to grade six?
3. Can the skills achieved by drill and practice be transferred to classroom mathematics activities?
4. Can the skills be retained over a period of time after the experimental phase?

Research Hypothesis

If two randomly selected groups of physically handicapped students received regular classroom instruction in mathematics and one of the groups received extra help in C.A.L. in mathematics, then there will be a difference in performance of the two groups over time on a standardized achievement test in math.

The Sample

The subjects in this study were students attending Ellen Douglass School for the physically handicapped. Ellen Douglass is part of Winnipeg No. 1 School Division and services all of the physically handicapped elementary students in the Winnipeg area who require special services that are not provided by the regular school system.

The children were bussed to school daily. School hours were 9:30 am to 3:30 pm. The school population consisted of 62 children. There were four classes from kindergarten to grade 6, one being an Educable Mentally Handicapped class, and one Trainable Mentally Handicapped class. The students who participated in this study were selected from five out of the six classes. The Trainable Mentally Handicapped class was not included as the programs available were not suitable for the retarded. Forty subjects were selected from the school to participate in the experiment. The ten remaining students from the five classes were not chosen due to the nature of the disability (i.e. blindness or because the programs were not suited to their age levels).

The subjects under study ranged from ages 5 to 14, with a mean age of 10.0 years. There were 20 girls and 20 boys. The subjects' I.Q. range was from 62 to 131. Seventy-five percent of the scores ranged below the I.Q. of 100. Four I.Q. scores were not available and some of the scores were antiquated by six years. There was some doubt as to the accuracy of some of the scores. The children ranged from grade one to grade six with a mean grade level of 3.2.

Forty subjects were randomly assigned to groups - 20 in a control group and 20 in an experimental group. A T-test was performed to insure that the means from the pre-test scores of the two groups were not significantly different ($p < .05$).

Four of the subjects were not available during the posttest and retention test phase. The experimental group dropped to N = 17 and the control group had 19 participating in the study.

The range of disabilities of the students who participated in the study can be found in Table One. A more complete analysis of the subjects' handicapping conditions and related disorders can be found in Appendix A. It should be noted that subjects 8, 15, 27, and 32 were the four students that were not available during posttest and retention test administration.

Limitations of the Sample

A number of limiting factors will be discussed and the generalization of results should be viewed in the context of sampling limitations.

Prior to carrying out the investigation, every subject (control and experimental group) experienced seven months familiarity training with the computer terminal and programs. Thus none of the subjects were naive to C.A.L. and it was safe to assume that the results obtained would not be affected by the novelty of the computer.

However, the size of the sample, time tabling difficulties, and available computer terminals imposed constraints upon the study. If the school population were larger and more computer terminals were available, the experimental model could have been made more robust by providing special training techniques

TABLE ONE

Diagnosis and Incidence of Students in the Study

Diagnosis	Incidence
Cerebral Palsy	13
Muscular Dystrophy	3
Muscular Atrophy	4
Myotonic Dystrophy	1
Spina Bifida	10
Phocomelia	3
Arthrogryposis	2
Osteogenesis Imperfecta	1
Accident	2
Louis-Barr Syndrome	1

for the control group such as C.A.L. in language. Also control group participation in peer group tutoring or programmed instruction might have been a more effective control group situation.

Due to the small population of the school and a wide range of age levels, a large variability of scores resulted. The age grouping ranged from 5 to 14 years and grade levels were from one to six (Stanford Achievement Test Scores).

The control and experimental groups were assigned randomly. However, the disabilities of the students in the control group may have differed, by chance, significantly from the experimental group (i.e. a greater number of neurological disorders could be assigned to one group).

Lastly, the results from this sample of physically handicapped students could not be generalized to all physically handicapped students. The students in the school are the more severely handicapped children in the Winnipeg area.

Instructional Programs

The computer software that was used in this study were drill and practice programs in mathematics. The programs were written by teachers and were in the "BASIC" language. BASIC is a powerful high level language that can be used on Cybershare Limited (formerly Phoenix Data System), which was the computer system used in this study.

Five programs in mathematics were used during this study. Examples of each program can be found in Appendix B. A short summary of each is as follows:

<u>Addsub 1</u>

Addsub 1 is a drill and practice program for either addition or subtraction. The largest sum, or remainder, can be no larger than 14. The objectives of this program were:

1. To give the student practice in addition
2. To give the student practice in subtraction
3. If specified by the range of numbers, the drill will give the student practice in carrying (in addition) and borrowing (in subtraction)

<u>Addsan</u>

Addsan is a drill in addition for remediation. There is a choice of how many digits (from 1 to 5) in each number and how many numbers (from 1 to 5) the student requires practice. The objectives of addsan were:

1. To give the student practice in adding
2. To give the student practice in carrying
3. To give the student practice in adding numbers by columns

<u>Subtsan</u>

This program provides drill in subtraction for remediation. It randomly generates problems with up to 5 digits in the top number. The objectives of subtsan were:

1. To provide practice in subtraction for remediation
2. To provide drill in borrowing
3. To provide practice in using concepts of date and time

Multsan

Multsan is a drill in multiplication. There is an option for the number of digits (from 1 to 5) in the number to be multiplied. Also, the student has the choice of either multiplying by a fixed or random number. The objectives of multsan were:

1. To give drill in multiplication
2. To progress along with the student (i.e. the difficulty of the problem is based on the student's level of knowledge. If he knows up to the 5 times tables, he can be drilled on just that)
3. The drill can be used for testing purposes simply by not giving the students an extra try.
4. The drill can be used to practice "carrying"

Divide

Divide is a drill in division. The student can do 1 to 15 randomly generated problems with an option of whether decimals are to be involved. The number of digits in the divisor and dividend can be selected. The objectives of divide were:

1. To give the student practice in the division of integers
2. To drill the division of decimal numbers

Measuring Instrument

The test that was chosen to assess the subjects' achievement in mathematics was the Stanford Achievement Test (1964), Arithmetic Computation Subtest. This test was chosen as its questions related fairly closely to the skills drilled in the computer program. Primary II Battery alternate forms W, X, and Y were used. The S.A.T. has been used extensively and as Trimble (Buros, 1972, p. 527) explains it, "As one might expect in the fourth extensive revision of a battery of tests made after nearly 50 years of experience gained in extensive use, these tests do superbly well what they claim to do."

The children in this study, or a large percentage of the subjects, had difficulty writing and printing. Because of their laboured skill in writing, it was questionable whether the S.A.T. should be timed or untimed (power). During the testing, the teachers noted the number of questions that the students answered in the specified time. Then the students were given an additional time period to finish the test. t. tests were executed for each testing situation to determine if the means for the untimed vs. timed situations were significant. Results showed that there was no significant difference between means ($p < .05$). Therefore, timed scores were used to interpret the results.

Apparatus - Computer Equipment and Facilities

The computer hardware that was used in this study was owned by the Province of Manitoba at Cybershare Ltd.. It was a CDC 6500 computer. A model 33 hardcopy teletype terminal using a telephone data set interfaced with a Vu Comm II cathode ray tube (C.R.T.) was used in the school as the instructional terminal. The C.R.T. monitor was necessary to accommodate the various heights of wheelchairs. Some of the students were not able to read the hard copy off the teletype, and, therefore, the necessity of the C.R.T monitor.

The total cost of the project was shared by three school divisions, who were also involved in C.A.L. with the handicapped, and the Department of Education. As is was necessary to use the C.R.T. at Ellen Douglass School, the rental cost was slightly higher than the other schools involved in the project. A breakdown of the cost involved in rentals and computer time can be found in Appendix C.

The terminal was situated in a spacious room that was used by child care workers during recess and noon hour, but was relatively free from use during the computer schedule. The child care workers' office was situated beside the computer room. If difficulties arose when students were working on the computer, the child care workers were close at hand for assistance.

Administration and Procedure

The study commenced on February 10, 1975 and continued until June 13, 1975. The actual experimental phase using C.A.L. with mathematics proceeded for 11 weeks. A more complete schedule of procedure is available in Figure One.

Pretest 1 and Pretest 2

The subjects were given two pretests. This was required as the students were not familiar with formal testing situations.

The first pretest was given between February 10 and February 14 and the second pretest was administered between February 17 and 21. The tests were administered in four classrooms. The test administrators were three teachers from the school and the experimenter. The students were randomly assigned to a teacher in the pretest situation. Each of the four testers administrated the S.A.T. to ten students during each pretest and also participated in scoring the tests.

Computer Scheduling Arrangements

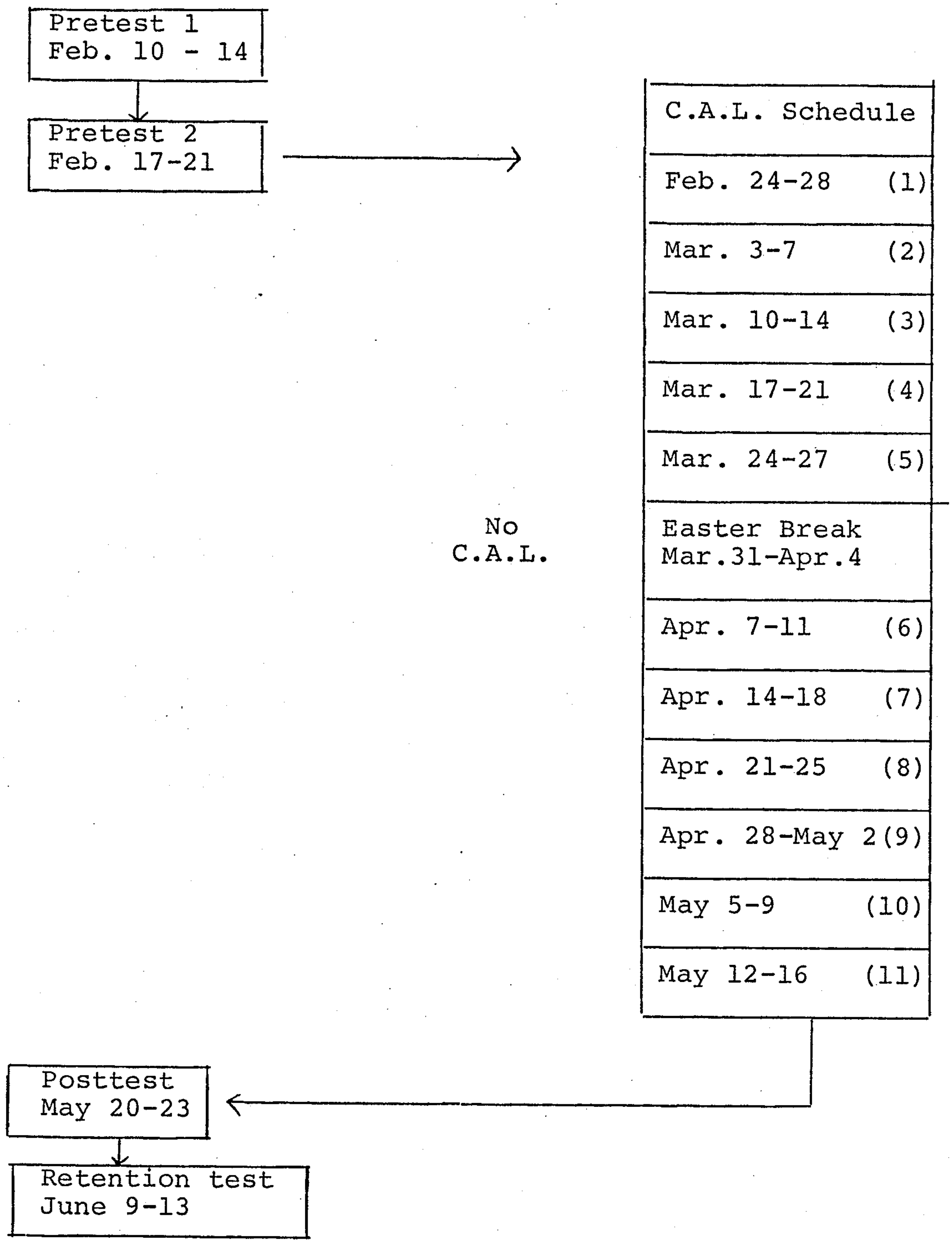
The scheduling for computer times was as follows: ten students were accommodated each day, so that each student was on the computer terminal every other day.

