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COMPUTER ASSISTED LEARNING WITH LOW AND AVERAGE ACHIEVING GRADE FIVE AND SIX STUDENTS

by

James O. Bakken

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ABSTRACT

This study investigated the use of computer-assisted learning in mathematics as a drill and practice program for low and average-achieving grade five and six students. Students were divided into three general arithmetic achievement groups (low, average, high) by means of the computation subtest of the Metropolitan Achievement Test. Three groups of randomly selected students from the low and average achieving groups of students were assigned to a control, a tutorial, or a computer-assisted learning situation. All groups received regular classroom instruction. The computer-assisted learning group received additional computer-assisted learning programs for a period of three months at three twenty-minute periods each six-day cycle. The tutorial group received extra group tutoring in mathematics from a resource teacher for the same amount of time - three twenty-minute periods per six-day cycle for three months. The resource teacher used computer generated drill sheets for this tutorial program. The subjects were administered the Metropolitan Achievement Test (Arithmetic Computation Subtest) before (pretest 1, pretest 2), after (posttest) and two weeks after (retention test) the different learning programs.

The results showed that there were no significant differences in arithmetic achievement between the three groups. However, there was a significant difference over time for all

groups. The Newman-Keuls probing procedure was used for descriptive purposes to determine where the significant effects over time occurred. This procedure with the results of the combined group of students, and the low-achieving students, indicated that there were significant differences at the .01 level between pretest (1) and the post-test and retention tests, and between pretest (2) and the post-test and retention tests. The results of the average-achieving group of students differed in that the level of significance achieved between the means of the pretest (2) and the retention test reached only the .05 level instead of the .01 level. These results suggest that significant learning took place over time with all groups and that this can be said with more certainty in reference to the low-achieving students.

Further descriptive tests revealed that the control group of average-achievers did not show significance over time while the C.A.L. groups for both average and low-achieving groups showed the greatest gains over time.

The results of this study, while failing to demonstrate statistically significant differences between groups, have provided some statistical support in favour of C.A.L. as a useful educational tool especially when used with low-achieving students.

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CHAPTER I

INTRODUCTION

If the development of computers continues as it is at present, then it is clear that, as Martin and Norman (1970, p. 16) state in The Computerized Society:

> "Children starting school today are going to ... spend almost their entire working lives in a world markedly different from today, in which it will be at least as important to understand and communicate with computers as driving a car is today."

In the nine years since the statement above was made, computer-assisted learning (C.A.L.) has mushroomed. Patrick Suppes (1971) predicted that by 1980, about 15% of students in the United States at all grade levels will be in daily contact with a computer for some aspect of their instruction, especially in elementary reading and mathematics. Recently, Cunningham (1977, p. 450) reported that the American Institute for Research recorded that between 1970 and 1975 there was a 12.8% increase in the number of secondary schools that use the computer for both administrative and instructional purposes. Approximately 27% of those secondary schools surveyed used the computer in some way for computer-aided instruction.

Expansion of C.A.L. was made possible by the recent development in computer technology which has made the use of computers in education economically feasible. A second important reason for the expansion of C.A.L. is the growing amount of research which has indicated that Programmed Instruction (P.I.) and C.A.L. are effective methods of teaching arithmetic, language and reading skills. This research will be reviewed in the next chapter. Further, the interest in C.A.L. among teachers has contributed tremendously to this growth as it promises an effective form of individualization and an accompanying change of role for the teacher. As Hansen and Harvey (1969) point out, the teacher's role can potentially change towards involving more individual counselling, discussing, and diagnosing functions; and fewer correcting, lecturing, and disciplining functions. The advantages outlined above have been particularly attractive to special education teachers.

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, the physically handicapped, the hearing and visually impaired. Little of the research, however, has been conducted with intact classrooms in regular public schools or with locally prepared teacher-made programs. Therefore, there is a need to evaluate any new application of C.A.L. which attempts to assist slow learning and average learning students.

Objectives of the Study

Of particular interest, at the time this study was conducted (1976), was the effect of teacher-made C.A.L. programs on the academic achievement of low-achieving and average-achieving students. In attempting to make C.A.L. an effective educational tool, several questions must be asked:

1. Can C.A.L. be used effectively in a regular elementary school?
2. Is it more effective with low-achieving groups than average-achieving groups of students?
3. Are locally available C.A.L. programs sufficiently developed to be a valuable teaching aid in a modern elementary school?
4. Will the use of C.A.L. directly or as a tutorial aid effect student achievement?
5. Can any gains in achievement be retained after the experimental phase?

It is the thesis of this study that C.A.L. can be an effective and practical instructional tool for assisting teachers in providing the optimum individualized program for students with learning problems.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

A fundamental premise of education is that all children shall have the opportunity to develop the knowledge, skills and attitudes that will enable them to lead a satisfying and productive adult life. Educators have long sought ways to improve the educational process and to correct the school's past failures in providing the performance standards and appropriate learning activities which develop the full potential of each individual.

One innovation of recent years which shows great potential for furthering individualized education is computer-assisted learning (C.A.L.). Generally stated, C.A.L. is the use of a computer to provide or assist the instructional process. Specific uses of C.A.L. and definitions will follow shortly. First, however, in order to appreciate the potential of C.A.L. it is necessary to indicate some of its theoretical base. It is the merging of several developments in education and the utilization of newer media and technology which offers hope that C.A.L. will contribute to the general upgrading of education. Major developments were made in the psychology of learning and instruction; programmed instruction; computer-managed and computer-assisted instruction. Other contributing developments were: the articulation of behavioral objectives and the specification of learner goals; the development of diagnostic and criterion-references testing and flexible scheduling and staffing.

Computer Assisted Learning - Terminology

Computers in education have several specific applications. To avoid confusion this section will first mention briefly the use of computers across the field of education. This study however, is concerned with a narrower definition of C.A.L. as will be outlined shortly.

Hall (1971) lists the following four uses of computer-assisted instruction. He suggests that computers in education can be used in the following ways:

1. Laboratory Computing Device. Hall states that prior to 1971 as many as 500 high schools in the United States were making use of classroom terminals to allow students direct access to a computer.

2. Record Keeper and Retriever. Computers provide school and administrators with a very efficient system of recording and retrieving student data. This assists with student program planning, curriculum design and educational administration.

3. Simulation. The computer presents real-life situations or problems for students to solve. In this active problem-solving situation the student experiments with alternative solutions that would be too expensive or impractical in real life. Medical and space research has made extensive use of simulation.

4. Tutor. This is the most common use associated with the term C.A.L. The most common form of C.A.L. is as a tutor which provides drill and practice problems to a student at a terminal. A more complex view of C.A.L. as a tutor involves the terminal presenting a sequential exposition which provides the primary source of instruction for the student. In this form a relatively complete source is presented to the learner by means of a computer.

More recently researchers have considered tutorial systems and drill and practice systems as separate systems. Taylor (1974) distinguishes between the two as follows:

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 occurs 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.

This research is concerned with the use of C.A.L. drill and practice. For this purpose the description of drill and practice used by Fiorentino (1977, p. 5) is the most appropriate.

> "As a remedial tool to reinforce previously taught concepts, the computer has a never-tiring approach to the repetitious job of drilling concepts and checking answers. Often built into the drill and practice program can be checks as to whether the pupil has reached a criterion level of proficiency, before advancement to more difficult concepts is allowed. Thus drill and practice is a learning method using repetition of skills or facts on a random bases to help in the job of memorization."

More recently Computer-Managed Learning (C.M.L.) has been referred to in the literature. Finch (1972, p. 46) describes C.M.L. as a system for educational management that integrates student information, curriculum data, and information on resources in order to assist the teacher with individualizing instruction. A comprehensive approach utilizing C.A.L. and C.M.L. would go a long way in improving individualized education.

For the purposes of this research, the studies referred to will be those using C.A.L. as described above by Fiorentino (1977).

Psychology of Learning and Instruction

We have learned much about the teaching and learning processes from various teaching models developed in the past. Historical models such as the Socratic model or that developed by the Jesuits very early taught us the importance of following a teaching model if we are to influence learning.

More recently, the models presented by people such as Thorndike (1913), Gagne (1962), Flanders (1960), Carroll (1962) and Stolurow (1965) have stressed the point that a model is necessary if we are to keep all of the facts, concepts and principles of the teaching/learning processes organized. The modification of a basic teaching model (Glaser, 1962) by De Cecco (1968) has provided us with an uncomplicated, yet fairly adequate, conceptualization of the teaching process. De Cecco's model has divided the teaching process into four components: (a) instructional objectives (b) entering behavior (c) instructional procedures and (d) performance assessment. This model is important to the recent innovations in educational technology for two reasons. First, as mentioned earlier, a model allows us to organize the great body of facts, concepts and principles which make up any field of educational study. Second, adequate teaching models allow innovations such as educational television, programmed instruction and computer-assisted learning to take their proper place in the teaching/learning process.

Basic Learning Conditions and Instructional Procedures

Programmed instruction and computer-assisted instruction, as compared to educational television, are two recent educational innovations which have taken a model of teaching seriously. Both these methods have made an attempt to consider some of the basic conditions necessary for learning. De Cecco (1968, p.248) defines external conditions of learning to include the following: continuity, practice, reinforcement, generalization and discrimination. While all of these conditions are important to varying degrees in most learning, only the concepts of practice and reinforcement will be discussed in this paper. This discussion is important as it relates to one major use of C.A.L. -- drill and practice.

School subjects such as arithmetic and spelling provide good examples of the importance of practice rather than on initial presentation. Ausubel and Robinson (1969, p. 274) estimate that as much as 75 percent of al elementary school teacher's time is spent not in the initial presentation of new ideas, but in the arranging, conducting, and evaluation of practice sessions. In the first four years of arithmetic instruction, comprising more than 400 hours of work, students learn at most a few hundred number combinations. Most of the student's time is spent in rehersing these facts in various setting, committing them to memory and applying them in simple problem situations.

In applying his "Law of Exercise" to the study of arithmetic, E.L. Thorndike (1922, 1923) argued that the frequent coupling of a response, such as "5", with a stimulus, such as "3 + 2" would lead to the gradual strengthening of their connecting "bond" so that ultimately the stimulus would acquire the power of eliciting the response. Ausubel and Robinson (1969, p. 275) point out that as a result of his own research, Thorndike went on to revoke his Law of Exercise. He found that there was improvement in blindfolded subjects' performance on drawing three inch lines only when they were told after each trial the magnitude of their error. With this result, Thorndike (1931, 1932) concluded that the frequency of pairing the stimulus and response had in itself little or no impact on the learning process, and that its supposed influence must be attributed to reward or knowledge of results. This position, bolstered by other theorists (Guthrie, 1952) generally led to a distinterest in and denunciation of the value of drill (the most highly structured and repetitive kind of practice) and practice in general.

Many educators continue to minimize the value of drill and practice. In fact, the term "drill" evokes unsavory connotations with many educators. As a result, there is not a great deal of current research in this area. Drill and practice, however, are a necessary and indispensable part of classroom teaching. Stroud (1942, p. 362-364) states:

> "In appraising drill as a teaching procedure, it is well to remember that it is not mere repetition but repetition of the conditions of learning that is effective. Drill can be

> effective, ineffective, or positively detrimental; spirited or spiritless. Pupils do not necessarily learn just because they engage in drill ... In the best educational practice, pupils are engaged in drill after the need for it has been demonstrated."

Thorndike's (1931, 1932) observations that knowledge of results was as important as the frequency of pairing the stimulus and response led to considerable research on how this "feedback" would facilitate learning. The benefits of knowledge of results can be presented from a variety of theoretical orientations - reinforcement, motivational or purely cognitive grounds. In continuing with the behavioristic orientation of E.L. Thorndike (1931), many other theorists (J.G. Holland, 1960; Hull, 1943; Skinner, 1938, 1958) tend to attribute the effects of feedback largely to "reinforcement" or to the direct strengthening effect of drive-reduction on the responses that are instrumental in obtaining a reward and gratifying a drive. Informing the learner that a given response is correct presumably gratifies cognitive, affiliative and ego-enhancing drives motivating the response and hence, according to such theorists, increases the probability of its recurrance (that is, "reinforces" the response), (Ausubel and Robinson, 1969, p. 299).

More recent research on the benefits of the knowledge of results has answered questions on the importance of the completeness, the frequency and the immediacy of feedback. Ausubel and Robinson (1969, p. 301) provide a good review of this research.

As Stroud pointed out (1942, p. 362-364), drill and practice does not always insure that students will learn. He suggests that it is best used after the need for it has been demonstrated. This advice is still very appropriate whether traditional teacher instruction is being used or an alternative instructional medium such as C.A.L. is being employed. In this study, C.A.L. is an adjunct to regular teacher instruction. The planning of the sequence of materials and initial presentation of the material is handled by the teacher. The need for drill and practice is identified by the teacher and then the C.A.L. is used.

Individualization and Alternative Instructional Media

Educators, beginning in the late nineteenth century (P.W. Search, 1894), have been interested in the goal of individualization. Between 1920 and 1930 educators, influenced by the work of Frederick Burk (Brubacker, 1966) devised and implemented several laboratory-type plans for self instruction in the lower school. While these plans required a great deal of support and versatility on the part of teachers, they were self-pacing and concerned with individualized achievement. Further early interest came from the mental testing movement. Early intelligence tests (Binet, 1916) clearly demonstrated differences in speed of task completion among pupils, differences easily confirmed by a teacher's own observations. At the time, a great deal of individualized education took place in rural one-room schools. Twenty-five children spread unevenly through ages 6 to 14 necessarily committed the teacher to individual pupil direction, recitation and evaluation.

Unfortunately, population increases and school consolidations brought a number of educational practices which dampened the zest, enthusiasm and the obviousness of the need for individualized instruction. Large classes brought about "tracking" and "streaming" and many of the teaching practices that still generally connote "teaching" as an inherently "person-mediated" activity. Separating children into homogeneous classes according to measured mental ability within age groups is an educational practice still with us even though studies have conclusively demonstrated that this practice fails to increase the achievement level of groups as a whole (J. Goodlad, 1960).

During this same sixty years, a number of alternative instructional media were developed to supplement traditional classroom instruction -- instructional radio, instructional television, programmed instruction and most recently, computer-assisted instruction. The initial application of this alternative media was primarily at the university level and was directed at developing mass communication methods of instruction. Large group lectures and the adaption of closed-curcuit television are examples of alternative media initially being directed away from individualization.

Interest in individualization had a surge about 20 years ago when B.F. Skinner (1958) advocated an educational technology built around the use of teaching machines. Teaching machines at the time were basically linear series of questions and answers to word problems called "frames". Skinner's teaching machines and Pressey's (1926) earlier concept of immediate confirmation soon developed into "programmed instruction".

In discussing individualized tutoring and programmed instruction, Skinner (1958) outlines several important findings that are directly relevant to C.A.L. programs.

1. The most important aspect of instruction was the arrangement of the instructional material and not necessarily the teaching machine itself.

2. Instruction should begin where the pupil is and should not move beyond what the pupil can comprehend.

3. Instruction should move at a rate consistent with the ability of the pupil to learn.

4. There should be immediate positive reinforcement for correct responses and incorrect responses should be corrected immediately.

C.A.L. has great potential for furthering individualized education. Care must be taken however, to ensure that the experience gained by the work of Pressey, Skinner and others is not lost and that the theoretical base remains in all of the applications of C.A.L. in education.

The use of alternative instructional media has tremendous potential in the area of special education. In order to understand better the potential of C.A.L. in education, it is important to examine and review the literature associated with programmed instruction and C.A.L. with many different groupings of exceptional children as well as with regular educational programs.

<u>Programmed Instruction</u> (P.I.)

In 1926 Sidney Pressey, (N.C.T.M. 1973, p. 137) of Ohio State University, developed a device by which his students might be tested and shown the results immediately. Pressey's work remained relatively unknown in educational circles until the principle of immediate confirmation was exploited in the military trainers used during World War II. Since that time programmed instruction, whether presented by machine or text, has demonstrated its effectiveness in most areas of education. De Cecco (1968, p. 487) describes P.I. by listing four of its major characteristics:

1. The material is broken down into small steps (or frames).

2. Frequent response is required of the student.

3. There is immediate confirmation of right answers or corrections of wrong answers for each response the subject makes.

4. The content and sequence of frames were subjected to an actual tryout with students and were revised on the basis of data gathered by the program author.

Programmed Instruction and Special Education

Malpass (1966) demonstrated the effectiveness of P.I. in teaching reading to slow learning, culturally different young children. Students were divided into a control group (traditional instruction) and experimental group (teaching machine and programmed workbooks). There were significant gains in vocabulary development for the machine taught over control, and workbook over control.

P. Jacobs (1968) also demonstrated the effectiveness of P.I. with culturally different groups. Differences in mathematics achievement were eliminated between high and low ability students.

Leslie Malpass (1967) reported on the use of P.I. with educable mentally handicapped students. Students from institutions and public school systems were assigned to three matched groups. One group received instruction from a teaching machine, another from programmed workbooks, and another by conventional classroom methods. After 20 hours of instruction over five months on the same material the groups using the P.I. materials (machines and workbooks) showed significantly higher gains.

Other researchers have demonstrated the effectiveness of P.I. with many different groups of exceptional children. Holden and Roberts (1973) used P.I. and programmed tutoring with slow learners. Donald Eldred (1966) conducted a three-year investigation to determine the effects of P.I. with emotionally disturbed and under-achieving adolescents. Pfau (1974) in reporting on the GE/Life Program stated that the program was being well received by every population of the handicapped as well as the non-handicapped.

Programmed instruction has been the forerunner to C.A.L. and the implications of P.I. with exceptional children are closely related to the development of C.A.L.

Computer-Assisted Learning -- Related Research

P.I. and C.A.L. have several characteristics in common which account, in part, for their effectiveness. Sandals (1973) has listed eight points showing how the use of individualized instruction (both P.I. and C.A.L.) benefit the handicapped child in comparison to traditional methods of instruction.

1. Small logical steps. Information is presented in small steps so it is easy to master before going on to the next small step.

2. Self-pacing. Handicapped children learn to schedule their learning and pace themselves more constructively and thus can work at their own speed.

3. Active Student Participation and Immediate Feedback. A cause and effect relationship is established because if the student receives immediate feedback, he will respond actively in order to get the reinforcement again. Such active participation and reinforcement enrich the learning environment for the students.

4. Attention span. The use of small steps accommodates the shorter attention span of handicapped learners. Thus the students can leave an individualized instruction session and return later without having to re-read much of the material.

5. Reduction of emotional dependence. The use of individualized techniques helps the student by providing the feedback but without the emotional connotations, praise, attention, encouragement, sympathy et cetera, that are usually experienced in the handicapped student and teacher situation.

6. Patience of machine and program. The individualized instruction system does not upset the handicapped student emotionally. That is, it does not scold the student if he makes a mistake, and it never forgets to provide positive reinforcement when appropriate. Thus, the program establishes a consistent form of reinforcement which is not always true of the teacher.

7. Tutorial role of the teacher. The individualized instruction system frees the teacher of routine chores, and thus, enables him to establish a close rapport with each of his students.

8. Motivation. The handicapped student appears to be more highly motivated when working with individualized techniques in comparison to traditional teaching techniques. This increased motivation often is observed in the form of improved behavior. (Sandals, 1973, p. 36-38).

William Norris (1977) suggests that after industry, the next area where C.A.L. will become cost effective is in special education, which today is very costly. In discussing the PLATO system of C.B.E. he lists several advantages of C.A.L.:

> "...infinite patience, the epitome of personalization, nearly limitless versatility, and delivery of uniformly high quality. But it's much more than that. It's a knowledge, fact, information and educational delivery system of the first order, using many media and structures. It offers the promise of profound and beneficial impact on the delivery and application of knowledge in ways that free us from the fetters of an educational process virtually unchanged from the days of its great namesake teacher, Plato. (Norris, 1977, p. 452).

Norris' optimism for C.A.L. is supported by numerous research findings. While C.A.L. is effective in a number of subject areas, this review will focus specifically on C.A.L. and its application in arithmetic to low-achieving students.

C.A.L. and Mathematics Instruction

Computer-assisted instruction offers many advantages to the teaching of mathematics. Gibson (1971) summarized these as follows:

1. C.A.L. can provide highly individualized mathematical instruction to a number of pupils daily.

2. C.A.L. can perform an immediate analysis of the accuracy of pupils mathematical responses, making possible individualized instruction.

3. It can keep each pupil and his teacher informed of the individual pupil progress.

4. It can provide reports to the teacher on class performance and item reliability for use in daily planning. (Gibson, 1971, p. 11)

Patrick Suppes (1971) in reviewing C.A.L. programs developed at Stanford from 1963 to 1970, was optimistic about the continued potential of C.A.L. especially in the areas of elementary reading and mathematics. In 1975 Jamison, Suppes, and Wells concluded that although there were often no significant differences in achievement, drill and practice on the computer took less time and did not require an additional effort from the teacher. They also concluded that when small amounts of C.A.L. were used as a supplement, achievement appeared to improve, particularly for slower students.

Capasso and Lachat (1974) in a U.S. national survey of "math programs that work" state that C.A.L. demonstrates statistical evidence for its success at all grade levels. These authors provide a directory containing comprehensive descriptions of diagnostic-prescriptive mathematics programs used successfully in New Jersey School Districts.

The general effectiveness of C.A.L. drill and practice mathematics programs was reviewed by Henry Palmer (1973). Drill and practice programs were provided to elementary students in 14 districts of a Los Angeles county as a means of improving students' math abilities. Both the California Test of Basic Skills (C.T.B.S.) and the California Arithmetic Test (C.A.T.) were administered before and after to both the experimental group (C.A.L.) and the control group. In general, the results indicated that: 1) the mean post-test scores for the experimental group exceeded those of the control groups; 2) a higher percentage of experimental than control students exceeded their expected growth rates for the period; and 3) the students receiving C.A.L. experienced growth rates substantially beyond normal expectations. This program, at moderate costs, promoted student learning, reduced teacher's remedial work and aided in the diagnosis and prescription of student academic needs.

Generally, research on C.A.L. in larger centers show statistically significant differences in support of C.A.L. Jamison, Dean, and others (1971) found that elementary arithmetic programs developed by The Institute for Mathematical Studies in the Social Sciences at Stanford University, performed well with under-achieving children. The authors acknowledged the difficulty of making C.A.L. available in rural areas as well as urban areas.

Earlier, J. Prince (1969) had attempted to use the Suppes-Stanford C.A.I. Mathematics drill and practice programs in McComb, Mississippi, an area remote from where the programs were developed. The study reports significant educational differences between groups of children receiving C.A.L. and the control group which received only traditional instruction. The report states that the McComb School Administration, while agreeing that C.A.L. appeared to be a feasible way to close the gap between disadvantaged and more affluent youth, felt there were too many problems with C.A.L. to continue the program. Problems listed included the cost of the project, the lack of sufficient programs, the plurality of computer languages and the doubts as to its widespread implementation.

Other researchers are much more optimistic in their point of view, even though they do not get statistically significant results. Lynne Durward (1973) describes C.A.L. in arithmetic at South Hill Elementary School. Grade six and seven students were divided into three groups. The "computer group" each received 5 minutes of C.A.L. in arithmetic per day in addition to regular classes. The "help group" received five minutes of group instruction per day in addition to regular arithmetic classes.

The "zero group" received no additional instruction. Pre- and post-tests were administered. Results indicated that there were no statistically significant differences. An attitude questionnaire was also administered. The researcher reports however, that although not statistically significant, the results showed that C.A.L. improves arithmetic skills, and that C.A.L. in addition to regular instruction is superior to an equivalent amount of regular classroom instruction in improving arithmetic skills.

Not all studies of C.A.L. projects with elementary arithmetic have produced positive results. Abramson and Weiner (1971) reported negative results in evaluating the New York City C.A.L. Project in elementary arithmetic. The authors list the following possible reasons for why the drill and practice program was not successful. They were: 1) the students were exposed to about one-third the number of lessons originally intended, 2) the software did not appropriately compensate for individual differences, 3) achievement test results showed no consistent pattern favoring C.A.L. or non-C.A.L. groups, and, 4) the amount of drill and practice in C.A.L. and non-C.A.L. classes was not observably different. This study suggests that there is a continued need for research on C.A.L.

C.A.L. with Low-Achieving Students

Several research studies discuss the effectiveness of C.A.L. with low-achieving students. These will be presented to support the position that more research is necessary in this area.

Litman (1973) reported on a C.A.L. system that has been implemented in 21 elementary schools in Chicago. The system runs on a Univac 418-111 computer which processes concurrently the reading, language arts, and mathematics drill and practice strand programs of the Computer Curriculum Corporation. All students participating in the program qualified for compensatory education in that they were at least one year below grade level when entering the program. Results reported indicated that the program was very successful with students gaining nearly one month's academic gain for each month in the program. This was considerably better than the national average for compensatory education students, which this study reports as being 5.6 months for every 8 months of instruction. Litman, in the same report, states that teachers were freed from drill activities for more creative work.

Several studies indicate that more research is required. Demshock (1968) in examining C.A.L. use in teaching spelling to grade 5 and 6 students recommends that additional research is needed to study the use of C.A.L., particularly with low-ability students. Dunwell, Stephens and others (1972) concluded that C.A.L. was an efficient means of teaching spelling, that it was sensitive to individual needs, effective with weaker students and useful for remedial work. Shaw (1968) demonstrated the effects of three instructional strategies on achievement in a remedial arithmetic program. The three strategies presented via computer were drill, drill with feedback, and mixed drill. All strategies, including the control group, produced statistically significant differences on both the post-test and delayed post-test (retention test). The author suggests that these results indicate some effects other than those of the treatment may have been operating.

Fiorentino (1977, p. 30) summarizes twenty studies that involved C.A.L. and mathematics. His review, in general indicates that C.A.L. is most effective when it is used by pupils who are below grade level or more effectively for low ability pupils than for average or high ability pupils. Eighteen of the twenty studies reviewed reported that C.A.L. students achieved better than non-C.A.L. Fiorentino's summary(1977, p.30) is reproduced in Appendix A.

Computer-Assisted Learning in Manitoba

Since May of 1974 there has been an ongoing study in Winnipeg which investigates the uses of C.A.L. in schools having children and adolescents who have physical handicaps, hearing impairments, emotional or behavioral handicaps and/or learning problems. This study has involved eight different schools, each adapting the use of C.A.L. to the special needs of a handicapped group of students. Three of these studies will be reviewed. Hill (1976) investigates the use of C.A.L. with the physically handicapped, Fiorentino (1977) investigated the use of C.A.L. for pupils with learning disorders. Reeves is investigating the use of C.A.L. with children and adolescents with hearing impairments. A review of these studies is important to this study in that similar research designs and the same C.A.L. programs have been used. These studies have used the same C.A.L. programs through the use of remote terminals, they have shared the same program development staff and made use of similar inservice and training programs.

Hill (1976) reported on a two-year study of C.A.L. and the physically handicapped. During the first year of the project, the students and staff of the school were given a seven-month period of orientation during which staff and students were given training in computer use and C.A.L. programs were adapted to the unique needs of the physically handicapped students. A five-month study was then carried out in which two groups of randomly selected students were assigned to control and experimental situations. Both groups received regular classroom instruction in mathematics, and the experimental group received additional C.A.L. in mathematics for two days a week, for a period of three months. All students were administered the Stanford Achievement Test in mathematics before, during and after the C.A.L. sessions. Statistically, no significant differences were shown between the two groups. However, there were significant differences shown over time between the pre-tests and post-test, and pre-test and retention-test. Although statistical significance was not shown, Hill (1976) states that the educational relevance of the C.A.L. was apparent to teachers and administrators. Hill (1976) supports this educational significance graphically by displaying a seven-month gain for the experimental group during the three-month period versus a three-month gain for the control group during the same period. Hill (1976, p. 63) in presenting future considerations, questions the experimental design and suggests the use of an additional experimental group. This, she states, would provide a more robust model from which to draw more general conclusions.

Fiorentino (1977) reported on a study which investigated the effectiveness of using C.A.L. programs as a way of individualizing instruction for pupils with learning problems. The study took place from September 1974 to June 1975 in a junior high school which operates special education programs for pupils who have a long history of failure and difficulty in functioning in regular school programs. The sample of pupils included those who have specific learning disabilities, low mental ability, behavior disorders, social difficulties, and emotional and psychological problems.

As with the Hill study, students and staff went through a five-month orientation phase during which time students were familiarized with computer and C.A.L. programs were further adapted to provide appropriate drill and practice exercises for the basic skills needing to be improved. Seventy-five students were randomly selected to take part in the study. From this sample three groups of twenty-five were randomly chosen and randomly assigned to receive regular classroom instruction as well as C.A.L. treatments. One group received C.A.L. mathematics while the second group received C.A.L. in language arts. The third group received only regular classroom instruction. Assessments were made by using the Stanford Achievement Test in all three groups on pre-tests, post-test and a retention test. The study ran ten weeks during which time each treatment group received a fifteen-minute C.A.L. session once every two days. Each session was supervised by an older student proctor.