The daily time schedule incorporated these time allotments:

A.M.	P.M.
9:00 - 9:30	12:30 - 1:00
9:30 - 10:00	1:00 - 1:30
10:00 - 10:30	1:30 - 2:00
11:00 - 11:30	2:30 - 3:00
11:30 - 12:00	3:00 - 3:30

Figure One

Flowchart of Procedure



It was realized that due to field trips, swimming, illnesses, computer failure, and inservices, some sessions were missed. However, the students received from 23 to 27 sessions (averaging 25) during the 11 week experimental period. Because of the six-day cycle and many other commitments such as physiotherapy, occupational therapy, speech therapy and arts and crafts, makeup classes were too difficult to schedule.

The computer schedule enabled the child 30 minutes of computer time every second day. However, the student worked on drill and practice for 15 - 20 minutes and 10 minutes was taken to assist the child to and from class.

After the students had written the pretests, the experimental groups were placed on a program associated with their achievement results on the tests. The experimenter and teacher chose the appropriate level to suit the students' needs in math. Each student's performance was recorded on a criterion reference chart (refer to Appendix D for a complete hierarchy of mathematical levels). When a student achieved 90% on a level, he or she was then placed on the next appropriate level. A 90% proficiency level was chosen, as it was assumed that if a student scored 9 out of 10 questions correctly, then he or she understood and could cope with that level. Johnson and Kress (1972) and Miller (1973) interpret the 90% proficiency level as an independent level of achievement. They state that for an independent knowledge of materials, scores should be no lower than 90%.

The control and experimental groups received approximately the same amount of classroom instruction in mathematics as had been regularly assigned. The amount of time for classroom instruction varied from teacher to teacher. Most of the children were taught individually or in small groups.

Volunteers from Winnipeg high schools and a graduate student from the University of Manitoba **(Faculty of Education)** assisted the students with "logging-in" procedures and execution of the experiment. Volunteer and adult help in the school was not unusual for the students. At the same time that C.A.L. volunteers were associated with the computer project, additional volunteers were helping children in the classroom.

Posttest and Retention Test

The posttest was administered during the week of May 20-23 and the retention test was given three weeks later during the week of June 9-13. The same procedure was used during these testing situations as with the pretests. Students were randomly assigned to four teachers. The teacher administered the test to a group of 10 students. Testing took place in the teacher's home classroom.

Statistical Procedure

Analysis of Variance

The test for significant differences over the repeated measures of pretest (1), (2), posttest and retention test administration was performed using a 2 x 4 Analysis of Variance for Repeated Measures design.

The following are the statistical hypotheses of the Analysis of Variance for Repeated Measures. A more complete explanation of derivations and formula can be found in Winer (1971) Chapter 4.

1. Null Hypothesis

$$H_o = \alpha_1 = \alpha_2 = 0$$

If two groups of physically handicapped children are administered standardized achievement tests both at the beginning and completion of the study, then there will be no significant difference between the treatment effects (means) of the levels of factor A (i.e. experimental versus control group means).

Alternative Hypothesis

$$H_1 = \text{not } H_o$$

If two groups of physically handicapped children are administered standardized achievement tests both at the beginning and completion of the study, then there will be a significant difference between the treatment effects (means) of the levels of factor A (i.e. experimental versus control group means).

2. Null Hypothesis

$$H_o = \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$$

If two groups of physically handicapped children are administered standardized achievement tests both at the beginning and completion of the study, then there will be no significant difference between the treatment effects (means) of the levels of factor B (over a period of time).

Alternative Hypothesis

$$H_1 = \text{not } H_o$$

If two groups of physically handicapped children are administered standardized achievement tests both at the beginning and completion of the study, then there will be a significant difference between the treatment effects (means) of the levels of factor B (over a period of time).

3. Null Hypothesis

$$\alpha_1\beta_1 = \alpha_1\beta_2 = \alpha_1\beta_3 = \alpha_1\beta_4 = \alpha_2\beta_1 = \alpha_2\beta_2 = \alpha_2\beta_3 = \alpha_2\beta_4 = 0$$

If two groups of physically handicapped children are administered standardized achievement tests both at the beginning and completion of the study, then there will be no significant difference between the experimental and control group treatment effects (means) in respect to the mathematics scores over a period of time.

Alternative Hypothesis

$$H_1 = \text{not } H_o$$

If two groups of physically handicapped children are administered standardized achievement tests both at the beginning and completion of the study, then there will be a significant difference between the experimental and control group treatment effects (means) in respect to the mathematics scores over a period of time.

After an examination of the results an aposteriori multiple comparison test was used. This was accomplished by using the Newman-Keuls method for determining whether significant differences were between the pretests, posttest, and/or retention tests. Winer (1971) states that with unequal sample sizes it is convenient to work with treatment means.

Thus, using Newman-Keuls, the following means over time were tested for significant differences:

H_o			H_1
$\bar{X}_1=\bar{X}_2$	(pre 1 = pre 2)	or	$\bar{X}_1\neq\bar{X}_2$
$\bar{X}_1=\bar{X}_3$	(pre 1 = post)	or	$\bar{X}_1\neq\bar{X}_3$
$\bar{X}_1=\bar{X}_4$	(pre 1 = ret.)	or	$\bar{X}_1\neq\bar{X}_4$
$\bar{X}_2=\bar{X}_3$	(pre 2 = post)	or	$\bar{X}_2\neq\bar{X}_3$
$\bar{X}_2=\bar{X}_4$	(pre 2 = ret.)	or	$\bar{X}_2\neq\bar{X}_4$
$\bar{X}_3=\bar{X}_4$	(post = ret.)	or	$\bar{X}_3\neq\bar{X}_4$

Significant differences were compared between pretests (1 and 2), posttests, and retention tests at the .05 and .01 levels.

Further investigation of the results was accomplished by using the test for simple main effects. If the AB interaction is significant, the experimenter will normally proceed to test for simple main effects. In this study there was a significant interaction at the .10 level. However, there was no significance at the .05 level. Due to the large variability of subjects in the sample and the small sample size, it was felt that for descriptive purposes only, the test for simple main effects, be computed and discussed.

For descriptive purposes, the intercorrelations between pretests (1) and (2), and posttest and between pretests (1) and (2) and retention test were calculated. The intercorrelations were calculated for the experimental and control groups. These results will indicate whether the increased scores, if any, between pretests and posttest could be attributed to overall treatment effects.

CHAPTER 5

RESULTS

This chapter will present the results of this study. A discussion of the results related to the null hypotheses will be found in the discussion section of this thesis.

The raw data tables are found in Appendix E. The scores are represented in the form of grade point scores (year/month). The means, variances, and standard deviations can be found in Appendix F.

Analysis of Variance

The Analysis of Variance summary table can be found in Table Two. For Hypothesis 1, the critical value needed for significance at the .05 level was 4.08 (df = 1,34). There was no significant difference between the experimental and control group means. Thus null hypothesis 1 was accepted.

The critical value for Hypothesis 2 was 2.68 at the .05 level (df = 3,102). The F ratio was significant at the .05 level. The computed F ratio reveals that there was a significant difference between the means of the levels of factor B, but it does not tell where the difference was. Null Hypothesis 2 was therefore rejected and the Alternative Hypothesis accepted.

The critical values needed for significance at the .05 level (df = 3,102) for Hypothesis 3 was 2.68. The observed F ratio showed there was no significant interaction. Therefore Null Hypothesis 3 was accepted.

TABLE TWO

Analysis of Variances Summary Table

for Repeated Measures Design

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio	
A (Treatment)	2.82	1	2.82	0.59	
Subj. w groups	161.26	34	4.74		
B (Math scores)	6.80	3	2.26	12.04	**
AB	1.36	3	0.45	2.42	*
BX subj. w groups	19.20	102	0.18		
TOTALS	191.16	143			

** $p < .05$

* $p < .10$

An aposteriori probing technique explained in the investigation section was used. The data for Newman-Keuls is shown in Table 3. In part (l) the means of the levels of B are arranged in rank order from low to high. Differences between the pairs of ordered means are computed. In part (iii) the critical values for the ordered differences between pairs are computed. The pairs of means which can be considered different are indicated by asterisks in part (IV). The computed values in (iii) are compared to the differences in ordered means (i). If (i) is greater than, or equal to (iii), then there is a significant difference shown. Levels of significance at the .05 level were found between pretest (1) and posttest and retention test and pretest (2) and posttest and retention test. At the .01 level significance was found between pretest (1) and the retention test and pretest (2) and the retention test.

The test for simple main effects was used in order to answer the following questions: (refer to Appendix E for clarification of letters a_1, a_2, b_1, etc.).

(1) Is there a difference between a_1 and a_2 at b_1 or

a_1 and a_2 at b_2 or

a_1 and a_2 at b_3 or

a_1 and a_2 at b_4

TABLE THREE

Test on Means Using Newman-Keuls Procedure

		b_1	b_2	b_3	b_4
ordered means		2.59	2.63	2.87	3.13
		b_1	b_2	b_3	b_4
(i)	b_1		.04	.28	.54
	b_2			.24	.50
	b_3				.26
(ii)	q.95 (r,102)		2.80	3.36	3.69
	q.99 (r,102)		3.70	4.20	4.50
(iii)	$S_{\bar{B}}$q.95 (r,102)		.20	.24	.27
	$S_{\bar{B}}$q.99 (r,102)		.27	.30	.33

		Pre (1)	Pre (11)	Posttest	Retention
(iv)	Pre (1)		--	*	**
	Pre (2)			*	**
	Posttest				--

* $p < .05$

** $p < .01$

(2) Is there a difference between b_1 b_2 and b_3 and b_4 at a_1 or between b_1 b_2 and b_3 and b_4 at a_2

The results are shown in Table Four. An examination of the data reveals that the experimental group showed a significant difference over time at the .01 level.

The intercorrelations were calculated for the experimental and control groups. Results of the correlation matrices can be found in Table Five. Results from this investigation showed that pretests to retention tests for both groups are highly correlated and significant at .05 and .01 levels.

A graph of the results showing the mean scores of the experimental and control groups can be found in Figure Two.

TABLE FOUR

Analysis of Variance Table for Simple Main Effects

Source	SS.	df	MS		F
1. Between subjects					
2. Between A at b_1	.01	1	.01	$(\frac{2}{6})$	.007
3. Between A at b_2	.69	1	.69	$(\frac{3}{6})$	.52
4. Between A at b_3	1.02	1	1.02	$(\frac{4}{6})$	.77
5. Between A at b_4	2.48	1	2.48	$(\frac{5}{6})$	1.87
6. Within cell	180.47	136	1.32		
7. Within subjects					
8. Between B at a_1	6.42	3	2.14	$(\frac{8}{11})$	11.26**
9. Between B at a_2	1.46	3	0.49	$(\frac{9}{11})$	2.58
10. AB	1.36	3	0.45	$(\frac{10}{11})$	2.37
11. BX subj. w. groups	19.20	102	0.19		

* $p < .05$ = F critical = 4.08 (df = 1,34) 2.68 (df = 3,102)

** $p < .01$ = F critical = 3.95 (df = 3,102)

TABLE FIVE

Correlation Matrices for Control and Experimental Groups

Experimental Group

	$1(Pre^1)$	$2(Pre^2)$	3)Post)	4(Ret.)
$1(Pre^1)$	1.00			
$2(Pre^2)$	0.74**	1.00		
3(Post)	0.64**	0.87**	1.00	
4(Ret.)	0.64**	0.86**	0.92**	1.00

* $p < .05$ r critical = .48 df (15)

** $p < .01$ r critical = .60 df (15)

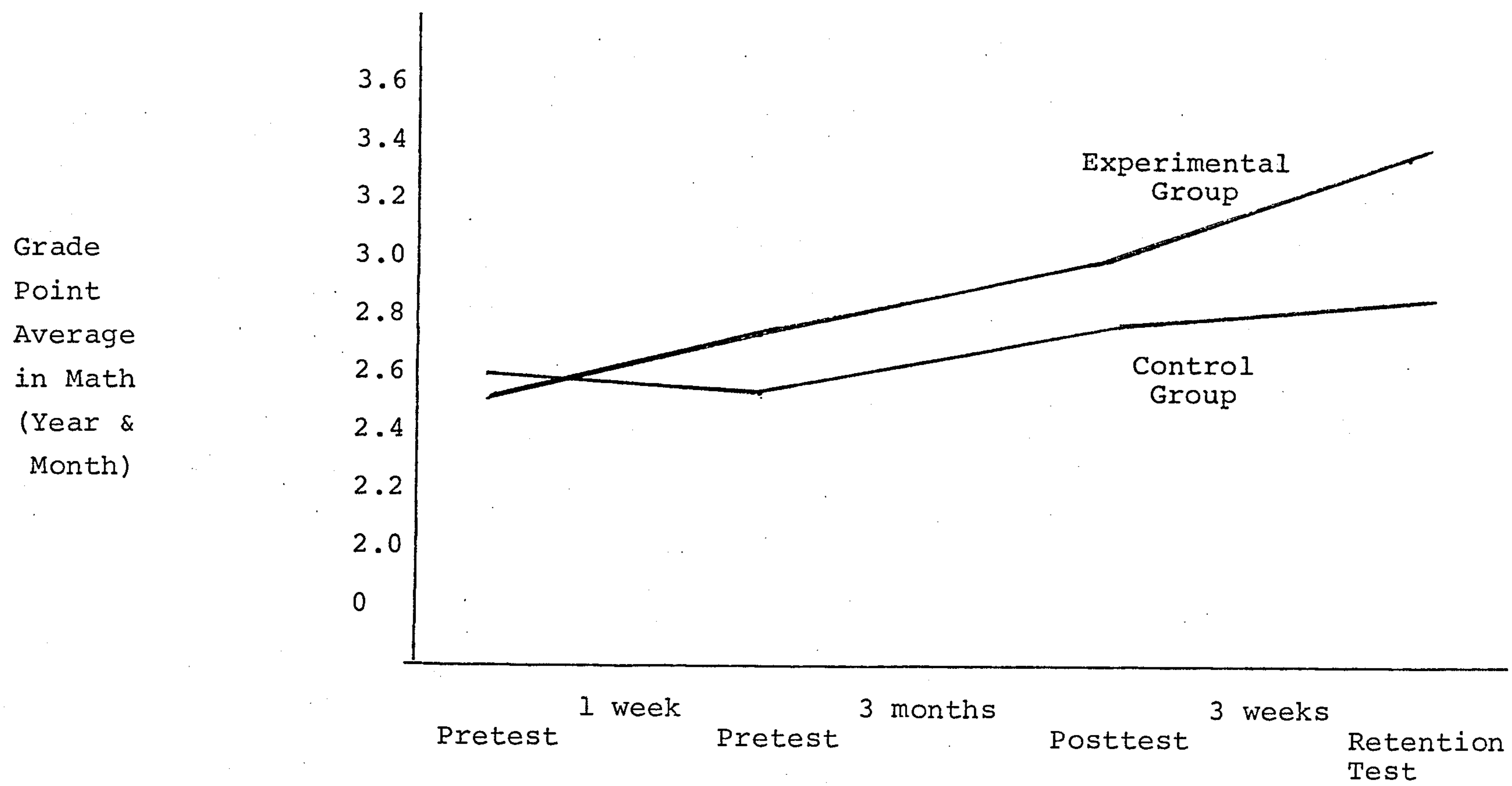
Control Group

	$1(Pre^1)$	$2(Pre^2)$	3(Post)	4(Ret.)
$1(Pre^1)$	1.00			
$2(Pre^2)$	0.95**	1.00		
3(Post)	0.92**	0.96**	1.00	
4)Ret.)	0.87**	0.92**	0.95**	1.00

* $p < .05$ r critical = .45 df (17)

** $p < .01$ r critical = .57 df (17)

Figure Two



Mean scores in Math over a period of four months

CHAPTER 6

DISCUSSION AND CONCLUSIONS

With respect to the basic problem, this study had demonstrated that physically handicapped students were able to work independently on the computer terminal regardless of age or severity of handicapping conditions. C.A.L. was shown to be a practical means of remedial instruction with this population of students.

Analysis of Variance

Null hypothesis (1) was accepted revealing that there was no significant difference between experimental and control groups due to treatment effects.

Null hypothesis (2) was rejected showing a significant effect over time. To determine where the significance occurred, Newman-Keuls probing procedure was used. Results showed significance between pretest (1) and the posttest and retention tests, and between pretest (2) and the posttest and retention tests. Results imply that learning occurred over a four month period. There was no significant difference between posttest and retention test scores. However, it is interesting to note that the experimental group mean rose four months, while the control group scores increased by one month in the one month retention period. During the retention interval, C.A.L. could have played a role in learning. This will be discussed in more depth later in the chapter.

Null Hypothesis (3) was accepted at the .05 level but rejected at the .10 level. Reasons for lack of significance at the more conservative level was felt to be due to the large variability of scores. Students' S.A.T. scored ranged from 1 to 6.7 grade point levels. With a small sample and large variances, significance was difficult to achieve.

For descriptive purposes only, the results from the test for simple main effects will be discussed. Results showed that the experimental group achieved significance over time at the .01 level. The control group showed no significance over time at the .05 level. The experimental group thus showed superiority and significant gains over the control group when comparing group mean scores over time.

Results of the correlations reveal that gains in learning were consistent over the four month period within both treatment groups. However, correlations for the first pretest were not as highly correlated with the posttest and retention tests as the correlations for the second pretest. This result shows that pretest (1) was perhaps a less reliable predictor of scores than pretest (2). Because these children experienced few testing situations, it was necessary to administer the two pretests to obtain more accurate results.

Overall, the results of the study did not show statistical significance. For the teacher, however, there are educational gains from this study. In comparing the mean scores, the experimental group increased seven months in mathematics from pretest to retention test, while the control group increased three months in mathematics during the same time period. Especially when dealing with a handicapped population such as the children at Ellen Douglass School, some merit must be accorded to C.A.L. as a form of drill and practice in mathematics. For a more individual analysis of the results refer to Appendix F.

General Comment

Previous research in the area of C.A.L. with the handicapped has shown that C.A.L. can be as effective as traditional classroom instruction and, in some cases, more effective. Some interesting observations have been obtained from this present study and reveal meaningful educational implications.

Some of the students using C.A.L. far exceeded the expectations of their teachers. Because of the motivation present with C.A.L., basic facts were learned more quickly by these students. They were ready to proceed to the next level in mathematics, but in some cases had to wait until the teacher taught the new concept in the classroom.

Several children who showed a negative attitude toward mathematics in the classroom showed a greater interest in classroom mathematics activities.

Teachers were excited to see the ease and efficiency that students displayed when doing mathematics on the computer terminal. For many of the children, getting ready to do arithmetic is an involved process. The teacher first must put a table and slant board on the wheelchair, place a typewriter on the table, and insert the paper. Mathematics assignments must be made specially so as to line up properly in the typewriter. C.A.L. eliminates this process. Also, few of the children have the strength or co-ordination to erase errors. The computer allows the student to make corrections easily.

Students worked much faster on the computer than in the classroom. Some children would take 10 minutes to do 10 questions on the computer terminal, whereas, in the classroom, a similar 10 questions would take up to one half hour to complete.

A positive result from C.A.L. was the concern of teachers to individualize more closely in mathematics. Although this experimenter does not believe this began soon enough, it was apparent during the last phase of the study. As discussed previously, a four month gain was shown by the experimental group from the posttest to the retention test and a one month gain was shown by the control group. The teachers and this experimenter felt that this large gain was due to a closer relationship between classroom instruction and results of the C.A.L. drills.