Fiorentino (1977) reports a significant difference between the three groups over time in their performance in math skills. The C.A.L. math group showed a five and one-half month gain in math skills for the three and one-half month period. The other two groups reported approximately zero gain in mathematics for the same period. There were no differences between groups as a result of C.A.L. language arts. Sandals (1976) in commenting on the non-gains with C.A.L. language arts suggests that at that time, available C.A.L. programs in language arts were inadequate and not as extensive as the math programs. Fiorentino (1977, p. 94) concludes in his study that pupils with learning problems can manage the use of a computer terminal and C.A.L. with very little help; that pupils with learning problems were able to improve their basic skills in arithmetic and spelling; and that C.A.L. is a promising means of individualizing instruction.

The third centre for the Winnipeg study is the Manitoba School for the Deaf, a combined residential day-school for severely and profoundly deaf students. C.A.L. has been used in this school since October, 1974. Several C.A.L. programs, especially in language arts, employing the Rhode Island Language Curriculum were developed. A formal study, using a similar experimental design as the studies by Hill and Fiorentino was conducted in 1976-77. The results provide further information on the effectiveness of C.A.L. in mathematics and language arts achievement with hearing-handicapped children.

Future studies of the Winnipeg project will report on the effectiveness of C.A.L. with trainable handicapped children and the study of the effect of information retrieval and management systems.

This thesis reports on the effect of C.A.L. on arithmetic achievement in low-achieving and average-achieving students. It reviews the experiment conducted at a fourth site of the Winnipeg Project in 1976.

CHAPTER 3

INVESTIGATION

The Problem

The research studies reviewed have demonstrated that C.A.L. is an effective method for teaching arithmetic skills to elementary school children. Both P.I. and C.A.L. have been shown to be effective with many kinds of exceptional children. At the same time however, most research studies suggest that C.A.L. is still in the initiation stage and many basic questions need to be asked. This is especially true of locally-prepared, teacher-made C.A.L. programs and the use of these programs in a regular elementary school.

The underlying problem represented in this study comes from the concerns indicated above. Can locally available C.A.L. programs have an effect on the arithmetic achievement of grade 5 and grade 6 students? More specifically, the questions to be answered in this study are:

1. Can the arithmetic computation skills of low and average achieving students be increased through the use of C.A.L. drill and practice exercises?
2. Can the arithmetic computation skills of low and average achieving students be increased through additional tutoring by a resource teacher using C.A.L. produced drill and practice materials?
3. Is C.A.L. more effective than additional tutoring from a resource teacher?

4. Can the skills gained by C.A.L. or extra tutoring from the resource teacher be retained over time after the experimental phase?

Research Hypothesis

If three randomly selected groups of low-achieving and average-achieving students received regular classroom instruction in mathematics and additionally received either;

1) extra help in mathematics from C.A.L.;
2) extra help in mathematics from a resource teacher using computer generated drill sheets, or;
3) no additional help;

then there would be a difference in performance of the three groups over time on a standardized achievement test in mathematics.

The Sample

The subjects in the study were fifth and sixth grade students attending Britannia Elementary School in the St. James-Assiniboia School Division. The school population totalled 433 students of whom 62 pupils were in the fifth grade and 84 pupils were in the sixth grade. All of the 162 grade five and six students from which the sample was drawn lived within the school area.

Britannia Elementary School is located in the eastern section of the St. James-Assiniboia School Division. The school neighbourhood is surrounded by a large industrial area to the north and a large commercial area to the east. The socio-economic status of the area is a mixture of working class and single parent families. There was not a disproportional number of immigrant or native/metis children in the neighbourhood. Grade five students were assigned to teachers on a ratio of 21 to 1. Grade six students were assigned to teachers on a ratio of 28 to 1. There were three special education teachers on staff: 1 resource teacher, 1 behavioral resource teacher, and one special class teacher (educable mentally handicapped). Special class students (E.M.H.) used C.A.L. programs but were not part of this study. Several disturbing and emotionally disturbed students were maintained in regular programs through the assistance of a behavioral resource teacher. These students were part of the study.

All grade five and six students (162) were initially tested twice with the Computation Subtest of the alternate forms of the Metropolitan Achievement Test, Intermediate form. Using the mean scores of these two pretests all students were then randomly assigned to groups of low-achieving students, average-achieving students or high-achieving students.

Low-achieving students for this study were defined as those students whose mean arithmetic achievement on the two pretests of the Metropolitan Achievement Test, Intermediate form was more than one year below the current grade placement. A similar definition was used by Litman (1973) when he studied C.A.L. in elementary schools in Chicago. Average-achieving students were defined as those students whose arithmetic achievement was plus or minus one year from their current grade placement. High-achieving students were defined as those students achieving more than one grade level above current grade placement.

Random assignment of students to experimental groups was then made by using a standard table of random numbers and the method outlined by Downie & Heath (1965, p. 121). High-achieving students were not included in this experiment and were used as proctors.

The subjects used for this study were those students whose scores on the Computation Subtest of the Metropolitan Achievement Test placed them in low-achieving or average-achieving groups. The subjects under study ranged from 10.1 years of age to 12.3 years of age with a mean age of 11.3 years. The subjects' I.Q. range, as measured with Lorge-Thorndike group tests, ranged from 84 to 116 (Appendix A). I.Q. scores were not available on eight subjects. There was very little confidence placed in the group I.Q. scores available for the students. Therefore, these were not a placement variable.

Thirty subjects from both the low-achieving group and the average-achieving group were randomly assigned to groups -- 20 in a control group, 20 in an experimental group (C.A.L.) and 20 in a second experimental group. A repeated T-Test was performed to insure that the means from the pre-test scores of the three groups were not significantly different (p .05).

Six of the subjects assigned to the control group were accidently assigned to a computer proctor group making them unsuitable as control group candidates. The control group dropped to N = 14 and the two experimental groups each had 20 participating subjects.

Subject information can be found in Appendix B. It should be noted that subjects 31, 32, 33, 34, 57 and 58 were removed from the control group for the reason stated above.

Limitations of the Sample

A number of limitations of the sample will be discussed. The generalization of results must be viewed in the context of these limitations.

All subjects in this investigation, prior to the formal investigation, experienced three and one-half months of familiarity training with the same computer terminal and related procedures. 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.

The general operation and scheduling of the regular school program put several constraints upon the study. During the early part of the study the school was subject to a major supervisory overview of all facets of the school's operation and instruction. While this should have effected all members of the control and experimental groups equally, it may have caused all teachers in the school to devote more attention and preparation time than normal, especially to low-achieving students. All students came from intact classes of students, therefore the scheduling of students to the C.A.L. program had to be secondary to regular school programs.

The control and experimental groups were randomly assigned. However, because of unique neighbourhood variables and school staffing variables the results could not be generalized to all low-achieving or average-achieving students in the Winnipeg area.

Instructional Programs

The programs that were used in this study were drill and practice programs in mathematics. These programs were all written and developed by teachers and were in the "BASIC" language. BASIC is a powerful high-level language that was used on a CDC 6500 computer at Cybershare Limited. Five programs in mathematics were used in this study. Examples of each program can be found in Appendix B. A short summary of each is as follows:

Addsub 1

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 program's objectives are:

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 in "borrowing" in subtraction.

Addsan

Addsan is a program that provides drill in addition for remediation. The program provides a choice of how many digits (from 1 to 5) in each number and how many numbers (from 1 to 5) with which the student requires practice. The objectives of the program are:

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.

Subsan

Subsan is a program that provides drill in subtraction for remediation. Problems with up to 5 digits in the top number are randomly generated. The objectives of this program are:

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 program that provides drill in multiplication. The student has a choice of the number of digits in the multiplication (1 to 6) and also a choice as to a fixed or random multiplier. The objectives of this program are:

1. To give the student drill in multiplication.
2. To provide programs which can be varied in their instructional level as the student progresses.
3. To provide a program which can also be used as a test.

Divide

Divide is a program that provides drill in division. The student has a choice of the number of questions to be done (1 to 15) from randomly generated questions. The student also has a choice of the number of digits in the divisor and divident or whether decimals are to be used. The objectives of this program are:

1. To give the student drill in division.
2. To give the student drill in division involving decimals.

Measuring Instrument

The Metropolitan Achievement Test (1970) -- Mathematics Computation subtest was used for all measures of arithmetic achievement throughout the study -- alternate forms of the test (F and G) were used for the first two pre-tests, scheduled one week apart. These same alternate forms were used again fifteen weeks later for the post-test and retention test. This test was used in this study because it was used in the division on a regular basis and therefore familiar to teachers and students. An examination of the questions in the mathematics computation subtest showed that they were very similar to the skills that are drilled on the computer programs. In general, Finley (Buros, 1972, p. 67) summarizes the Metropolitan Achievement Tests as follows:

> "To be applauded for scope, both vertical and horizontal, for the measurement of important outcomes, for careful standardization, for a clear and attractive format...this is a superior test series representative of the high quality and useability of modern achievement test."

Finley (Buros, 1972, p. 67) in the same review of the M.A.T. suggests cautions in interpreting the scores of "poor learners" due to the operation of chance grade scores.

The test was administered as directed in the Teacher's Directions by two resource teachers and the experimenter who assisted with the testing portion of this study. All testing was done in the first part of the morning using class periods which had been scheduled for either mathematics or language arts. Testing directions were reviewed prior to testing sessions and the testers were cautioned to be aware of student responses which would indicate excessive guessing, such as finishing the test quicker than was possible. All students in grades 5 and 6 regardless of whether they were a part of the study were tested on each occasion.

Apparatus - Computer Equipment and Facilities

The computer hardware used in this study was a CDC 6500 computer that was owned by the Province of Manitoba at Cybershare Ltd. The instructional terminal in the school was a model 33 hard-copy teletype which produced a carbon copy of all student work. The cost of the project was shared by the participating school divisions and the Manitoba Department of Education. A breakdown of the costs involved is in Appendix G.

The terminal was situated in a large classroom which served as a resource room for students in the intermediate grades. The terminal was partitioned visually from the instructional area of the classroom. Regularly scheduled tutorial programs took place in the same room although these students were not visable to the students using the terminal.

Administration and Procedure

The study began in October, 1975 and continued until June, 1976. The actual experimental phase using C.A.L. in mathematics began on February 15th, 1976 and continued for thirteen weeks. The pretesting and post-tests took place before and after this thirteen-week experimental phase. A complete schedule of the procedure is available in Figure One.

Introductory Phase

This phase was a very important part of the study. For four months prior to the experimental investigation students and teachers in the school had an opportunity to become familiar with the operation of the computer terminal. All teachers and the school administrators received a half-day inservice on computer-assisted learning and how the terminal operated. During this period all students from grades three to six had an opportunity to use a C.A.L. program. This was done to assure that experimental bias effects such as the Hawthorne Effect would be operating at a minimum during the experimental stage. This introductory period was necessary to allow the teachers sufficient exposure to and experience with C.A.L. so that it would be considered as an adjunct part of the school programs. The time was also necessary to train student proctors or volunteers and to modify the programs to fit the curricular needs of Britannia School students. Recording and charting procedures were established during these periods.

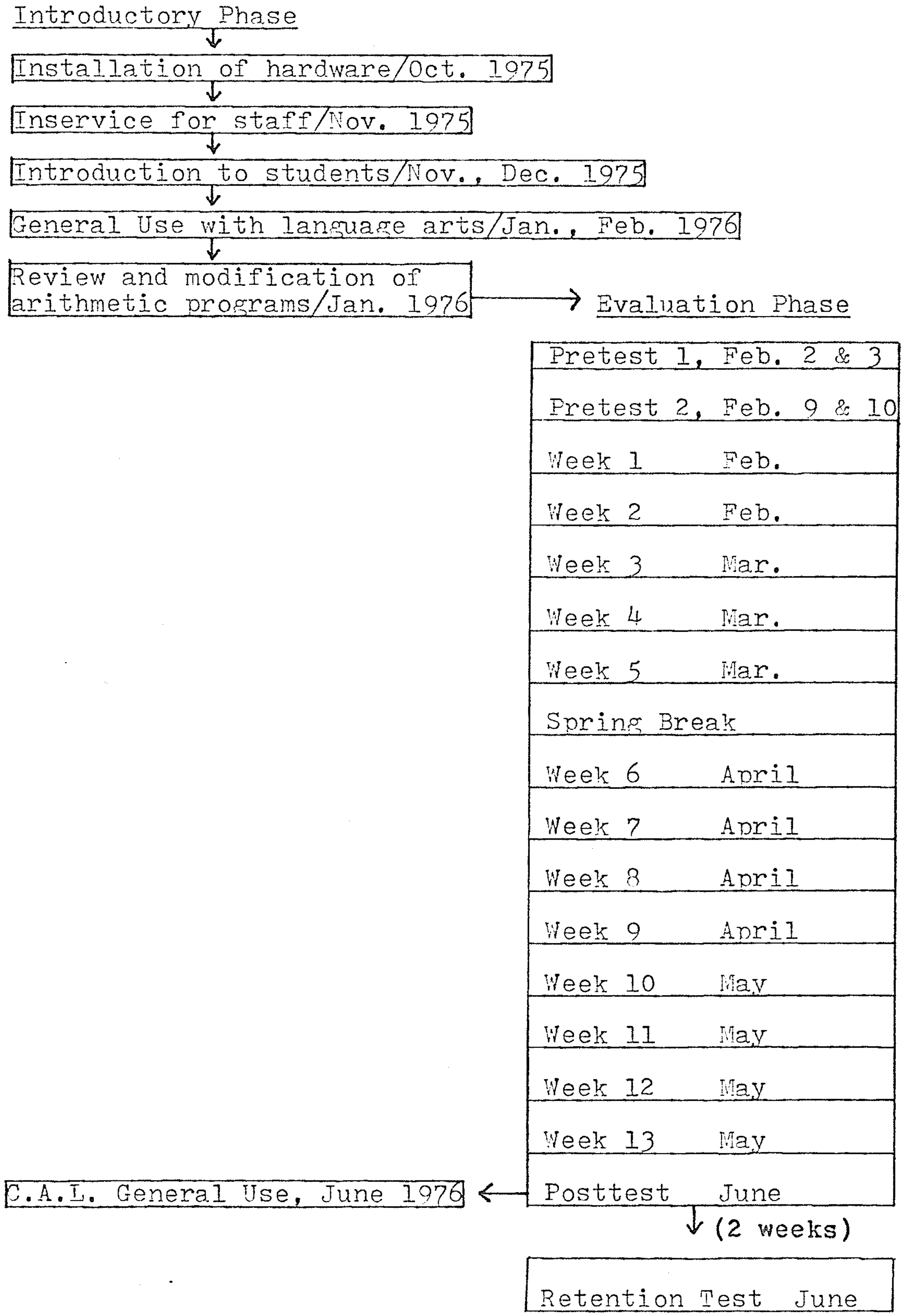
Experimental Phase - Pretest

All subjects were given two pretests. This was required to assure that all subjects were familiar with a formal testing situation.