If the classroom teachers had been more aware of the student's performance on the computer and co-ordinated results of C.A.L. with classroom instruction at the beginning of the study, C.A.L. would perhaps have been more effective.

Implications and Future Considerations

The results of the study show educational relevance and support the use of C.A.L. as an efficient means of presenting drill and practice skills to the physically handicapped. However, improvements in some areas are warranted. The information gained from the investigation should be considered in future studies with C.A.L..

One of the major criticisms of the project was that programs for grades 1 and 2 and grade 6 were too limited. More programs were needed in the areas of missing addends, fractions, money problems, and calculations with decimals.

Because of the results of this study, programs were made available for the project. An additional 15 programs were written to include the areas mentioned above. Programs were made appropriate for preprimary and retarded levels as well as the advanced 5 and 6 levels.

In addition to the lack of programs available to the primary and grade 6 levels, it was felt that a closer liason between the school project co-ordinator and teachers should have been made available. In order to use C.A.L. effectively, teachers must have a closer supervision in the type of programs that their students are using. Classroom instruction should be closely related with the C.A.L. drills. Meetings with the teachers at two week intervals, to discuss the student's progress, would help to alleviate this problem and thus strengthen the effectiveness of C.A.L..

It was also mentioned by the teachers that a three month period was not long enough to assess the gains of handicapped children. It was felt that a five or six month period would result in more realistic gains.

Volunteers were an extremely necessary part of this study and future investigators should realize their importance. Because of the mobility problems and age of the students, volunteers were necessary to supervise the logging-in procedures. Without their assistance, the project could not have been carried out as efficiently.

Further studies in this area should use experimental models that include control groups or contrast groups that are receiving additional instruction of some type. The control group could be given computerized drill and practice sheets in math, calculators, or remedial drill by volunteers for the same period of time as the experimental group engaged in C.A.L.. Such experimentation would provide a more robust model from which to draw more general conclusions.

Other important considerations when implementing computers with the handicapped are listed below.

1. There is an interest shown by the Occupational Therapy Department at Ellen Douglass to develop programs to teach "activities for daily living". Programs could be written in the areas of nutrition, money management, and personal hygiene.

2. A synthetic talker called "Votrax" could be considered as a method of remedial instruction for the handicapped. Votrax is a computerized voice synthesizer. The student reads the hard copy while listening to the text of the program. Votrax could provide remediation for the visually handicapped or for children who have difficulties in the area of reading.

3. There is a need for an information retrieval system to aid the teacher in the maintenance of student records. This system would enable complete daily records to be available. Printouts would provide information on each student, giving student name, program used, percentage correct and home room number. Record keeping would be minimal with this system.

In conclusion, the future of computers with exceptional children looks encouraging. However, the future of computers can be only as effective as the degree of acceptance by teachers, principals, parents, and administrators who are involved with a computer project.

Summary and Conclusions

In regard to the Analysis of Variance results, the data supported the acceptance of null hypothesis (1) that there was no significant difference between the experimental and control group means. However, significant differences over time were found between the pretests, posttests and retention test in rejecting null hypothesis (2). The aposteriori Newman-Keuls technique showed the differences to be between pretest (1) and the posttest and retention test, and between pretest (2) and the post and retention tests. The third null hypothesis was accepted showing that there was no difference in performance of the two groups over time. For descriptive purposes only, the test for simple main effects was computed showing that the experimental group showed significant gains over time while the control group did not. Results of the correlations show consistent learning over a four month period. However, the reliability of pretest (1) was questionable.

The results of this study using C.A.L. to assist in drill and practice in mathematics are educationally relevant to teachers and administrators. Because of the ease with which physically handicapped students are able to manipulate the computer terminal and the relatively low expense involved, C.A.L. has shown potential with the handicapped. Motivation levels remained high throughout the project and many children continued to enjoy learning through C.A.L..

REFERENCES

Allen, J.D. & Rodgin, D.W. Mental Retardation in Association with Progressive Muscular Dystrophy. *American Journal of Disabled Children*, 1960, 100, 208.

Allen, R.M. & Jefferson, T.W. *Psychological Evaluation of the Cerebral Palsied Person*, Springfield, Ill: Charles C. Thomas, 1962.

Arledge, R.L. Ataxia Telangiectasis. *Physical Therapy*, 1968, 48 (10), 1089 - 1093.

Atkinson, R.C. & Wilson, H.A. Computer assisted instruction. *Science*, October 4, 1968.

Behrens, T.R., Clark, L. & Alprin, L. Mathematics curriculum supported by computer assisted instruction. *American Annals of the Deaf*, 1969, 114 (5), 889 - 92.

Bender, M.L. A voluntary prekindergarten language development and reading program for the entire four year old population of a city (an investigation of machine-taught reading). Final report. ERIC Document 020 855, 1968.

Berthold, H.C. & Sachs, R. Education of the minimally brain damaged child by computer and by teacher. *Journal of Aplet*, 1974, 11 (3), 121 - 124.

Blakeslee, B. *The Limb-Deficient Child*. Berkeley: University of California, 1963.

Bleck, E.E. & Nagel, D.A. *Physically Handicapped Children*. New York: Grune and Stratton, 1975.

Blencowe, S.M. (Ed.) *Cerebral Palsy and The Young Child*. Edinburgh: E & S. Livingstone Ltd; 1969.

Birch, J.W. & Stuckless, E.R. The development and evaluation of programmed instruction in language for children with auditory disorders. ERIC Document 003 602, 1962.

Bornstein, H. An evaluation of high school mathematics programmed texts when used with deaf students. ERIC Document 003 292, 1964.

Bowley, A.H. & Gardner, L. The Handicapped Child. Edinburgh: Churchill Livingstone, 1972.

Buros, O.K. The Seventh Mental Measurement Yearbook. Highland Park, N.J: Gryphon Press, 1972.

Coss, J.G., Forney, R.L., Wendland, L.V. & Pederson, E. Effectiveness of automated visual programmed instruction with paraplegic and other severely handicapped students. ERIC Document 010 839, 1966.

Crawford, A.N. A pilot study of computer-assisted drill and practice in seventh grade remedial mathematics. California Journal of Educational Research, 1970, 21 (4), 170 - 181.

Culbertson, L.B. C.A.I. - beneficial teaching tool at Texas School for the deaf. American Annals of the Deaf, 1974, 119 (1), 34 - 40.

Denhoff, E. & Robinault, I. Cerebral Palsy and Related Disorders. New York: McGraw-Hill, 1960.

Dezelle, W. The credibility of programmed material as an instructional technique with mentally retarded pupils. Education and Training of the Mentally Retarded, 1971, 6 (1), 16 - 19.

Evans, R. & Simpkins, K. Computer assisted instruction for the blind. _Education of the Visually Handicapped_, October, 1972, 83 - 84.

Faford, M.B. & Malouf, D. Computers as an instructional tool in special education. _Computers in Education Resource Handbook_, 1973 IX, 7 - 9.

Fish, L. Deafness in cerebral palsied school children. _Lancet_, 1955, 2, 370 - 371.

Fricklas, R. & Rusch, R. Trimodal reading instruction with inefficient learners. _The Slow Learning Child_, 1974, 2 (1), 44 - 52.

Gipson, J. Use of computer assisted instruction in mathematics for disadvantaged seventh grade youth. ERIC Document 049 057, 1971.

Gipson, J. Use of computer assisted instruction for teaching mathematics to the disadvantaged. ERIC Document 051 672, 1971.

Green, D.R. Learning to recognize words and letters on a C.A.I. terminal. ERIC Document 027 177, 1968.

Grigonis, D.F. Development and evaluation of programmed instruction in the teaching of verbs to deaf children in the primary grades. Final report. ERIC Document 056 424, 1970.

Haring, N.G. & Staples, J.M. Visual perception and eye-hand co-ordination. _Journal of American Physical Therapy Association_, 1966, 46, 129 - 135.

Jacobs, P.I. The development, use and evaluation of self instructional programs in Israel. ERIC Document 051 666, 1968.

Jamison, D. Cost and performance of C.A.I. for education of disadvantaged children, ERIC Document 054 978, 1971.

Johnson, M.S. & Kress, R.A. Remedial Reading Classroom and Clinic. Boston: Alyn and Bacon, 1972.

Kaplan, J.D. An example of a mathematics instructional program for disadvantaged children. Educational Technology, August, 1969, 40 - 43.

Karlsen, B. Teaching beginning reading to hearing impaired children, using a visual method and teaching machines. Final Report. ERIC Document 015 603, 1966.

Kirk, R.E. Experimental Design: Procedures for the Behavioral Sciences. Belmont, California: Cole Publishing Company, 1969.

Kirk, S.A. Educating Exceptional Children. Boston: Houghton Mifflin Company, 1962.

Knutson, J.M. Computer assisted instruction for vocational rehabilitation of the mentally retarded. ERIC Document 044 039, 1970.

Koehler, J. Spinal muscular atrophy of childhood. In E.E. Bleck and D.A. Nagal (Eds.), Physically Handicapped Children. New York: Grune & Stratton, 1975.

Langford, F. & Thomson, J. Spina Bifida in the classroom. The Times Educational Supplement, 1972, 8 (12), 29.

Litman, G.H. C.A.I. in Chicago. ERIC Document 087 423, 1973.

Malpass, L.F. Comparison of two automated teaching procedures for retarded children. ERIC Document 003 063, 1963.

Malpass, L.F. Programmed reading instruction for culturally deprived slow learners. ERIC Document 011 065, 1966.

Miller, W.H. Diagnosis and Correction of Reading Difficulties in Secondary School. New York: Students Centre of Applied Research in Education, 1973.

Nelon, E. An evaluation of computer assisted vocabulary instruction with mentally retarded children. Research Report No. 7322, ERIC Document 090 964, 1972.

Pfau, G. Programmed Instruction: An exploration into its effectiveness with the handicapped child. Audiovisual Instruction, November 1969, 24 - 27.

Pfau, G. Project LIFE a decade later: some reflections and projections. American Annals of the Deaf, October 1974, 549 - 553.

Pressey, S.L. A simple apparatus which gives tests and scores - and teaches. School and Society, 1926, 23, 373 - 376.

Pressey, S.L. A machine for automatic teaching of drill material. School and Society, 1927, 25, 549 - 552.

Pressey, S.L. Paper delivered at Project LIFE programming conference, Ohio State University, September 20, 1967.

Prince, J.D. A practitioner's report: results of two years of computer assisted instruction in drill and practice in mathematics for the period June 15, 1967 to May 30, 1969. Progress report no. 3. ERIC Document 032 769, 1969.