The first pretest -- M.A.T. Computation Subtest Form F was administered on February 2 and 3 to all 64 grade five students and all 82 grade six students. The second pretest -- M.A.T. Computation Subtest Form G, was administered one week later on February 9 and 10. The tests were randomly assigned to the classes to be tested. All tests were scored by the experimenter.

Figure One

Flowchart of Procedure



Computer Scheduling Arrangements

Scheduling of computer time for those students in the C.A.L. group was arranged so that each subject received three or four fifteen to twenty-minute sessions per week. Variations in the school programming due to field trips, concerts, illness and computer failure resulted in students averaging approximately 3.2 sessions per week. During the 13 weeks of the investigation the students received from 37 to 45 sessions (averaging 41). Student proctors and the supervising teacher supervised the movement and logging in of subjects so that maximum use of the terminal was made. Students were scheduled so that they did not miss regular mathematics classes. Sessions missed due to special events were not made up. Caution was exercised to see that no student missed sessions on a regular basis. The times of C.A.L. sessions varied for each student.

Tutorial Scheduling Arrangements

Scheduling of tutorial time for those students in the tutorial group was arranged so that each subject received three twenty-minute periods of group tutorials per week. Subjects were provided with computer-generated drill and practice materials according to their instructional level. All materials were self-scoring with computer-generated answer keys. Tutorial sessions were held for subjects in groups of 10 students. These were always held in the afternoon. Sessions missed due to special events were made up. All tutorial subjects received three twenty-minute sessions per six-day cycle.

Instructional Level of C.A.L. and Tutorial Materials

Both C.A.L. and Tutorial programs were seen as adjuncts to the regular math programs designed jointly by the classroom teacher and the resource teacher. The resource teacher then chose C.A.L. programs or computer-generated drill and practice materials that best fitted the instructional needs of the student. C.A.L. programs were generally provided according to the hierarchial levels established for these programs by C. Hill (1975) (refer to Appendix H). However, it was not possible to follow this hierarchy faithfully as the individual needs of the student often dictated a different ordering of programs. Program selection was left up to the supervising resource teacher. A proficiency level of 90% at each level was chosen. This is supported by Johnson and Kress (1972) who state that an independent level of achievement no lower than 90% mastery should be used.

The C.A.L. group, the tutorial group and the control group all received the same amount of classroom mathematics instruction. This amount of time was equal to the Department of Education requirements.

Student proctors from high-achieving grade six groups assisted the C.A.L. group with "logging-in" and with filing student records. These student proctors were trained and supervised by the supervising resource teacher. The use of student volunteers to assist with student programs was not novel to this program, although the use of student volunteers for this extended period was unusual. This will be discussed later in the limitations of the study.

Post-test and Retention Test

The post-test was administered in the first week of June and the retention test was administered two weeks later. The procedures used for these tests were the same as the pre-tests. These tests were scheduled in the morning using mathematics or language arts classes.

Research Design

This study has employed a time series design. Campbell and Stanley (1966, p.37) state that the essence of the time-series design is the presence of a periodic measurement process on some group or individual and the introduction of an experimental change into this time-series of measurements, the results of which are indicated by the discontinuity in the measurements recorded in the time series. F. Kerlinger (1964, p. 317) has represented such time designs as follows:

Y1 Y2 X Y3 Y4

He continues, (1964, p. 317) stating that the most serious problem in this design is that of "history", that is, the specific events occurring between the measurements in addition to the experimental variable.

This major problem with this research design has been controlled for by the addition of a control group. This is represented as follows:

Y1 Y2 X1 Y2 Y4	(C.A.L. Group)
Y1 Y2 X2 Y3 Y4	(Tutorial Group)
Y1 Y2 Y3 Y4	(Control Group)

As mentioned by Kerlinger (1964, p. 318) the Hawthorne Effect could produce change in this research design. This has been controlled, in part, by having had C.A.L. programs functioning as an adjunct to regular programs for a period of four months prior to this experiment. All students and teachers in the school were exposed to C.A.L. prior to the beginning of the study.

Statistical Procedure

Analysis of Variance

The test for significant differences over the repeated measures of pretest (1), pretest (2), post-test and retention test administration was performed using a 3 x 4 Analysis of Variance for Repeated Measures design.

The following are the statistical hypotheses of the Analysis of Variance for Repeated Measures. Wine (1971) offers a complete explanation of these procedures.

1. Null Hypothesis

$$H_0 = \alpha_1 = \alpha_2 = \alpha_3 = 0$$

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

Alternative Hypothesis

$$H_1 = \text{not } H_0$$

If three groups of students are administered standardized achievement tests, both at the beginning and at the 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 groups vs. control group means).

2. Null Hypothesis

$H_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$

If three groups of students are administered standardized achievement tests both at the beginning and at the completion of the study, then there will be no significant difference between levels of factor B (over a period of time).

<u>Alternative Hypothesis</u>

$H_1 = \text{not } H_0$

If three groups of students are administered standardized tests both at the beginning and at the 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

$$_1B_1=\alpha_1\beta_2=\alpha_1\beta_3=\alpha_1\beta_4=\alpha_2\beta_1=\alpha_2\beta_2=\alpha_2\beta_3=\alpha_2\beta_4=\alpha_3\beta_1=\alpha_3\beta_2=\alpha_3\beta_3=\alpha_3\beta_4= 0$$

If three groups of students are administered standardized achievement tests both at the beginning and at the completion of the study, then there will be no significant differences between the experimental groups and control group treatment effects (means) in respect to mathematics scores over time.

<u>Alternative Hypothesis</u>

$H_1 = \text{not } H_0$

If three groups of students are administered standardized achievement tests both at the beginning and at the completion of the study, then there will be a significant difference between the experimental groups (C.A.L. and Tutorial) and control group treatment effect (means) in respect to the mathematics scores over a period of time.

A post hoc examination of the results was made by using an aposteriori multiple comparison test. The Newman-Keuls method was used for determining whether significant differences existed between the pretests, post-tests, and/or retention tests. Winer (1971) states that it is convenient to work with treatment means.

For each group then, using Newman-Keuls, the following means overtime were tested for significant differences at the .05 and .01 levels.

H_0		H_1
$\overline{X}_1 = \overline{X}_2$	(pre 1 = pre 2)	$\overline{X}_1 \neq \overline{X}_2$
$\overline{X}_1 = \overline{X}_3$	(pre 1 = post)	$\overline{X}_1 \neq \overline{X}_3$
$\overline{X}_1 = \overline{X}_4$	(pre 1 = retention) or	$\overline{X}_1 \neq \overline{X}_4$
$\overline{X}_2 = \overline{X}_3$	(pre 2 = post)	$\overline{X}_2 \neq \overline{X}_3$
$\overline{X}_2 = \overline{X}_4$	(pre 2 = post)	$\overline{X}_2 \neq \overline{X}_4$
$\overline{X}_3 = \overline{X}_4$	(post = retention)	$\overline{X}_3 \neq \overline{X}_4$

For descriptive purposes, the results were further investigated by using the test for simple main effects. Normally this would only be done if a significant interaction effect was indicated. However, due to the small sample size it was felt that this further investigation was warranted and would be valuable for descriptive purposes.

Also for descriptive purposes, the intercorrelations between the pretests (1) and (2), and the post-tests and between the pretests (1) and (2) and the retention test were calculated. These intercorrelations were calculated for the experimental groups (C.A.L. and Tutorial and control group). These scores will indicate whether the increased scores, if any, between pretests and post-tests could be attributed to overall treatment effects.

CHAPTER 4

RESULTS

The results of this study will be presented in this chapter. A discussion of these results will be presented in a later 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 and standard deviations can also be found in Appendix E.

Analysis of Variance, Combined Groups of Students

The Analysis of Variance summary table for combined groups of students can be found in Table One. For Hypothesis 1, the critical value needed for significance at the .05 level was 3.18 (df = 2,54). There was no significant difference between groups, therefore, Hypothesis 1 was accepted.

The critical value for Hypothesis 2 was 2.67 at the .05 level (df = 3,150). The F ratio was significant at the .05 level. Null Hypothesis 2 was therefore rejected and the Alternate Hypothesis accepted. This indicates that there was a significant difference between the means at the levels of factor B.

The critical value for Hypothesis 3 was 2.16 at the .05 level (df = 6,150). The F ratio was not significant indicating that there was no significant interactions. Therefore, Null Hypothesis 3 was accepted.

TABLE ONE

Analysis of Variance Summary Table

for Repeated Measures Design

Combined Groups

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (Treatment)	5.53	2	2.77	1.09
Subj. w groups	126.52	50	2.53	
B (Math scores)	33.82	3	11.27	35.64 *
AB	2.16	6	.36	1.14
BX subj. w groups	47.44	150		
TOTALS	216.30	211		

* p .05

Analysis of Variance, Low-Achieving Students

The Analysis of Variance summary table for low-achieving students can be found in Table Two. For Hypothesis 1, the critical value needed for significance at the .05 level was 3.40 (df = 2,24). There was no significant difference between the C.A.L. group, the tutorial group or the control group means. Thus Null Hypothesis 1 was accepted.

The critical value for Hypothesis 2 was 2.74 at the .05 level (df = 3,72). The F ratio was significant at the .05 level. Null Hypothesis 2 was therefore rejected and the alternative Hypothesis accepted. The computed F ratio revealed that there was a significant difference between the means of the levels of factor B, but does not indicate where the difference was.

The critical value for Hypothesis 3 was 2.23 at the .05 level (df = 6,72). The F ratio was not significant indicating that there was no significant interactions. Therefore Null Hypothesis 3 was accepted.

Analysis of Variance, Average-Achieving Students

The Analysis of Variance summary table for average-achieving students is found in Table Three. For Hypothesis 1 the critical value needed for significance at the .05 level was 3.42 (df = 2,23). There was no significant difference between the C.A.L. group, the tutorial group, and the control group means. Thus Null Hypothesis 1 was accepted.

The critical value for Hypothesis 2 was 2.74 at the .05 level (df = 3,69). The F ratio was significant at the .05 level. Null Hypothesis 2 was therefore rejected and the Alternative Hypothesis was accepted. Accepting the Alternative Hypothesis means that there was a significant difference between the means of the levels of factor B, but does not indicate where this difference was.

The critical value of Hypothesis 3 was 2.23 (df = 6,69). The F ratio was not significant indicating that there was no significant interactions. Therefore, Null Hypothesis 3 was accepted.

An aposteriori probing technique explained in the investigation section was used. The data for the Newman-Keuls procedure is presented in Tables Four, Five and Six. In each table in part (1) 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 the values found in step (i) are greater than, or equal to, the values found in step (iii) a significant difference is indicated.

Newman-Keuls Procedure with Combined Groups - Table Four

Levels of significance at the .01 level were found between pretest (1) and the post-test and retention test and pretest (2) and the post-test and retention test.

Newman-Keuls Procedure with Low-Achievers - Table Five

Levels of significance at the .01 level were found between pretest (1) and the post-test and retention test and pretest (2) and the post-test and retention test.

TABLE TWO

Analysis of Variance Summary Table

for Repeated Measures Design

Low-Achieving Students

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (Treatment)	1.99	2	1.0	1.46
Subj. w groups	16.42	24	0.68	
B (Math scores)	16.81	3	5.60	27.47 *
AB	0.67	6	0.11	0.55
BX subj. w groups	14.69	72	0.20	
TOTALS	51.18	107		

* p .05

TABLE THREE

Analysis of Variance Summary Table

for Repeated Measures Design

Average-Achieving Students

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (Treatment)	8.08	2	4.04	1.87
Subj. w groups	49.77	23	2.16	
B (Math scores)	18.33	3	6.11	13.76 *
AB	2.05	6	0.34	0.77
BX subj. w groups	30.64	69	0.44	
TOTALS	108.89	103		

* p .05

TABLE FOUR

Test on Means Using Newman-Keuls Procedure - Combined Groups

ordered means		b_1	b_2	b_4	b_3
		5.41	5.58	6.38	6.16
(i)		b_1	b_2	b_4	b_3
difference between means	b_1		.17	.97	.75
	b_2			.80	.58
	b_4				.22
	b_3				
(ii) studentized range statistic	9.95 (r,150)		2.80	3.36	3.69
	9.99 (r,150)		3.70	4.20	4.50
(iii) $S_{\overline{B}}$ = .10	$S_{\overline{B}}$9.95 (r,150)		.28	.34	.37
	$S_{\overline{B}}$9.99 (r,150)		.37	.42	.46
(iv)		Pre (1)	Pre (11)	Retention	Posttest
Pre (1)			----	**	**
Pre (11)				**	**
Retention					----

* p .05   ** p .01

TABLE FIVE

Test on Means Using Newman-Keuls Procedure - Low-Achievers

ordered means		b_2	b_1	b_4	b_3
		4.95	5.03	6.61	5.87
(i) differences between means		b_2	b_1	b_4	b_3
	b_2		.08	.66	.92
	b_1			.58	.84
	b_4				.26
(ii) studentized range statistic		9.95 (r,69)	2.83	3.40	3.74
		9.99 (r,69)	3.76	4.28	4.60
(iii) $S_{\overline{B}}$ = .10		$S_{\overline{B}}$9.95 (r,69)	.28	.34	.37
		$S_{\overline{B}}$9.99 (r,69)	.38	.43	.46
(iv)		Pre (11)	Pre (11)	Retention	Posttest
	Pre (11)		----	**	**
	Pre (1)			**	**
	Retention				----

* p .05   ** p .01

TABLE SIX

Test on Means Using Newman-Keuls Procedure - Average-Achievers

ordered means		b_1	b_2	b_4	b_3
		5.80	6.16	6.69	6.69
(i)		b_1	b_2	b_4	b_3
differences between means	b_2		.36	.89	1.10
	b_4			.53	.74
	b_3				.21
(ii) studentized range statistic		9.95 (r,69)	2.83	3.40	3.74
		9.99 (r,69)	3.76	4.28	4.60
(iii) $S_{\overline{B}} = .14$		$S_{\overline{B}}$9.95 (r,69)	.40	.48	.52
		$S_{\overline{B}}$9.99 (r,69)	.53	.60	.64
(iv)		Pre (1)	Pre (2)	Retention	Posttest
Pre (1)			----	**	**
Pre (2)				**	**
Retention					----

* p .05   ** p .01

Newman-Keuls Procedure with Average-Achievers - Table Six

Levels of significance at the .01 level were found between pretest (1) and the post-test and retention test. Levels of significance at the .05 level were found between pretest (2) and the retention test and at the .01 level between pretest (2) and the post-test.

Test for Simple Main Effects

For descriptive purposes, the test for simple main effects was used to answer the following questions:

(1) Is there a difference between a_1, a_2 and a_3 at b_1 or
a_1, a_2 and a_3 at b_2 or
a_1, a_2 and a_3 at b_3 or
a_1, a_2 and a_3 at b_4?

(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 or
between b_1, b_2 and b_3 and b_4 at a_3?

The questions above were asked of combined, low-achieving and average-achieving groups. The results are presented in Tables Seven, Eight and Nine. (Also refer to Appendix E)

The intercorrelations were calculated for the C.A.L. group, the tutorial group, and the control group for the combined groups of scores, the low-achieving students and the average-achieving students. These results are presented in Tables Ten, Eleven and Twelve.

Graphs of the results showing the mean scores of the C.A.L. tutorial and control groups can be found in Figures two, three and four. Graphs of the learning curves of individual subjects and an analysis of group data are presented in Appendix I.

TABLE SEVEN

Analysis of Variance Table for Simple Main Effects

Combined Groups

Source	SS	df	MS	F
1. Between Subjects:				
2. Between A at B_1	.13	2	.07	.08
3. Between A at B_2	.32	2	.16	.18
4. Between A at B_3	4.26	2	2.13	2.45
5. Between A at B_4	.77	2	.39	.87
6. Within Cells	173.98	200	.87	
7. Within Subjects:				
8. Between B at A_1	22.78	3	7.59	23.72 **
9. Between B at A_2	11.07	3	3.68	11.50 **
10. Between B at A_3	5.62	5	1.87	5.84 **
11. BX subject with groups	47.44	150	.32	

* p .05 = F critical = 3.18 (df = 2,50), 2.67 (df = 3,150)

** p .01 = F critical = 3.91 (df = 3,150)

TABLE EIGHT

Analysis of Variance Table for Simple Main Effects

Low-Achieving Students

Source	SS	df	MS		F
1. Between Subjects:					
2. Between A at B_1	.30	2	.15	$(\frac{2}{6})$	.47
3. Between A at B_2	.37	2	.19	$(\frac{3}{6})$	.59
4. Between A at B_3	2.04	2	1.02	$(\frac{4}{6})$	3.19
5. Between A at B_4	.28	2	.14	$(\frac{5}{6})$	.44
6. Within Cells	31.11	96	.32		
7. Within Subjects:					
8. Between B at A_1	8.90	3	2.97	$(\frac{8}{11})$	14.85 **
9. Between B at A_2	5.07	3	1.69	$(\frac{9}{11})$	8.45 **
10. Between B at A_3	3.83	3	1.28	$(\frac{10}{11})$	6.40 **
11. BX subject with groups	14.69	72	.20		

* p .05 = F critical = 3.40 (df = 2,24), 2.71 (df = 3,72)

** p .01 = F critical = 4.08 (df = 3,72)

TABLE NINE

Analysis of Variance Table for Simple Main Effects

Average-Achieving Students

Source	SS	df	MS	F
1. Between Subjects:				
2. Between A at B_1	.54	2	.27 $(\frac{2}{6})$	.31
3. Between A at B_2	.49	2	.25 $(\frac{3}{6})$	.29
4. Between A at B_3	2.74	2	1.37 $(\frac{4}{6})$	1.57
5. Between A at B_4	2.55	2	1.28 $(\frac{5}{6})$	1.47
6. Within Cells	80.31	92	.87	
7. Within Subjects:				
8. Between B at A_1	2.72	3	4.24 $(\frac{2}{11})$	9.64 *
9. Between B at A_2	6.90	3	2.30 $(\frac{9}{11})$	5.23 *
10. Between B at A_3	2.75	3	.92 $(\frac{10}{11})$	2.09
11. BX subject with groups	30.64	69	.44	

* p .05 = F critical = 3.42 (df = 2,23), 2.74 (df = 3,69)

** p .01 = F critical = 4.08 (df = 3,69)

TABLE TEN

Correlation Matrices for C.A.L., Tutorial and Control Groups - Combined Groups of Students

C.A.L. Group	1(Pre 1)	2(Pre 2)	3(Post)	4(Retention)
1 (Pre 1)	1			
2 (Pre 2)	.74**	1		
3 (Post)	.67**	.66**	1	
4 (Retention)	.72**	.75**	.75**	1

* p .05 critical = .30 df (38) df = N-2

** p .01 critical = .39 df (38)

Tutorial Group	1(Pre 1)	2(Pre 2)	3(Post)	4(Retention)
1 (Pre 1)	1			
2 (Pre 2)	.80**	1		
3 (Post)	.65**	.45**	1	
4 (Retention)	.77**	.51**	.85**	1

* p .05 critical = .30 df (38)

** p .01 critical = .39 df (38)

Control Group	1(Pre 1)	2(Pre 2)	3(Post)	4(Retention)
1 (Pre 1)	1			
2 (Pre 2)	.71**	1		
3 (Post)	.43*	.58**	1	
4 (Retention)	.54**	.74**	.64**	1

* p .05 critical = .38 df (26)

** p .01 critical = .49 df (26)

TABLE ELEVEN

Correlation Matrices for C.A.L., Tutorial and Control Groups - Low-Achieving Students

C.A.L. Group	1(Pre 1)	2(Pre 2)	3(Post)	4(Retention)
1 (Pre 1)	1			
2 (Pre 2)	.70**	1		
3 (Post)	.24	.2I	1	
4 (Retention)	.60**	.68 **	.48**	1

* p .05 critical = .44 df (18)

** p .01 critical = .56 df (18)

Tutorial Group	1(Pre 1)	2(Pre 2)	3(Post)	4(Retention)
1 (Pre 1)	1			
2 (Pre 2)	.71**	1		
3 (Post)	.11	.48	1	
4 (Retention)	.14	.20	.69 **	1

* p .05 critical = .44 df (18)

** p .01 critical = .56 df (18)

Control Group	1(Pre 1)	2(Pre 2)	3(Post)	4(Retention)
1 (Pre 1)	1			
2 (Pre 2)	.40(note)	1		
3 (Post)	.49	.24	1	
4 (Retention)	.37	.46	.65*	1

* p .05 critical = .53 df (12)

** p .01 critical = .66 df (12)

Note: Significant prior to the removal of contaminated control S's.

TABLE TWELVE

Correlation Matrices for C.A.L., Tutorial and Control Groups - Average-Achieving Students

C.A.L. Group	1(Pre 1)	2(Pre 2)	3(Post)	4(Retention)
1 (Pre 1)	1			
2 (Pre 2)	.66**	1		
3 (Post)	.72**	.58**	1	
4 (Retention)	.64**	.60**	.53**	1

* p .05 critical = .44 df (18)
** p .01 critical = .56 df (18)

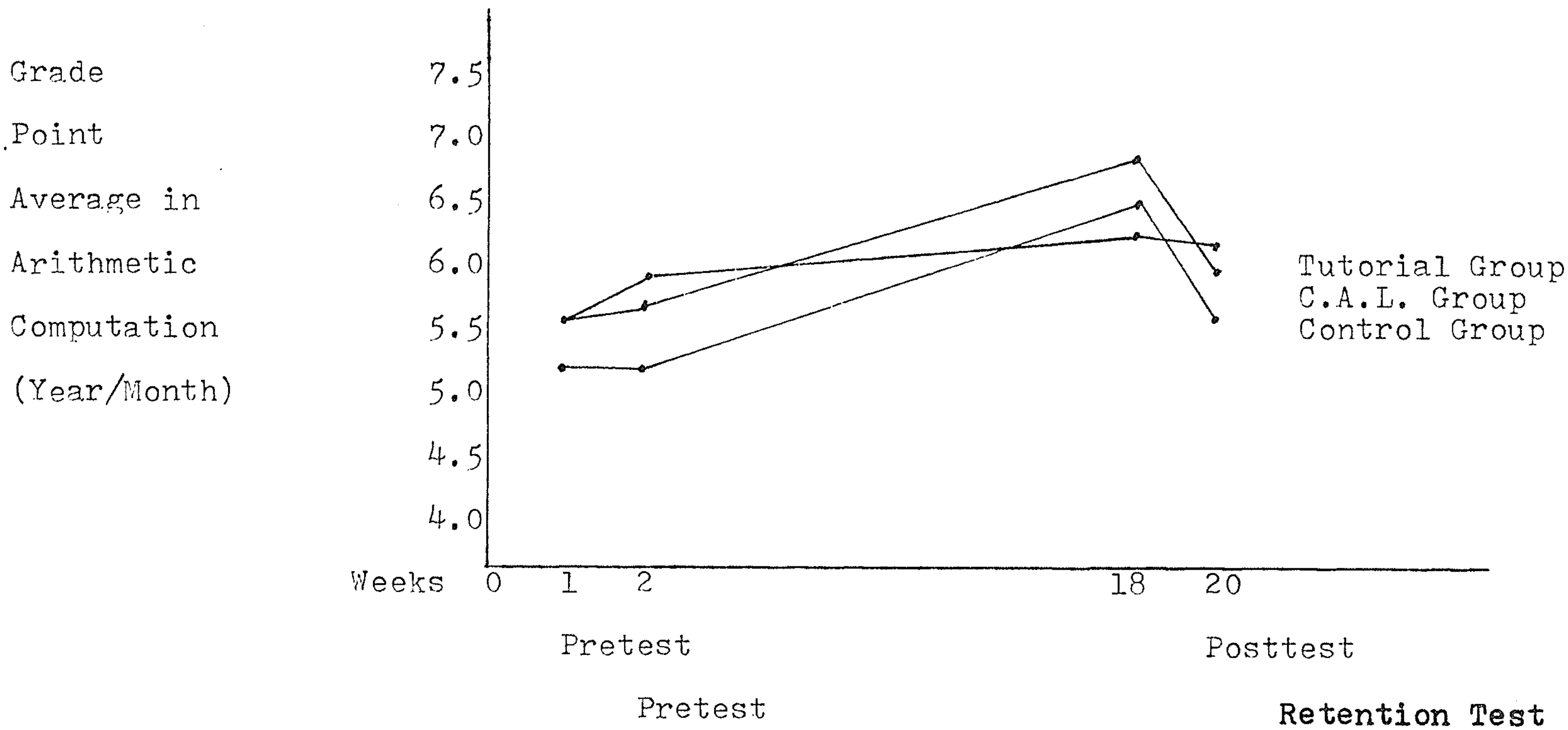
Tutorial Group	1(Pre 1)	2(Pre 2)	3(Post)	4(Retention)
1 (Pre 1)	1			
2 (Pre 2)	.55**	1		
3 (Post)	.62**	.01	1	
4 (Retention)	.32	-.03	.40	1

* p .05 critical = .44 df (18)
** p .01 critical = .56 df (18)

Control Group	1(Pre 1)	2(Pre 2)	3(Post)	4(Retention)
1 (Pre 1)	1			
2 (Pre 2)	.73 **	1		
3 (Post)	.49	.65	1	
4 (Retention)	.70**	.84**	.90	1

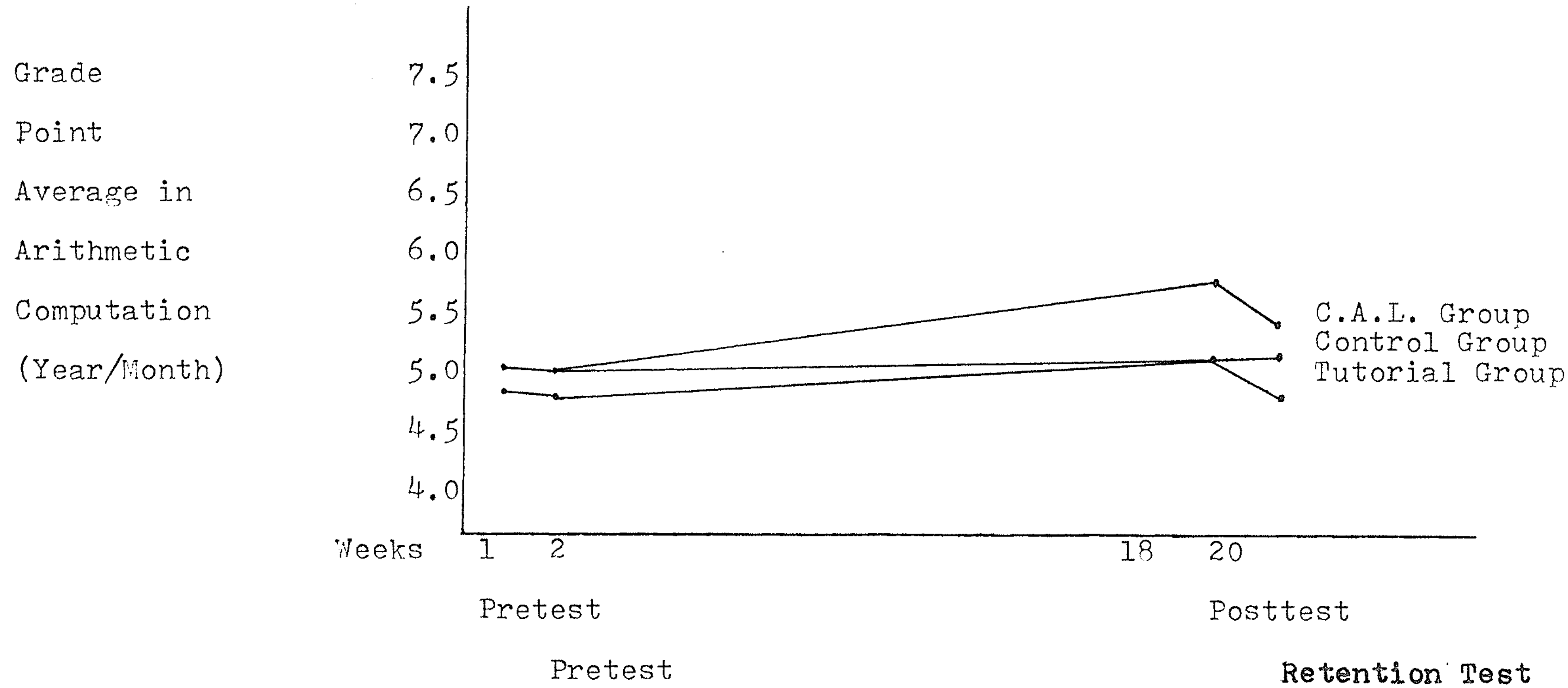
* p .05 critical = .53 df (12)
** p .01 critical - .66 df (12)