Rey, C. Ataxia-telangiectasis - report of a case. Journal of Disabled Children. 1960, 99, 238 - 241.

Roy, H.L., Schein, J.D. & Frisina, R.D. New methods of language development for deaf children. ERIC Document 001 195, 1964.

Salisbury, A.B. Overview of C.A.I. Educational Technology, October, 1971, 48 - 50.

Sandals, L.H. Computer assisted learning with the developmentally handicapped. Unpublished Doctoral Thesis, University of Calgary, 1973.

Santin, Report on an experiment in teaching of reading to adolescent trainable retarded. ERIC Document 050 501, 1971.

Sharrard, W.J. Paediatric Orthopaedics and Fractures. Philadelphia: F.A. Davis Company, 1971.

Smith, J.L. & Cogan, D.G. Ataxia-Telangiectasis. Arch. Opthal, 1959, 62, 364 - 369.

The Spastics Society, Facts About Cerebral Palsy. London: The Spastics Society, 1967.

Steg, D. The effects of individualized programmed instruction of initial reading skills and language behavior in early childhood. ERIC Document 028 026, 1968.

Stoval, G.F. A comparative study of C.A.I. in arithmetic computation in the public schools of McComb, Mississippi. Unpublished doctoral thesis, 1969.

Street, W.P. Computerized instruction in mathematics versus other methods of mathematics instruction under ESEA Title I programs in Kentucky. ERIC Document 068 354, 1972.

Suppes, P. & Fletcher, J.D. Computer assisted instruction in mathematics and language arts for deaf students. ERIC Document 093 365, 1974.

Swaiman, K.F. & Wright, F.S. _Neuromuscular Diseases of Infancy and Childhood_. Illinois: Charles C. Thomas, 1970.

Tachdjian, M.O. _Pediatric Orthopedics: Volume II_. Toronto: W.B. Saunders Co., 1972.

Taylor, S. The effectiveness of C.A.I.. ERIC Document 092 074, 1974.

Thibodeau, G.P. & Vitello, S.J. The use of programmed instruction in developing the computational skills of mentally retarded children. _Mental Retardation_, August 1974, 46 - 48.

Tulane University of Louisiana, Head Start Evaluation and Research Centre, Tulane University, Annual Report. ERIC Document 029 705, 1968.

Warner, D. Experimental phonetic reading program for exceptional pupils. ERIC Document 015 848, 1967.

Wershow, H.J. Muscular dystrophy: A positive approach to care. _Nursing Outlook_. 1966, 14 (1), 49 - 53.

Winer, B.J. _Statistical Principals in Experimental Design_. New York: McGraw-Hill Inc., 1971.

Woodburn, M. Social Implications of Spina Bifida. Scotland: NFER Publishing Company Ltd., 1975.

Worder, N.K. & Vignos, P.J. Intellectual functions in childhood progressive muscular dystrophy. Pediatrics, 1962, 29, 968.

Zillweger, H. & Hanson, J.W. Psychometric studies in muscular dystrophy type 3A (Duchenne). Developmental Medicine and Neurology, 1967, 9, 576 - 581.

APPENDICES

APPENDIX A

SUMMARY DATA - SUBJECT POOL

APPENDIX A

SUMMARY DATA - SUBJECT POOL

Subject	Sex	Age	Test/ Date/IQ	Grade Level	Diagnosis	Degree of Disability	Related Disorder
1	F	14	OTIS/ 70/71	4.5	Cerebral Palsy	Severe	VH*
2	F	12	PPVT/ 69/75	4	Cerebral Palsy	Severe	
3	M	13	OTIS/ 72/84	4.5	Spina Bifida	Moderate	
4	M	13	OTIS/ 70/77	4.5	Cerebral Palsy	Moderate	HIPI**
5	M	13	PPVT/ 69/67	4.5	Arthro- gryposis	Moderate	SI***
6	M	12	WISC/ 72/62	1.5	Osteogenesis Imperfecta	Severe	HIAPI****
7	F	12		3.5	Myotonic Dystrophy	Moderate Progressive	SI***
8	F	14		3	Cerebral Palsy	Severe	SI***
9	M	12	SB/ 68/78	4	Spina Bifida	Severe	
10	F	12	OTIS/ 70/107	6	Muscular Atrophy	Severe Progressive	

APPENDIX A (cont'd.)

SUMMARY DATA - SUBJECT POOL

Subject	Sex	Age	Test/ Date/IQ	Grade Level	Diagnosis	Degree of Disability	Related Disorder
11	F	12	OTIS/ 70/111	6	Muscular Atrophy	Severe Progressive	
12	M	12	WISC/ 68/74	4	Phocomelia Thalidomide	Moderate	
13	M	12	OTIS/ 70/108	6	Phocomelia Thalidomide	Moderate	
14	M	12	OTIS/ 72/85	5	Cerebral Palsy	Mild	
15	F	12	OTIS/ 72/70	5	Cerebral Palsy	Mild	VIPI*****
16	M	11	OTIS/ 72/83	6	Cerebral Palsy	Moderate	
17	F	13	OTIS/ 72/92	5	Cerebral Palsy	Moderate	SI***
18	M	9	OTIS/ 74/76	3	Cerebral Palsy	Moderate	SIH******
19	M	10	OTIS/ 74/6.8MA	3	Accident	Mild	SI***
20	F	10	OTIS/ 74/122	4	Spina Bifida	Moderate	

APPENDIX A (cont'd.)

SUMMARY DATA - SUBJECT POOL

Subject	Sex	Age	Test/ Date/IQ	Grade Level	Diagnosis	Degree of Disability	Related Disorder
21	F	12	WISC/ 74/85	4	Cerebral Palsy	Moderate	
22	M	10	OTIS/ 74/8.7MA	4	Louis-Barr Syndrome	Moderate Progressive	
23	M	11	OTIS/ 74/83	4	Spina Bifida	Mild	
24	M	9	OTIS/ 74/91	3	Muscular Dystrophy	Severe Progressive	
25	M	11	OTIS/ 74/79	4	Spina Bifida	Moderate	
26	F	8	WISC/ 70/V79	2	Cerebral Palsy	Severe	
27	M	6	PMA/ 74/107	1	Accident	Moderate Severe	
28	F	6	PMA/ 74/112	1	Cerebral Palsy	Moderate	
29	F	7	PMA/ 74/86	1	Cerebral Palsy	Mild	
30	M	6	PMA/ 74/131	2	Muscular Atrophy	Severe Progressive	

APPENDIX A (cont'd.)

SUMMARY DATA - SUBJECT POOL

Subject	Sex	Age	Test/ Date/IQ	Grade Level	Diagnosis	Degree of Disability	Related Disorder
31	F	8	PMA/ 74/82	2	Spina Bifida	Mild	S & HI*******
32	F	8	PMA/ 74/104	2	Muscular Atrophy	Moderate Progressive	
33	M	10		1	Muscular Dystrophy	Moderate Progressive	
34	F	7	PMA/ 74/89	1	Spina Bifida	Moderate	
35	F	9		2	Spina Bifida	Mild	
36	M	7	PMA/ 74/98	1.5	Muscular Dystrophy	Moderate Progressive	
37	F	7	PMA/ 74/86	1.5	Spina Bifida	Mild	
38	F	6	PMA/ 74/100	1.5	Arthro- gryposis	Moderate	
39	M	5		1.5	Phoco- melia	Moderate	
40	F	7	WPPSI/74 Verbal-high perf.mildly retarded	1	Spina Bifida	Moderate	VI

APPENDIX A

SUMMARY DATA - SUBJECT POOL

LEGEND

*	Visual Handicap
**	Hearing impairment
***	Speech impairment
****	Hearing impairment - auditory perceptual impairment
*****	Visual impairment - perceptual impairment
******	Speech impairment - hyperactive
*******	Speech and hearing impairment