Figure Two



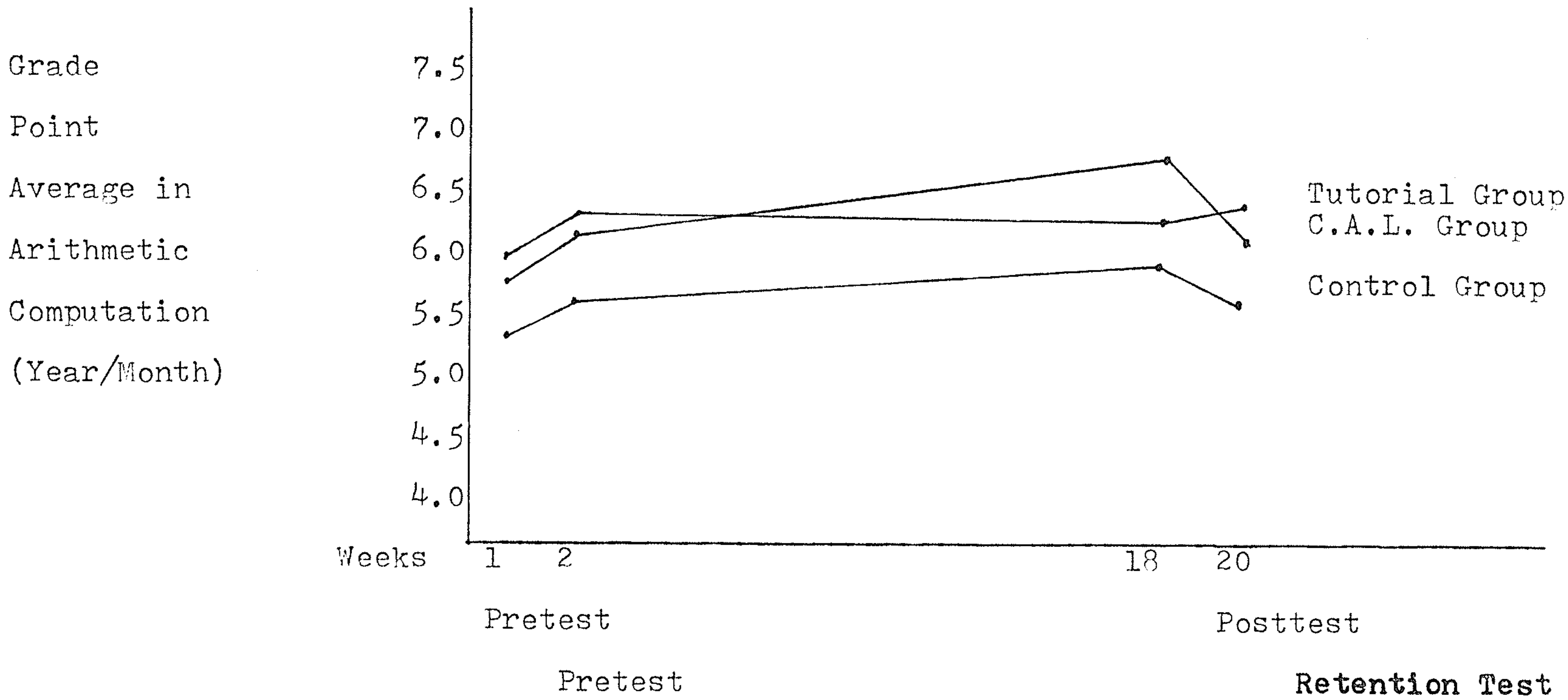
Mean Scores in Arithmetic Computation over a period of five months. Combined Average and Low-Achievers.

Figure Three



Mean Scores in Arithmetic Computation over a period of five months - Low-Achievers.

Figure Four



Mean Scores in Arithmetic Computation over a period of five months.
Average Achievers.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

With respect to the basic problem, this study has demonstrated that C.A.L. and computer-generated drill sheets can be a useful teaching tool to an elementary resource teacher. Both were seen as a practical and inexpensive way to provide remedial instruction to low-achieving and average-achieving students. This study, however, has failed to provide statistical evidence that locally produced C.A.L. programs can make statistically significant differences in arithmetic achievement in elementary grade children in comparison to the other experimental treatments used in this study. Further exploration of the statistical results do allow several supportive statements to be made about the educational significance of C.A.L. even though statistical significance was not demonstrated. This discussion follows in this chapter.

Statistical Analysis

For each ability grouping — the combined low and average achieving students, the low-achieving students and the average-achieving students — the null hypothesis$_1$ was accepted indicating that there was no significant difference between groups due to treatment effects. With each ability grouping null hypothesis$_2$ was rejected indicating that there was a significant effect over time. The null hypothesis$_3$ was accepted for each grouping indicating that there was no significant interaction.

The Newman-Keuls probing procedure was used to determine where the significant effect over time occurred. Results of the combined group of students, and the low-achieving students showed that there were significant differences at the .01 level between $pretest_{(1)}$ and the post-test and retention tests, and between $pretest_{(2)}$ and the post-test and retention tests. The results of the average-achieving group of students differed in that the level of the significance achieved between means of the $pretest_2$ and the retention test reached only the .05 level instead of the .01 level. The Newman-Keuls results suggest that significant learning took place over time with all groups and that this can be said with more certainty in reference to the low-achieving students.

The test for simple main effects was conducted for descriptive purposes. An examination of the results (Tables Seven, Eight, Nine) revealed that for combined groups of students and the low-achieving students, significant results over time occurred for the C.A.L. group, the tutorial group and the control group. The average-achieving group showed significant results at the .05 level for the C.A.L. and the tutorial groups only. The control group of average-achievers did not show significant gains over time. For the average-achievers then, the two experimental groups showed superiority over the control group when comparing group means over time.

Examination of the correlations (Tables Ten, Eleven, Twelve) reveals that gains in learning over the period of the study were not highly consistent. There are several possible reasons for this. Removal of results of contaminated control S's affected these results. Scheduling the post-test and retention test late in the academic year (June) may have produced low correlations between the post and retention tests. Overall, the results of the study did not show statistical significance. This failure to achieve statistical significance, while disappointing, does not mean that the results are not educationally significant. Examination of the mean scores over time reveals academic gains for all cases except for the control group of average achievers. This examination also showed that the groups receiving C.A.L. assistance made greater gains (Figures Two, Three, Four). Examination of the correlation matrices also indicated that there was greater consistency over time with the C.A.L. group. Individual scores of all subjects are graphed and discussed in Appendix I.

General Comment

As mentioned earlier, F. Kerlinger (1966, p. 317) states that the most serious problem in a time-series design of research is that of "history", that is, controlling the number of specific events that occur between the measurements in addition to the experimental variable. This study attempted to control for this problem by including "control" groups in the design. Unfortunately the number of variables affecting scores in elementary schools, do not seem to be controlled for by the simple addition of a "control" group. Therefore, in the opinion of this experimenter, uncontrolled "history" is the main problem of this research project. Statistical significance will continue to be difficult to achieve in using intact elementary school classrooms. However, it is in these settings that such questions need to be asked.

This study and previous research has shown that C.A.L. can be as effective as traditional instruction. In addition to this, several observations from this research suggest interesting educational implications.

Through the use of C.A.L. and computer-produced drill sheets, the resource teacher was able to provide remedial arithmetic drill and practice to forty students three times per week for three months while continuing with other assigned teaching duties. What has traditionally been a rather burdensome chore for both teacher and students became a much more meaningful, exciting exercise. Not required to provide this amount of necessary remedial drill and practice, the resource teacher was able to attend to the more professional duties of a teacher such as individual student programming.

The use of high-achieving students as "proctors" to assist with the daily operation of the computer terminal produced several interesting observations. The proctors were extremely responsible and responsive to their assigned duties. They were very excited and proud of their ability to explain, and assist with the calling up of computer programs. The proctors' attitude towards the project remained high for the duration of the project. Most interesting though, was the fact that their arithmetic achievement on the M.A.T. rose more than expected.

General teacher interest in this project developed slowly. All teachers and school administrators were provided with a one-day inservice prior to the experimental phase beginning and all classrooms of children in the school were given demonstrations of the programs. Significant teacher interest and concern for C.A.L. developed after the project demonstrated that a minimum of teacher effort would be required to operate the terminal. Interest was further developed after a demonstration that computer-generated drill sheets could greatly reduce the teachers' workload and free them for more professional involvement in the education of their students.

In presenting C.A.L. as an adjunct to regular classroom instruction, all the grade 5 and 6 teachers had to re-examine their present use of drill and practice exercises in the mastery of basic arithmetic skills. This consideration of the teaching/learning act is a positive result of C.A.L. which generally resulted in better individualized instruction throughout the school. Over time this increased awareness of the importance of proper drill and practice would contribute to the general effectiveness of C.A.L. by fostering a closer relationship between classroom instruction and C.A.L. drills.

Implications and Future Considerations

The results of the study showed that C.A.L. can be a powerful educational tool for teachers. While this study failed to show statistical significance, it did demonstrate that C.A.L. can operate usefully as an adjunct to regular classroom instruction. The study has however, pointed out several limitations both of research design and terminal operation.

Reference has already been made to the problem of a time series design experiment. An alternative research model should be investigated. Perhaps, a design employing a N=1 form might be most productive for in-school research. Individual scores of all subjects are graphed and discussed in Appendix I.

More emphasis should be placed on demonstrating educational significance rather than statistical significance. This would be possible through the use of criterion-referenced assessments rather than norm-referenced achievement tests. Criterion-referenced student assessments would strengthen the use of C.A.L. by allowing the instructors to match C.A.L. drills more closely to needed areas of instruction.

Further studies employing a time-design should pay close attention to scheduling. While a full three months is necessary for the "treatment" phase, having the post-test and retention test occur during the month of June is a mistake. The test-taking ability of elementary school students does not appear quite as productive as it is at other times of the year. Final scheduling of tests had to accommodate track and field days and field trips. These events may have affected student achievement, particularly on the retention test.

The information retrieval system which became available after the conclusion of this experiment will greatly aid the teacher in the maintenance of student records and in planning student programs. This information system will assist future research in this area.

Scheduling of students on C.A.L. would have been much more effective had two or more teletype terminals been available. Whether this would have improved academic achievement is another research question, but certainly more access to C.A.L. programs would have assisted in the operation of the program.

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 groups due to different treatments. This was true in all cases: low-achieving students, average-achieving students, and the combined group. Significant differences over time were found with all groups: C.A.L., tutorial and control group, with both low-achieving and average-achieving students. Null hypothesis (2) was therefore rejected. The aposteriori Newman-Keuls technique showed the differences to be between pretest (1) and the post-test and retention test, and between pretest (2) and the post and retention tests. Used for descriptive purposes, the test for simple main effects indicated that with average-achieving students there was a significant gain over time by the C.A.L. and the tutorial groups, but not by the control group. The test for simple main effects indicated that with low-achieving students there was a significant gain over time for all groups but the greatest gain was made by the C.A.L. group.

This study has used locally produced C.A.L. drill and practice programs with intact classes of grade five and six students. This will make this study educationally relevant to teachers wishing to use C.A.L. While failing to demonstrate statistical significance in favour of C.A.L. or computer-generated drill sheets, it does provide supportive observations which suggest that C.A.L. is of definite benefit to arithmetic achievement. Interest in computer-assisted learning remained high throughout the project and continued to be a source of motivation for both low-achieving and average-achieving students.

Since the completion of this study, there are now many more C.A.L. programs available in a wider range of activities both in mathematics and language arts. These will contribute greatly to the effectiveness of computer-assisted learning.

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APPENDIX A

Studies That Involve C.A.L.

APPENDIX A

Studies That Involve C.A.L. in Mathematics

- (Fiorentino, 1977)

STUDY	MODE	SUBJECT	GRADE LEVEL	RESULTS**
Arnold (1970)	Drill & Practice	Arithmetic	3 - 6	+
Carlson & Others (1974)	-	Arithmetic	1 - 6	+
Crawford (1970)	Drill & Practice	Arithmetic	7	=
Davies (1972)	Drill & Practice	Arithmetic	2 - 6	+
Durward (1973)	Drill & Practice	Arithmetic	6 - 7	+
Gibson (1971)	Drill & Practice	Arithmetic	7	+
Hill (1976)	Drill & Practice	Arithmetic	3 - 6 Handicapped	+
Jacobson (1975)	Drill & Practice	Arithmetic	4 - 5	+
Jamison & Others (1973)	-	Arithmetic	5,6	+
Knutson & Prochnow (1970)	Drill & Practice	Math (Money)	*E.M.R.	+
Palmer (1973)	Drill & Practice	Arithmetic	3 - 6	+
Perry (1973)	Mixed	Consumer Arithmetic	secondary	+
Prince (1969)	Drill & Practice	Arithmetic	1 - 6	+
Romans (1974)	Mixed	Mathematics	-	+
Sandals (1973)	Mixed	Maths & Social Skills	*E.M.R.	+
Scrivens (1970)	Drill & Practice	Arithmetic	3 - 6	+
Street (1972)	Drill & Practice	Arithmetic	3 - 7	=
Suppes & Morningstar (1969)	Drill & Practice	Arithmetic	2 - 6	+
Suppes & Morningstar (1972)	Drill & Practice	Arithmetic	3	+
Suppes & Others (1973)	-	Arithmetic	elementary & secondary (deaf)	+

*E.M.R. refers to educable mentally retarded children.
**In this and subsequent tables a "+" indicates that the C.A.L. students achieved better than non-C.A.L. A "-" indicates that C.A.L. students did less well, while "=" indicates the same level of achievement.

APPENDIX B

Summary Data - Subject Pool

APPENDIX B

Summary Data - Subject Pool

SUBJECT	SEX	AGE	GRADE LEVEL	TEST/DATE/IQ
1	F	10.6	5	LT/74/94
2	M	10.6	5	LT/74/99
3	M	10.1	5	-
4	M	10.4	5	LT/74/104
5	F	10.7	5	LT/74/89
6	F	10.8	5	LT/74/83
7	M	10.2	5	WISC/75/96
8	M	10.4	5	LT/74/108
9	M	11.2	5	LT/74/106
10	F	10.1	5	-
11	F	11.9	6	LT/73/94
12	F	11.3	6	LT/73/101
13	M	11.4	6	LT/73/107
14	M	11.3	6	LT/73/94
15	F	11.3	6	OTIS/73/88
16	M	11.6	6	LT/73/89
17	F	11.4	6	LT/73/102
18	M	11.8	6	LT/73/116
19	F	12.3	6	OTIS/73/112
20	F	11.2	6	LT/73/97
21	M	10.2	5	LT/74/101
22	F	11.3	5	LT/74/104
23	M	10.8	5	-
24	M	10.4	5	-

APPENDIX B (cont'd)

Summary Data - Subject Pool

SUBJECT	SEX	AGE	GRADE LEVEL	TEST/DATE/IQ
25	F	10.6	5	-
26	F	10.3	5	OTIS/73/113
27	F	10.3	5	LT/74/116
28	M	10.4	5	WISC/74/88
29	M	10.3	5	LT/74/84
30	M	10.9	5	LT/74/89
31*	F	11.1	6	-
32*	F	12.2	6	LT/73/108
33*	F	11.4	6	LT/73/84
34*	M	11.2	6	LT/73/83
35	M	11.8	6	LT/73/106
36	F	11.7	6	LT/73/96
37	M	11.4	6	OTIS/74/111
38	M	11.1	6	LT/78/94
39	F	11.8	6	LT/73/94
40	M	11.6	6	LT/73/89
41	M	10.4	5	LT/74/97
42	M	10.6	5	OTIS/73/104
43	M	11.2	5	WISC/74/96
44	F	11.4	5	LT/74/88
45	M	10.9	5	LT/74/101
46	F	10.8	5	LT/74/112
47	F	10.8	5	LT/74/84
48	F	10.8	5	-

APPENDIX B (cont'd)

Summary Data - Subject Pool

SUBJECT	SEX	AGE	GRADE LEVEL	TEST/DATE/IQ
49	M	10.4	5	LT/74/116
50	F	10.4	5	LT/74/97
51	M	11.2	6	OTIS/72/112
52	M	12.3	6	LT/73/88
53	F	11.8	6	-
54	F	11.6	6	LT/73/84
55	F	11.8	6	LT/73/106
56	M	11.2	6	LT/73/96
57*	F	11.4	6	PPUT/75/84
58*	M	11.4	6	LT/73/89
59	F	12.2	6	LT/73/101
60	M	11.1	6	LT/73/110

*Subjects removed from control group.