APPENDIX B

SAMPLE COMPUTER PROGRAMS

```
PROGRAM   ADDSUB1

THIS IS A DRILL AND PRACTICE PROGRAMME FOR ADDING OR
SUBTRACTING. THE PARAMETERS ARE TO BE SELECTED BY
THE TEACHER.

DO YOU WANT ADDITION ('+'), SUBTRACTION ('-'), OR BOTH ('B')? +

SMALLEST POSSIBLE SUM (FROM 1 TO 18)? 1

LARGEST POSSIBLE SUM (FROM  1  TO 19) ? 6

HOW MANY QUESTIONS (FROM 1 TO 20) DO YOU WANT ? 3

TYPE IN YOUR FIRST NAME HERE? CATHI
TYPE IN YOUR LAST NAME HERE ? HILL

--------------------------------------------------------------

HELLO CATHI, TRY ADDING THESE PROBLEMS.


      2
+     2
------
  ? 4
     <CATHI


      0
+     4
------
  ? 3
        X

      0
+     4
------
  ? 4
     <CATHI


      4
+     1
------
  ? 5
     <CATHI

-----------------------------------------------------------

WELL, CATHI HILL. YOU HAVE DONE  4  PROBLEMS.

YOU HAD  3  CORRECT ANSWER(S) AND  1  WRONG ANSWER(S).

THAT GIVES YOU  75  PERCENT CORRECT.

SO LONG, CATHI. HAVE A HAPPY DAY.
```

```
 76/03/15. 14.52.37.
PROGRAM   ADDSAN

SELF CONSTRUCTED DRILLS IN ADDITION FOR REMEDIATION

HOW MANY PROBLEMS (FROM 1 TO 10) DO YOU WANT TO DO? 3


HOW MANY NUMBERS (FROM 2 TO 5) DO YOU WANT TO ADD ? 3


HOW MANY DIGITS (FROM 1 TO 5 )DO YOU WANT IN EACH NUMBER? 2

DO YOU WANT AN EXTRA TRY ('T') OR NO EXTRA TRY ('NT') ? T

PLEASE INDICATE WHETHER YOU WANT  ALL DATA ('D')
OR FIRST AND LAST NAME ONLY (F)
? F


WHAT IS YOUR FIRST NAME ? CATHI

AND WHAT IS YOUR LAST NAME? HILL

HELLO CATHI HOW ARE YOU TODAY?

DO YOU WANT TO SEE THE DIRECTIONS? TYPE 'YES' OR 'NO'.
? YES
1) TODAY YOU WILL BE DOING SOME ADDING PROBLEMS.
2) WHEN THE MACHINE STOPS TYPE IN YOUR ANSWER FOR
   EACH COLUMN, ONE AT A TIME.
3) AFTER YOU PUSH A NUMBER BOTTON ALWAYS PUSH THE
   RETURN BUTTON.

OK LET'S BEGIN...




      5    6
      5    4
      1    0
(+) ----------
         ? 0
     ? 2
? 1
VERY GOOD CATHI

 1  2  0   IS THE CORRECT ANSWER
```

```
      4    8
      4    2
      0    8
(+) ----------
         ? 8
    ? 9
RIGHT YOU ARE DOING FINE CATHI

 0  9  8   IS THE CORRECT ANSWER



      7    0
      4    5
      3    5
(+) ----------
         ? 9
                              SORRY TRY AGAIN
         ? 0
    ? 8
                              SORRY TRY AGAIN
    ? 5
? 1
RIGHT ON CATHI KEEP UP THE GOOD WORK

 1  5  0   IS THE CORRECT ANSWER

THE DRILL IS OVER CATHI . YOU HAD  3  CORRECT ANSWER(S)
AND  0  WRONG ANSWER(S).
WITH  2  EXTRA TRIES.
THAT GIVES YOU  100  PERCENT CORRECT.

DO YOU WANT TO DO ANY MORE PROBLEMS TODAY? ANSWER
'YES' OR 'NO'.? NO
THANK YOU FOR COMING TO PRACTICE TODAY CATHI.
I HOPE THAT I WILL HEAR FROM YOU AGAIN SOON.
```

```
 76/03/15. 15.32.37.
PROGRAM   SUBTSAN

SELF CONSTRUCTED DRILLS IN SUBTRACTION FOR REMEDIATION

HOW MANY PROBLEMS (FROM 1 TO 10) DO YOU WANT TO TRY ? 3

HOW MANY DIGITS (FROM 1 TO 5) DO YOU WANT IN THE LARGER
NUMBER? 3

HOW MANY DIGITS(FROM 1 TO  3 )DO YOU WANT IN THE SMALLER
NUMBER? 2

DO STUDENTS GET A EXTRA TRY('T') OR NO EXTRA TRY('NT')
? NT

DO YOU WANT FIRST AND LAST NAMES('F') OR FULL DATA('D')
? D

WHAT IS YOUR FIRST NAME ? CATHI

WHAT IS YOUR LAST NAME? HILL

WHAT IS THE DATE TODAY? MARCH 3

WHAT TIME IS IT ? 3:00

HELLO CATHI,HOW ARE YOU TODAY?

DO YOU WANT TO SEE THE DIRECTIONS? TYPE YES OR NO.
? NO

OK,LETS GET STARTED...


        5     8     7
              1     0
(-) ---------------
                 ? 7
          ? 7
      ? 5
YES THAT'S GOOD CATHI KEEP UP THE GOOD WORK...
```

```
 5  7  7   IS THE CORRECT ANSWER.


      5    9    3
           9    2
(-) ---------------
              ? 1
        ? 9
NO CATHI YOUR ANSWER IS NOT CORRECT. THE ANSWER
SHOULD HAVE BEEN  0 . WE WILL TRY A NEW PROBLEM


      4    0    3
           6    8
(-) ---------------
              ? 4
NO CATHI YOUR ANSWER IS NOT CORRECT. THE ANSWER
SHOULD HAVE BEEN  5 . WE WILL TRY A NEW PROBLEM


      9    4    4
           5    3
(-) ---------------
              ? 1
        ? 9
    ? 8
RIGHT ON CATHI YOU ARE DOING FINE

 8  9  1   IS THE CORRECT ANSWER.


      6    0    0
           6    1
(-) ---------------
              ? 9
        ? 3
    ? 5
YES THAT'S GOOD CATHI KEEP UP THE GOOD WORK...

 5  3  9   IS THE CORRECT ANSWER.

THE DRILL IS OVER CATHI HILL. YOU HAD  3  CORRECT
 2 WRONG AND HAD  0  EXTRA TRIES.
THAT GIVES YOU  60.  PERCENT CORRECT

DO YOU WANT TO DO ANY MORE PROBLEMS TODAY? TYPE YES OR NO
? NO
THANK YOU FOR COMING TODAY CATHI .
I HOPE THAT I WILL SEE YOU AGAIN SOON.
```

```
PROGRAM   MULTSAN

SELF-CONSTRUCTED DRILL IN MULTIPLICATION
FOR REMEDIATION.

HOW MANY PROBLEMS (FROM 1 TO 10) DO YOU WANT TO DO? 3

HOW MANY DIGITS (FROM 1 TO 5) DO YOU WANT IN TOP NUM? 1

DO YOU WANT TO MULTIPLY BY A FIXED CONSTANT ('C')
OR BY A RANDOMLY GENERATED NUMBER ('R') ? C

WHAT NUMBER (FROM 1 TO 9) DO YOU WANT TO MULTIPLY BY? 6

DO YOU WANT AN EXTRA TRY ('T') OR NO EXTRA TRY ('NT')
FOR EACH PROBLEM? T

DO YOU WANT FIRST AND LAST NAME(F) OR FULL DATA(D)? F

WHATIS YOUR FIRST NAME ? CATHI

WHAT IS YOUR LAST NAME? HILL

HELLO CATHI, HOW ARE YOU TODAY?

DO YOU WANT TO SEE THE DIRECTIONS? TYPE 'YES' OR 'NO'.? NO

OK,LET'S BEGIN...


        5
        6
(X)  -----
      ? 0
? 3
VERY GOOD CATHI

 3  0   IS THE CORRECT ANSWER


        9
        6
(X)  -----
      ? 4
? 5
RIGHT ON CATHI YOU ARE DOING FINE

 5  4   IS THE CORRECT ANSWER
```

```
       7
       6
(X) -----
     ? 2
? 3
NO, CATHI. YOU ANSWERED THIS COLUMN WRONG.
TRY AGAIN... AAA? 4
RIGHT ON CATHI YOU ARE DOING FINE

 4  2   IS THE CORRECT ANSWER

THE DRILL IS OVER, CATHI. YOU HAD  3  CORRECT ANSWERS,
 0 WRONG ANSWER(S), AND  1  EXTRA TRIES.
THIS GIVES YOU  100  PERCENT.

DO YOU WANT A CHANCE TO DO MORE PROBLEMS TODAY,YES OR NO? NO

THANK YOU FOR COMING HERE TODAY CATHI.I HOPE
THAT I WILL SEE YOU AGAIN SOON.



  76/03/15. 15.47.06.
 PROGRAM   DIVIDE

 THIS IS A DRILL IN DIVISION FOR REMEDIATION.

 HI, THERE. WHAT IS YOUR FIRST NAME? CATHI

 WHAT IS YOUR LAST NAME, CATHI ? HILL


 HOW MANY PROBLEMS (FROM 1 TO 15) WOULD YOU LIKE TO DO ? 3


 DO YOU WANT TO WORK WITH DECIMALS ? NO


 HOW MANY DIGITS (FROM 1 TO 9) DO YOU WANT IN
 THE NUMBER YOU DIVIDE INTO? 4


 HOW MANY DIGITS (FROM 1 TO  4 ) DO YOU WANT IN THE
 NUMBER THAT YOU DIVIDE BY ? 1



                    -------
       5          )  4250

 = ? 850
```

VERY GOOD, CATHI. THAT IS CORRECT. THE ANSWER IS 850 .

```
             -------
3          )  3306
```

= ? 1102

EXCELLENT, CATHI. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS 1102 .

```
             -------
7          )  3535
```

= ? 505

TREMENDOUS, CATHI. THAT IS RIGHT. THE ANSWER IS 505 .

THE DRILL IS OVER, CATHI.

NUMBER OF PROBLEMS ATTEMPTED: 3

NUMBER OF PROBLEMS CORRECT: 3

PERCENTAGE: 100

WOULD YOU LIKE TO DO SOME MORE PROBLEMS ? NO

GOOD-BYE, CATHI. HAVE A NICE DAY.

APPENDIX C

SUMMARY OF COST

APPENDIX C

SUMMARY OF COSTS

Ellen Douglass School was one of three other schools involved in this project. The total annual cost for the whole project was $15,000. The Department of Education assumed 60% of the total cost and the School Divisions were responsible for 40%. Winnipeg School Division paid $2,000 for a ten month period and the Department of Education contributed $3,000 to the Ellen Douglass School project.

A breakdown of monthly costs for the terminal at Ellen Douglass is as follows:

Display screen and printer rental	$200.15
Monthly line cost	7.65
Computer connect time (ports)	100.00
Processing time	25.00
Paper costs	10.00

Additional costs covered undergraduate and graduate service fellowships, program development and consultative services, and discounted disc storage space.

The cost effectiveness per student showed that during the three month experimental period, 11 students made a total gain of 59 months. The cost per pupil was approximately $21.00 per month gain.

APPENDIX D

HIERARCHY OF MATHEMATICS

LEVELS

APPENDIX D

Name_______________

Room #_____________

Computer Time Periods_____________________________

1	Add: one digit + one digit (under 10) ex: 4+5 Addsub 1	DATE SCORE				
2	Add: one digit + one digit (over 10) ex: 7+6 Addsan					
3	Subt: one digit - one digit (under 10) ex:9-6 Addsub 1					
4	Add: two digits + one digit ex: 35 + 6 Addsan					
5	Subt: two digits - one digit ex: 14 - 8 Subtsan					
6	Add: two digits + two digits ex: 36 + 42 Addsan					
7	Subt: two digits - two digits ex: 42 - 27 Subtsan					
8	Mult: one digit x 1 ex: 9 x 1 Multsan					
9	Mult: one digit x 2 ex: 7 x 2 Multsan					
10	Mult: one digit x 3 ex: 8 x 3 Multsan					

APPENDIX D (cont'd.)

Name_______________________

Room #_____________________

Computer Time Periods______________________________

11	Mult: one digit x 4 ex: 7 x 4 Multsan	DATE SCORE			
12	Mult: one digit x 5 ex: 7 x 5 Multsan				
13	Add: 3 digits+3 digits ex: 426+337 Addsan				
14	Subt: 3 digits-3 digits ex: 436-242 Subtsan				
15	Mult: 2 digits x 1 ex: 25 x 1 Multsan				
16	Mult: 2 digits x 2 ex: 25 x 2 Multsan				
17	Mult: 2 digits x 3 ex: 36 x 3 Multsan				
18	Mult: 2 digits x 4 ex: 37 x 4 Multsan				
19	Mult: 2 digits x 5 ex: 85 x 5 Multsan				
20	Divide:1 digit÷1 digit (no decimal) 2 8 Divide				
21	Divide:2 digits ÷ 1 digit (no decimal) 2 24 Divide				

APPENDIX D

Name ____________________

Room # __________________

Computer Time Periods ______________________________

22	Mult: 1 digit x 6 ex: 7 x 6 Multsan	DATE SCORE			
23	Mult: 1 digit x 7 ex: 8 x 7 Multsan				
24	Mult: 1 digit x 8 ex: 8 x 8 Multsan				
25	Mult: 1 digit x 9 ex: 7 x 9 Multsan				
26	Divide: 1 digit ÷ 1 digit (decimal) 2 7 Divide				
27	Divide: 2 digits ÷ 1 digit (decimal) 2 35 Divide				
28	Mult: 2 digits x 6 ex: 27 x 6 Multsan				
29	Mult: 2 digits x 7 ex: 29 x 7 Multsan				
30	Mult: 2 digits x 9 ex: 37 x 8 Multsan				
31	Mult: 2 digits x 9 ex: 94 x 9 Multsan				
32	General Review (higher level mathematics) Specify (may be 3 digit multiplication) (2 digit divisor etc.)				

APPENDIX E

RAW SCORE DATA TABLES

APPENDIX E

RAW SCORE DATA TABLES

Experimental Group a_1

Subjects	Pretest b_1	Pretest b_2	Posttest b_3	Retention Test b_4
1	0	1.8	2.1	1.9
2	1.6	1.7	1.7	1.6
3	1.8	1.7	1.9	2.9
4	1.8	3.5	4.8	5.0
5	1.9	1.9	1.9	3.1
6	2.1	1.9	2.4	2.6
7	2.4	1.7	1.7	2.1
8	2.4	2.3	3.3	3.2
9	2.5	2.4	2.7	3.5
10	2.9	2.9	2.9	2.6
11	3.1	2.4	2.8	3.2
12	3.2	3.2	3.8	3.8
13	3.3	3.3	3.7	3.9
14	3.5	3.6	3.3	3.9
15	3.5	3.9	4.6	5.4
16	3.9	3.7	3.9	4.1
17	4.0	5.3	4.3	5.0

APPENDIX E (cont'd.)

RAW SCORE DATA TABLES

Control Group a_2

Subjects	Pretest b_1	Pretest b_2	Posttest b_2	Retention Test b_4
1	1.8	2.0	1.7	1.8
2	1.5	1.5	1.7	1.5
3	1.4	1.4	1.3	1.3
4	1.5	1.7	1.5	1.3
5	1.8	1.8	1.6	1.7
6	1.9	1.9	2.1	2.7
7	1.9	1.5	1.7	1.1
8	2.1	1.8	1.7	2.6
9	2.5	1.9	3.0	2.7
10	2.5	1.9	2.3	2.4
11	2.6	2.7	2.9	2.5
12	2.7	2.3	2.4	2.6
13	2.8	2.7	2.8	3.2
14	2.9	2.4	2.1	2.7
15	2.9	3.0	2.8	3.0
16	3.5	4.0	4.4	4.4
17	3.7	3.7	4.8	5.0
18	3.8	3.9	4.8	6.2
19	6.7	5.4	5.9	5.9

APPENDIX F

MEANS AND STANDARD DEVIATIONS

APPENDIX F

MEANS AND STANDARD DEVIATIONS

	Pretest 1 (b_1)	Pretest 2 (b_2)	Posttest (b_3)	Retention Test (b_4)
Experimental Group a_1	N = 17	N = 17	N = 17	N = 17
	$\overline{X}_{1,1}=2.5$	$\overline{X}_{1,2}=2.7$	$\overline{X}_{1,3}=3.0$	$\overline{X}_{1,4}=3.4$
	S = 1.05	S = 1.07	S = 1.04	S = 1.183
	$S^2=1.10$	$S^2=1.03$	$S^2=1.02$	$S^2=1.40$
Control Group a_2	N = 19	N = 19	N = 19	N = 19
	$\overline{X}_{2,1}=2.6$	$\overline{X}_{2,2}=2.5$	$\overline{X}_{2,3}=2.7$	$\overline{X}_{2,4}=2.8$
	S = 1.18	S = 1.10	S = 1.66	S = 1.49
	$S^2=1.39$	$S^2=1.08$	$S^2=2.77$	$S^2=2.27$

APPENDIX G

ANALYSIS OF INDIVIDUAL DATA

APPENDIX G

A subjective analysis of the individual data will be discussed. There was an inconsistency in several of the individual scores and an explanation of these scores will be discussed as follows. A graph of the learning curves of the individuals showing gains and losses in both control and experimental groups are shown in figures 3,4,5 and 6.

Experimental Group

Subjects 1, 6, 8, 10 and 14 showed consistent gains from pretest to retention test. Subjects 1 and 6 showed increases of 1.8 and 1.7 months from pretest 1 to pretest 2. Both subjects showed extreme nervousness in the first pretest. This accounted for such low scores during this test.

Subjects 4, 9, 12, 13 and 19 showed no gains during the pretest to retention test. It was felt that in these cases the computer programs were not appropriate to the needs of the students. More classroom experience was needed in order to develop the mathematical concepts being drilled on the computer.

Subjects 5 and 7 showed no gains until the retention test, and at this time gains of over a year were shown. During the posttest examination, these children wrote their tests in different rooms, isolating them from their peer group. The teacher felt that the students performed poorly because they were in strange rooms and away from their friends during this testing phase.

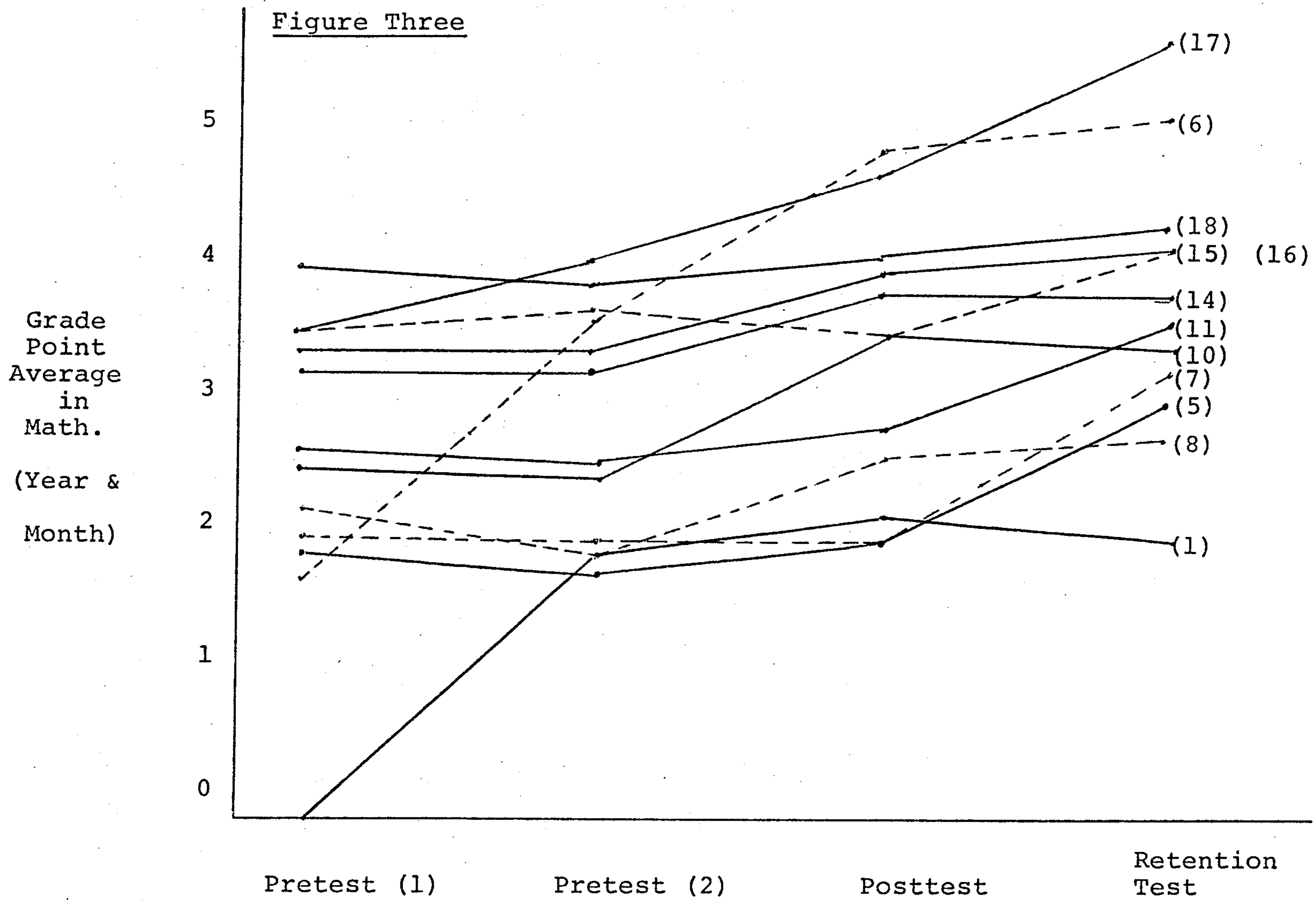
Control Group

Subjects 1, 3, 4, 5, 7, 10, 12, 13, 15, 16 and 20 showed no gains from pretest to retention test having only classroom instruction. This tends to be a typical learning pattern in mathematics with handicapped children. Additional teaching methods could perhaps change this pattern.

Students 2, 6, 8, 9, 12 and 14 showed some gains. These children were progressing steadily in most other subjects as well as in the area of mathematics.