APPENDIX C

Sample Computer Program Output

```
DO YOU WANT TO DO ADDITION ('+') OR SUBTRACTION ('-') ? ADDITION

PLEASE ANSWER WITH EITHER '+' OR '-'.

DO YOU WANT TO DO ADDITION ('+') OR SUBTRACTION ('-') ? +

SMALLEST POSSIBLE SUM (FROM 1 TO 18)? --5

LARGEST POSSIBLE SUM (FROM  5  TO 19) ? 15

HOW MANY QUESTIONS (FROM 1 TO 20) DO YOU WANT ? 5

TYPE IN YOUR FIRST NAME HERE? DAVID
TYPE IN YOUR LAST NAME HERE ?

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

HELLO DAVID. TRY ADDING THESE PROBLEMS.


      5
      9
------
  ? 14
      <DAVID


     11
+     1
------
  ? 12
      <DAVID


      8
+     4
------
  ? 12
      <DAVID


      8
+     1
------
     9
      <DAVID
```

```
DRILL NUMBER    DISCRIPTION
   1            ADDITION
   2            SUBTRACTION
   3            MULTIPLICATION
   4            ADDITION, SUBTRACTION AND MULTIPLICATION

WHICH DRILL DO YOU WANT(1,2,3 OR 4) ? 1

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

HOW LARGE AN ANSWER (1-99) DO YOU WANT TO WORK WITH ? 99

WHAT IS YOUR FIRST NAME ? BERNIE

HELLO BERNIE, WHAT IS YOUR LAST NAME?

WELL BERNIE, WE ARE GOING TO WORK WITH MISSING NUMERALS

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


1)IN EACH PROBLEM THERE WILL BE A MISSING NUMBER
2) FIGURE OUT WHAT MISSING NUMBER WILL MAKE THE
  PROBLEM RIGHT.
3) WHEN THE MACHINE STOPS TYPE IN THE MISSING NUMBER
4) THE SIGNS I WILL USE ARE: ADD(+); SUBTRACT (-);
   AND MULTIPLY (X).

HERE IS AN EXAMPLE....


 9   +  (  )  =   47
(  )=? 38


OK BERNIE, LET'S GET STARTED....



(  )  +   14  =   81
(  ) =? 77
 THAT IS NOT RIGHT BERNIE

(  )  +   14  =   81
(  ) =? 67

CORRECT BERNIE

 67 + 14 = 81 IS THE CORRECT ANSWER
```

```
HI, THERE. WHAT IS YOUR FIRST NAME? DAVID

WHAT IS YOUR LAST NAME, DAVID ?

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? 5

HOW MANY DIGITS (FROM 1 TO  5 ) DO YOU WANT IN THE
NUMBER THAT YOU DIVIDE BY ? 2

                   -------
       26        )  73710

= ? 2835

EXCELLENT, DAVID. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS  2835 .

                   -------
       55        )  76945

= ? 13145

NO, DAVID. THAT IS WRONG. THE ANSWER IS  1399 .

                   -------
       21        )  87024

= ? 1-4144

VERY GOOD, DAVID. THAT IS CORRECT. THE ANSWER IS  4144 .

THE DRILL IS OVER, DAVID.

NUMBER OF PROBLEMS ATTEMPTED:  3

NUMBER OF PROBLEMS CORRECT:  2
```

STUDENT REPORT LISTING

THE FOLLOWING SECTION WILL DESCRIBE HOW THE TEACHER IS TO OBTAIN A REPORT LISTING

THE FOLLOWING UNDERLINED STATEMENTS MUST BE TYPED

```
BATCH
SRFL,20000.     -- SYSTEM RESPONSE

/CALL,LIST***   -- THE ASTERISKS (***) REPRESENT THE
                   SCHOOL CODE.
```

NB. *** THERE MAY BE A DELAY OF UP TO A MINUTE BEFORE
*** THE SYSTEM CONTINUES WITH THE REST OF THE
*** RESPONSE. THIS IS DUE TO THE FACT THAT SEVERAL
*** PROGRAMS MUST BE EXECUTED BEFORE THE LISTING.

```
*** THE TEMPORARY FILE IS BEING SORTED ***

*** THE TEMPORARY FILE IS BEING MERGED ***
```

NOTE AT THIS POINT YOU HAVE ENTERED THE LISTING PROGRAM AND YOU WILL BE ASKED QUESTIONS DEPENDING ON THE TYPE OF LISTING YOU WANT.

HERE ARE EXAMPLES OF THE TWO TYPES OF LISTNGS

```
PROGRAM   SENPATI

DO YOU WANT FULL DATA (F) OR SHORTENED DATA (S) ? S

PLEASE ENTER FOUR VALUES (TYPE 31,31,F,D FOR FULL DATA).
? 1,1,RUNNEYMEDE.

IS THIS YOUR CORRECT NAME ?    RUNNEYMEDE              ? YES

DRILL (1)  LEVEL 1, PAST TENSE, TOPIC A


 ( 1 )  THE FIREMAN STOPPED

WHAT IS THE VERB  ? STOPPED

    <  TERRIFIC THINKING RUNNEYMEDE


                              THE FIREMAN STOPPED
                              ----------- =======


WHAT SENTENCE PATTERN IS THIS ? 1


    <  YOU ARE RIGHT RUNNEYMEDE


CONGRATULATIONS RUNNEYMEDE       YOU HAVE COMPLETED THE DRILL.
WOULD YOU LIKE TO TRY ANY MORE PROBLEMS ? NO

                               ***  WORK COMPLETED TODAY  ***

NUMBER OF ANSWERS RIGHT =  2
NUMBER OF ANSWERS WRONG =  0
PERCENTAGE CORRECT =   100

YOU DID VERY WELL TODAY RUNNEYMEDE       HAVE A NICE DAY.


*** REMEMBER TO TYPE:     APPEND,   ,WORK
*** WHEN YOU FINISH
```

MARIE

*** COUNTXT ***

	LARGE SEQ	NQ	NR	MARK
76/07/29.	2	2	1	50
76/07/29.	3	2	2	100

NUMBER OF SESSIONS: 2 AVERAGE MARK: 75

RUNNEYMEDE

*** SENPAT1 ***

	DRILL NUM	NQ	NR	MARK
76/08/18.	1	1	2	100
76/08/18.	1	1	2	100

NUMBER OF SESSIONS: 2 AVERAGE MARK: 100

```
BATCH
$RFL,20000.
/CALL,RSPROG

***** THE TEMPORARY FILE IS BEING SORTED *****


***** THE FILES ARE BEING MERGED *****

DO YOU WANT A REPORT LISTING? YES OR NO ? YES

DO YOU WANT AN ENTIRE SCHOOL LISTING? YES OR NO ? NO

HOW MANY STUDENTS DO YOU WANT TO SELECT ? 2

PLEASE TYPE IN STUDENT NAMES ALPHABETICALLY USING
LAST NAMES. IF THE LAST NAMES ARE  IDENTICAL THEN
DETERMINE THEIR ORDER BY FIRST NAMES.

TYPE IN THE LAST NAME AND FIRST NAME WHEN ASKED

LAST NAME ?
FIRST NAME? CATHY

LAST NAME ?
FIRST NAME? SANDY

PLEASE CHECK THE FOLLOWING LISTING FOR SPELLING ERRORS
TYPE IN THE NUMBER OF THE NAME THAT CONTAINS THE ERROR
AND RETYPE THE LAST AND FIRST NAMES WHEN ASKED.

 1 )            CATHY

 2 )                      SANDY

ARE THERE ANY SPELLING ERRORS? YES OR NO? YES

TYPE IN THE NUMBER OF THE INCORRECT NAME? 2

CORRECT LAST NAME ?
CORRECT FIRST NAME? SANDY

 2 )                      SANDY

IS THE NAME SPELLED CORRECTLY ? YES

ARE THERE ANY OTHER MISPELLED NAMES? YES OR NO? NO
```

MONTHLY STUDENT REPORT
SEPTEMBER 1976

SANDY

- -

*** ALPHA1 ***

	DRILL NUM	NQ	NR	MARK
76/08/19.	4	5	4	80

NUMBER OF SESSIONS: 1 AVERAGE MARK: 80

- -

*** STORY1 ***

	NQ	NR	MARK
76/08/19.	1	1	100

NUMBER OF SESSIONS: 1 AVERAGE MARK: 100

****

*** END OF MONTHLY STUDENT REPORT ***

NB. *** PLEASE REMEMBER THIS FACT ***

IN THE INFORMATION SYSTEM THERE ARE TWO FILES

THE TEMPORARY FILE KEEPS THE STUDENT RECORDS UNTIL A TEACHER ASKS FOR A REPORT LISTING. WHEN THE REPORT HAS BEEN LISTED THE TEMPORARY FILE IS EMPTIED, AND IS RETURNED AS AN EMPTY FILE, ON WHICH NEW STUDENT RECORDS MAY BE STORED.

THE PERMANENT FILE KEEPS THE RECORD OF THE SORTED AND MERGED STUDENT RECORDS, WHICH MAY BE ACCESSED BY THE TEACHER WHEN A REPORT LISTING IS REQUIRED

AT THE END OF EACH MONTH, THE PERMANENT FILE FOR THAT MONTH WILL BE REMOVED FROM THE SYSTEM AND WILL BE REPLACED BY A NEW EMPTY PERMANENT FILE.

THEREFORE ON THE LAST SCHOOL DAY OF THE MONTH PLEASE RUN A LISTING OF THE ENTIRE SCHOOL

THE SECOND ITEM THE STUDENT MUST DO IS TO SAVE THE RESULTS OF THE PROGRAM THAT HE/SHE HAS JUST COMPLETED ON THE INFORMATION SYSTEM. THIS IS DONE IN THE FOLLOWING MANNER.

NOTE THAT THE STUDENT HAS TO LEARN ONLY 1 NEW LINE. THIS LINE IS THE LAST THING THAT MUST BE TYPED AFTER THE PROGRAM HAS STOPPED.

HERE IS THE SENTENCE

APPEND,***,WORK

NB. THE THREE ASTERISKS (***) REPRESENT THE SCHOOL CODE WHICH IS UNIQUE TO EACH SCHOOL.

YOU WILL BE GIVEN YOUR SCHOOL CODE BY YOUR RESEARCH ASSISTANT IN YOUR SCHOOL.

NOTE THAT THE PROGRAMS HAVE BEEN MODIFIED TO REMIND THE STUDENT OR SUPERVISOR OR MONITOR TO TYPE IN THIS LAST SENTENCE.

HERE IS AN EXAMPLE OF HOW TO SAVE STUDENT RESULTS

```
BYE CAPTAIN CANADA. SEE YOU AGAIN SOON.


*** REMEMBER TO TYPE:     APPEND,    ,WORK
*** WHEN YOU FINISH


CP      0.648 SECS.

RUN COMPLETE.

APPEND,***,WORK     THIS IS WHERE YOU TYPE IN YOUR
                     SENTENCE IE. AFTER THE PROGRAM


CP      0.333 SECS.
READY.
```

NB. *** IF THIS SENTENCE APPEND,***,WORK IS NOT
*** TYPED IN AFTER THE PROGRAM THEN THE STUDENT
*** RESULTS WILL NOT BE SAVED

APPENDIX D

Raw Scores By Group

APPENDIX D

Raw Scores - C.A.L. Group

C.A.L. GROUP	Pr1	Pr2	M	May 21 Po	Re
Student No. 1.	5.6	5.0	5.30	7.5	5.9
2.	5.4	4.9	5.15	5.9	5.3
3.	5.6	5.3	5.45	5.0	5.9
4.	5.4	5.9	5.65	6.3	5.9
5.	5.6	5.7	5.65	6.8	6.6
6.	4.9	4.9	4.90	6.1	5.7
7.	4.6	5.1	4.85	5.9	5.5
8.	4.9	5.0	4.95	6.8	6.3
9.	4.1	4.3	4.20	5.6	4.6
10.	5.4	4.3	4.85	6.3	5.3
11.	5.1	5.3	5.2	6.3	5.3
12.	5.7	6.3	6.0	8.1	6.0
13.	5.1	6.0	5.55	7.1	6.0
14.	5.0	5.0	5.0	6.5	6.0
15.	6.0	5.9	5.45	6.0	6.1
16.	6.0	7.1	6.55	7.1	7.5
17.	6.0	6.6	6.3	7.5	8.7
18.	6.6	5.7	6.15	8.1	7.3
19.	6.8	7.3	7.05	7.5	6.8
20.	6.1	7.5	6.8	8.5	7.5

N=20

APPENDIX D

Raw Scores - Tutorial Group

TUTORIAL GROUP	Pr1	Pr2	M	Po	Re
Student No. 21.	4.9	4.8	4.55	6.8	6.8
22.	4.6	4.8	4.7	5.7	5.4
23.	4.4	4.5	4.45	5.1	5.3
24.	4.9	4.7	4.8	5.9	5.4
25.	4.1	4.1	4.1	5.0	5.1
26.	5.3	4.4	4.85	4.9	5.7
27.	5.7	5.4	5.55	6.0	5.4
28.	5.3	4.9	5.1	4.4	4.1
29.	5.0	5.1	5.05	6.6	5.7
30.	4.9	5.0	4.95	5.6	5.9
31.	5.3	5.3	5.3	6.6	6.6
32.	5.9	6.0	6.0	7.1	7.3
33.	6.0	5.6	6.0	6.3	6.1
34.	5.7	5.7	5.7	5.7	6.8
35.	4.9	5.7	5.3	5.1	4.4
36.	6.8	7.5	7.15	6.6	7.7
37.	5.9	7.1	6.5	6.0	5.8
38.	6.1	7.3	6.7	7.7	7.1
39.	6.8	6.4	6.1	9.7	9.6
40.	7.3	7.5	7.4	7.3	9.4