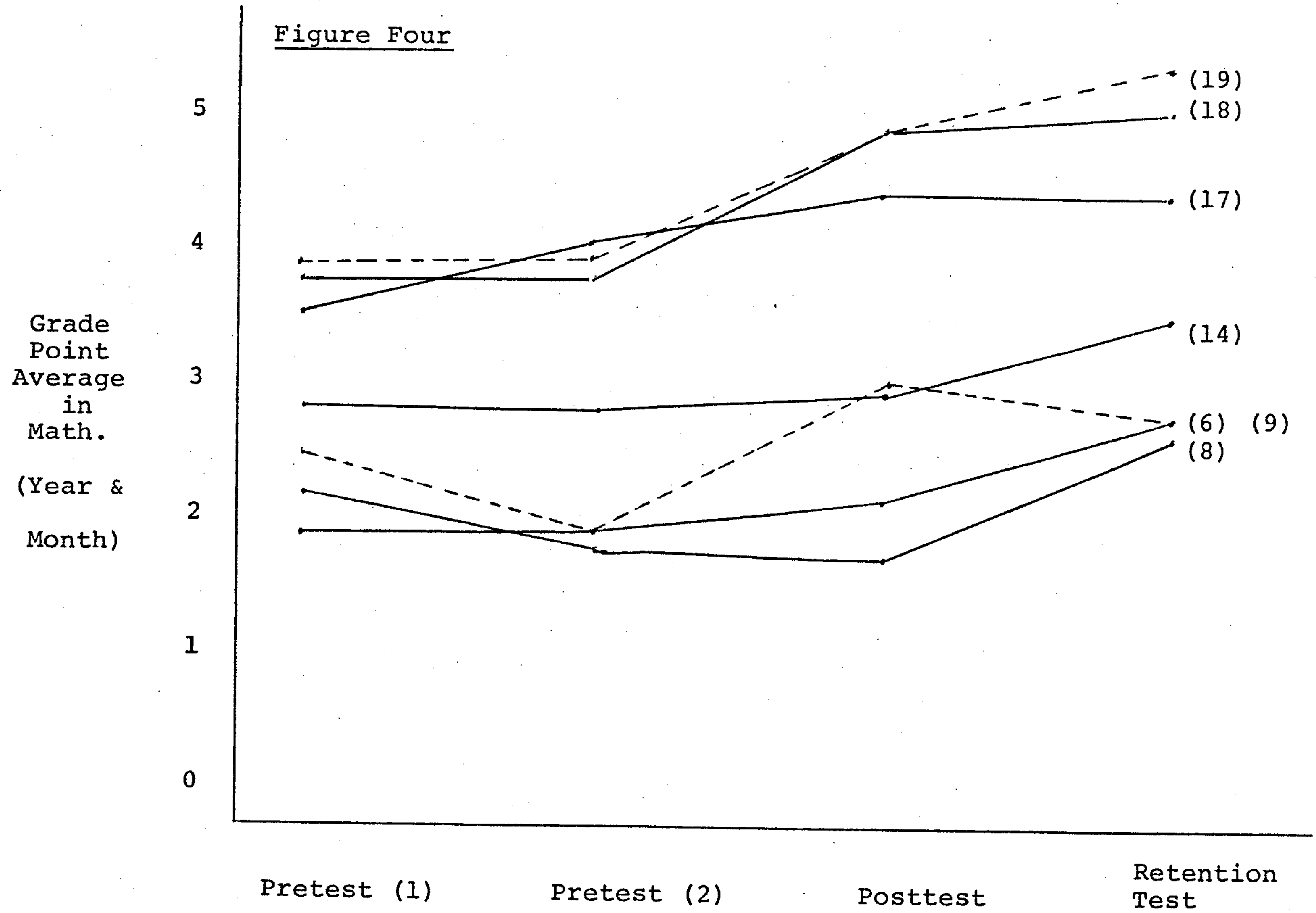
Some of the older students were told that eligibility for high school would be contingent upon good grades in all areas. Students 17, 18 and 19 showed large gains in mathematics. It was felt that these gains could be related to their aspirations for high school entrance.

Figure Three



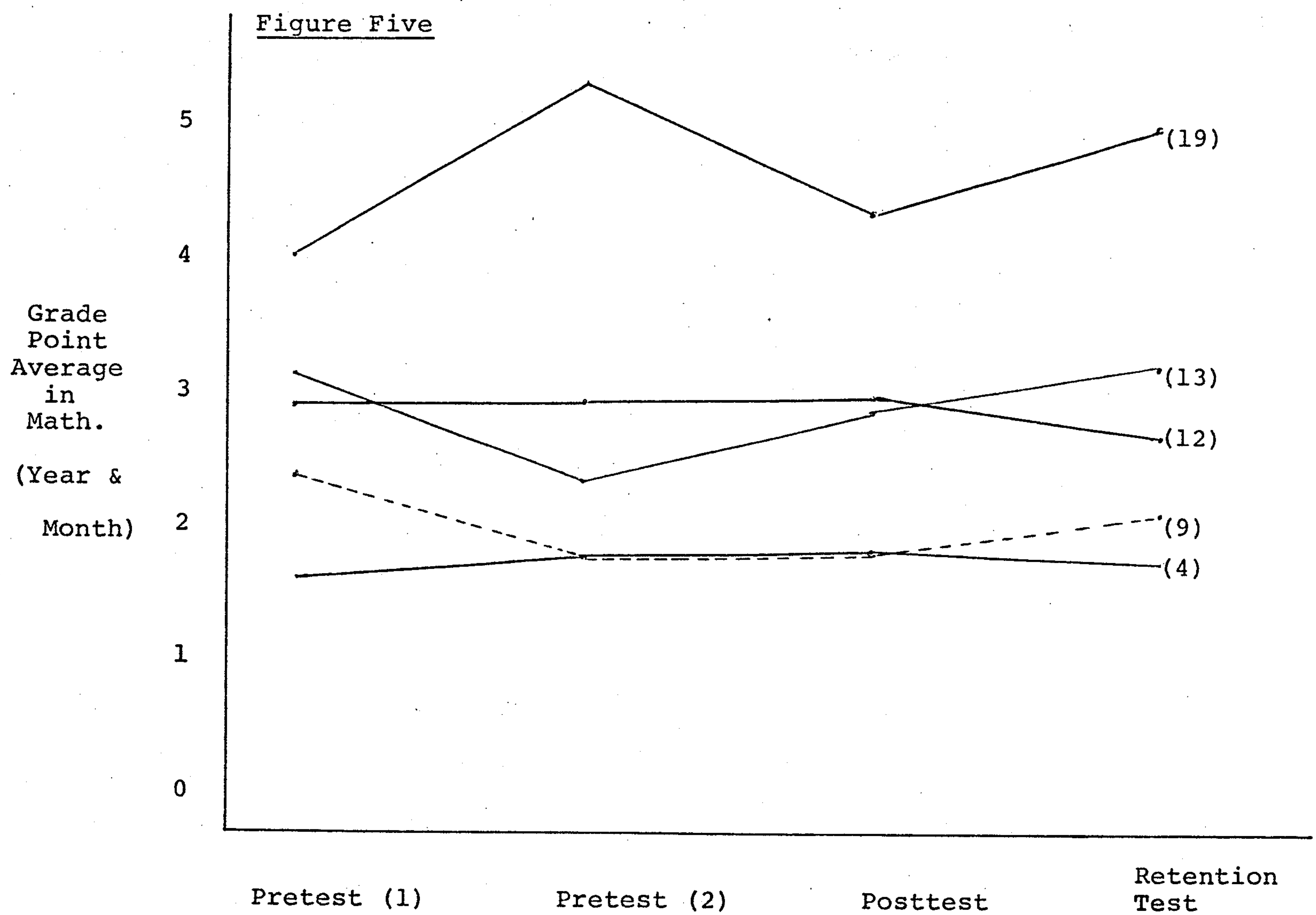
Learning Curves of Individuals Showing Gains (Experimental Group)

Figure Four



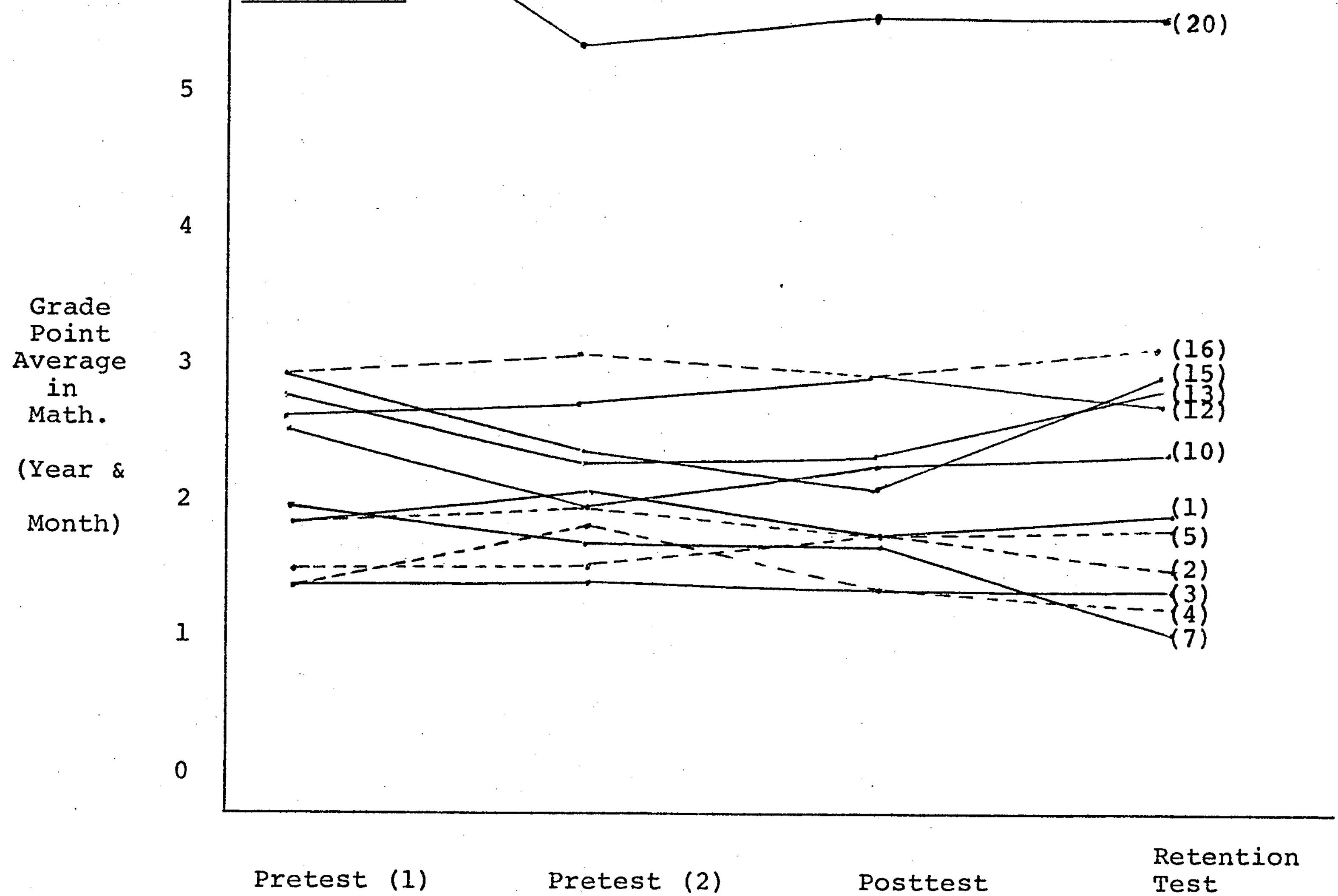
Learning Curves of Individuals Showing Gains (Control Group)

Figure Five



Learning Curves of Individuals Showing No Gain (Experimental Group)

Figure Six



Learning Curves of Individuals Showing No Gain(Control Group)