APPENDIX D

Raw Scores - Control Group

CONTROL GROUP	Pr1	Pr2	M	June 1 Po	Re
Student No. 41.	4.4	4.6	4.5	6.0	5.4
42.	5.1	4.8	4.9	5.7	6.3
43.	5.1	4.1	4.5	5.4	5.7
44.	4.6	4.6	4.6	5.1	4.4
45.	6.0	4.6	4.8	6.3	5.9
46.	5.7	5.0	5.35	5.9	5.4
47.	5.3	5.6	5.45	7.3	6.1
48.	5.1	5.3	5.1	6.6	5.4
49.	5.1	5.9	5.5	5.9	
50.	4.6	5.6	5.0	6.0	5.9
51.	6.1	5.9	6.0	6.0	5.6
52.	4.9	6.0	5.45	6.8	6.3
53.	5.0	5.3	5.15	6.6	6.0
54.	5.4	6.0	5.7	5.7	6.3
55.	5.4	5.3	5.35	6.6	5.7
56.	6.6	7.5	7.0	6.8	7.3
57.	7.5	7.2	7.3	8.5	9.2
58.	6.1	6.3	6.2	N/A	N/A
59.	6.1	7.3	6.6	9.7	9.3
60.	6.0	5.9	5.95	6.8	6.5

APPENDIX E

Data Treatment Design

APPENDIX E

DATA TREATMENT DESIGN - RAW SCORES

		Pretest 1	Pretest 2	Post-test	Retention test
Average Achievers	C.A.L.	5.1 5.7 5.1 5.0 5.0	5.3 6.3 6.0 5.0 5.9	6.3 8.1 7.1 6.5 6.0	5.3 6.0 6.0 6.0 6.1
		6.0 6.0 6.6 6.8 6.1	7.1 6.6 5.7 7.3 7.5	7.1 7.5 8.1 7.5 8.5	7.5 8.7 7.3 6.8 7.5
	Tutorial	5.3 5.9 6.0 5.9 4.9	5.3 6.0 5.6 5.7 5.7	6.6 7.1 6.3 5.7 5.1	6.6 7.3 6.1 6.8 9.4
		6.8 5.9 6.1 6.8 7.3	7.5 7.1 7.3 5.4 7.5	6.6 6.0 7.7 9.7 7.3	7.7 5.3 7.1 9.6 9.4
	Control	6.1 4.9 5.0 5.4 5.4	5.9 6.0 5.3 6.0 5.3	6.0 6.8 6.6 5.7 6.6	5.6 6.3 6.0 6.3 5.7
		6.6 7.9 6.1 6.1 6.0	7.5 7.2 6.3 7.3 5.9	6.8 8.5 - 9.7 6.8	7.3 9.2 - 9.3 6.5
Low Achievers	C.A.L.	5.6 5.4 5.6 5.4 5.6	5.0 4.9 5.3 5.9 5.7	7.5 5.9 5.0 6.3 6.8	5.9 5.3 5.9 5.9 6.6
		4.9 4.6 4.9 4.1 5.4	4.9 5.1 5.0 4.3 5.3	6.1 5.9 6.8 5.6 6.3	5.7 5.5 6.3 4.6 5.3
	Tutorial	4.9 4.6 4.4 4.9 4.1	4.8 4.8 4.5 4.7 4.1	6.8 5.7 5.1 5.9 5.0	6.8 5.4 5.3 5.4 5.1
		5.3 5.7 5.3 5.0 4.9	4.4 5.4 4.9 5.1 5.0	4.9 6.0 4.4 6.6 5.6	5.7 5.4 5.1 5.7 5.9
	Control	4.4 5.1 5.1 4.6 5.0	4.4 4.8 4.1 4.6 4.6	6.0 5.7 5.4 5.1 6.3	5.4 6.3 5.7 4.4 5.9
		5.7 5.3 5.1 5.1 5.2	5.0 5.3 5.2 5.9 5.6	5.9 7.3 6.6 5.9 6.0	5.4 6.1 5.4 6.2 5.9

APPENDIX E

DATA TREATMENT DESIGN - MEANS AND STANDARD DEVIATIONS

		Pretest 1	Pretest 2	Post-test	Retention test
Average Achievers	C.A.L.	$\bar{X}$ = 5.74 S = .67	$\bar{X}$ = 6.27 S = .85	$\bar{X}$ = 7.27 S = .83	$\bar{X}$ = 6.72 S = 1.02
	Tutorial	$\bar{X}$ = 6.09 S = .72	$\bar{X}$ = 6.31 S = .92	$\bar{X}$ = 6.81 S = 1.27	$\bar{X}$ = 7.53 S = 1.48
	Control	$\bar{X}$ = 5.95 S = .88	$\bar{X}$ = 6.27 S = .80	$\bar{X}$ = 7.05 S = 1.25	$\bar{X}$ = 6.91 S = 1.42
Low Achievers	C.A.L.	$\bar{X}$ = 5.15 S = .51	$\bar{X}$ = 5.14 S = .48	$\bar{X}$ = 6.22 S = .70	$\bar{X}$ = 5.7 S = .56
	Tutorial	$\bar{X}$ = 4.82 S = .55	$\bar{X}$ = 4.77 S = .37	$\bar{X}$ = 5.6 S = .76	$\bar{X}$ = 5.58 S = .50
	Control	$\bar{X}$ = 5.06 S = .36	$\bar{X}$ = 4.95 S = .56	$\bar{X}$ = 6.02 S = .62	$\bar{X}$ = 5.67 S = .56

APPENDIX F

C.A.L.M. Manual

Computer Assisted Learning Manual

C.OMPUTER A.SSISTED L.EARNING M.ANUAL :

- DRILL AND PRACTICE IN...
  (1) MATHEMATICS
  (2) LANGUAGE ARTS
  (3) FRENCH
- SKILL SHEETS
- EDUCATIONALLY-BASED GAMES
- INSTRUCTIONS FOR USE OF...
  (1) SHORTENED DATA
  (2) INFORMATION SYSTEM

AFFILIATED SCHOOLS :

BRITANNIA ELEMENTARY SCHOOL
ST. JAMES ASSININBOINE SCHOOL DIVISION #2
- KEITH GRAHAM

CENTRAL NORTH UPGRADING CENTER
TRANSCONA, SPRINGFIELD SCHOOL DIVISION
- ONFRIO FIORENTINO

ELLEN DOUGLASS SCHOOL FOR THE HANDICAPPED
WINNIPEG #1 SCHOOL DIVISION
- CATHI HILL

MANITOBA SCHOOL FOR THE DEAF
- LOU REEVES

PROGRAMS WRITTEN AND COMPILED UNDER S.T.E.P. BY :

1975-1976 OLIVE RICARD
JOHN SYLVESTER
JOAN WASYLIW

1976-1977 CHERYL BALABERDA
SANDY MILOVANOVICH
RICK SIMANAVICIUS

ADVISOR: DR. LAURAN SANDALS
DEPARTMENT HEAD
EDUCATIONAL PSYCHOLOGY
FACULTY OF EDUCATION
UNIVERSITY OF MANITOBA

AUGUST 17, 1976

RECOGNITION DRILLS

A1. NUMTYPE- FINDING NUMBERS AND LETTERS ON THE KEYBOARD.
- LENGTH OF SEQUENCE BY SELECTION.

A2. NUMREC- RECOGNITION OF CORRESPONDING NUMBER OR LETTER SEQUENCE, BY MULTIPLE CHOICE.
- LENGTH OF SEQUENCE BY SELECTION.

A3. NUMSEQ- SEQUENCING A THREE-MEMBER NUMBER STRING.
- POSITION OF BLANK BY RANDOM SELECTION.
- RANGE: 1 TO 10, 1 TO 25, 1 TO 100
- BY SELECTION.

COUNTING DRILLS

A4. COUNT20- COUNTING DRILL USING BOXES AND SNOWFLAKES.
- PARAMETERS BETWEEN 2 AND 20 BY SELECTION

A5. COUNTXT- COUNTING DRILL USING S AND [] IN RANDOM SEQUENCES BY SELECTION.

A6. NUMLET- COUNTING DRILL USING NUMBER AND LETTER SEQUENCES.
- PARAMETERS 2 TO 20 BY SELECTION

ADDITION DRILLS

A7. ADDSAN- DRILL IN ADDITION.
- RANGE OF PROBLEMS FROM 2, 1-DIGIT NUMERALS TO 5,5-DIGIT NUMERALS ON SELECTION.

A8. ADDSUB1- DRILL IN ADDITION OR SUBTRACTION.
- PARAMETERS BETWEEN 1 AND 19 BY SELECTION.

A9. MISS1- ADDITION, SUBTRACTION, AND MULTIPLICATION EQUATIONS WITH MISSING NUMERALS.

A10. ADDODEC- DRILL IN ADDITION OF DECIMALS.

SUBTRACTION DRILLS

A11. SUBTSAN- DRILL IN SUBTRACTION.
- RANGE OF PROBLEMS FROM 2,1-DIGIT NUMERALS TO 2,6-DIGIT NUMERALS BY SELECTION.

A8. ADDSUB1- DRILL IN SUBTRACTION OR ADDITION.
- PARAMETERS BETWEEN 1 AND 19 BY SELECTION.

A9. MISS1- SUBTRACTION, ADDITION, AND MULTIPLICATION EQUATIONS WITH MISSING NUMERALS.

A12. SUBODEC- DRILL IN SUBTRACTION OF DECIMALS.
- 1 TO 20 RANDOMLY GENERATED PROBLEMS.
- 1 TO 6 DIGITS IN EACH NUMBER.
- CHOICE OF NUMBER OF DECIMAL PLACES IN THE NUMBERS.
- ALL BY SELECTION.

MULTIPLICATION DRILLS

A13. MULTSAN- DRILL IN MULTIPLICATION OF NUMERALS WITH 1 TO 5 DIGITS BY A CONSTANT 1-9 OR A RANDOMLY GENERATED NUMERAL BY SELECTION.

A9. MISS1- MULTIPLICATION, ADDITION, AND SUBTRACTION EQUATIONS WITH MISSING NUMERALS.

DIVISION DRILLS

A14. DIVIDE- DRILL IN DIVISION. CHOICE OF INTEGERS OR RATIONAL NUMBERS.
- DIVIDEND 1 - 9 DIGITS
- DIVISOR 1 - 5 DIGITS

WORDED PROBLEMS

A15. WORD1- SHORT SIMPLE WORDED PROBLEMS IN
- ADDITION, SUBTRACTION, MULTIPLICATION, AND DIVISION.

A16. WORD2- WORDED PROBLEMS USING COMPLETE SENTENCES IN ADDITION, SUBTRACTION, MULTIPLICATION AND DIVISION.

A17. MONEY1- SIMPLE WORDED PROBLEMS DEALING WITH MONEY IN ADDITION, SUBTRACTION, MULTIPLICATION AND DIVISION, AND RELATIONAL PROBLEMS.
- DECIMALS NOT INVOLVED.

A18. MONEY2- WORDED PROBLEMS IN DEALING WITH DOLLARS AND CENTS.
- INVOLVES ADDITION, SUBTRACTION, MULTIPLICATION, AND DIVISION.

A19. MONEY3- WORDED PROBLEMS THAT EACH INVOLVE TWO OPERATIONS.
- USES ALL POSSIBLE COMBINATIONS OF THE 4 MAJOR OPERATIONS.
- 1 TO 15 RANDOMLY GENERATED PROBLEMS BY SELECTION.

A20. RELATE- RELATIONAL PROBLEMS INVOLVING NUMBERS ONLY, OPERATIONS, WORDED PROBLEMS AND VARIABLES.

FRACTION DRILLS

A21. FRACT1- DRILLS IN ADDITION, SUBTRACTION MULTIPLICATION, DIVISION, REDUCTION, AND RELATIONAL FRACTIONS.
- 12 DIFFERENT DRILLS OF 1 - 10 RANDOMLY GENERATED QUESTIONS.
- PARAMETERS 1 - 9 OR 1 - 25 BY SELECTION.

LANGUAGE DRILLS

B1. ALPHA1- DRILL IN WRITING ALPHABET
- FILL IN MISSING BLANKS (UP TO 5) FROM ENTIRE ALPHABET WITH BLANKS
- COMPUTER HELP AVAILABLE BY REQUEST.
- USEFUL FOR OCCUPATIONAL THERAPY.

B2. ALPHA2- DRILL IN COMPLETING ALPHABETICAL 3-LETTER SEQUENCE.
- BLANK POSITION BY SELECTION.
- COMBINATION AVAILABLE.

B3. WKDAYS- PRACTICE IN VOCABULARY, SPELLING, AND SEQUENCE OF WEEKDAYS OR SEASONS.
- CAREFULLY PREPARED SEQUENCE OF DRILLS.

B4. MNTHS- PRACTICE IN VOCABULARY, SPELLING, AND SEQUENCE OF MONTHS.
- CAREFULLY PREPARED SEQUENCE OF DRILLS.

B5. WHOWHAT- BASED ON THE RHODE ISLAND CIRRICULUM FOR THE DEAF.
- ALSO APPLICABLE TO HEARING STUDENTS.
- DRILL IN 'PERSON OR THING', WHO WHAT, AND VERBS.
- SIX DRILLS OF TEN QUESTIONS EACH.

B6. BEVERBS- BASED ON THE RHODE ISLAND CIRRICULUM FOR THE DEAF.
- ALSO APPLICABLE TO HEARING STUDENTS.
- BE VERBS, AUXILIARY WORDS, QUESTIONS
- PRACTICE IN SENTENCE FORMATIONS USING CORRECT PUNCTUATION.
- SIX DRILLS OF TEN QUESTIONS EACH.

B7. SENPAT1- BASED ON THE RHODE ISLAND CIRRICULUM FOR THE DEAF.
- DRILL IN SENTENCE PATTERN #1
- ALSO APPLICABLE TO HEARING STUDENTS.
- DIVIDED INTO THREE VOCABULARY LEVELS.
- EACH LEVEL IS DIVIDED INTO 3 TENSES.
- EACH TENSE DIVIDED INTO 3 TOPICS.
- COMBINATION DRILLS PROVIDED

B8. RHODE1- BASED ON THE RHODE ISLAND CIRRICULUM FOR THE DEAF.
- ALSO APPLICABLE TO HEARING STUDENTS.
- DRILL IN WHO AND WHAT WORDS, ADVERBS, THE QUESTION FORMAT AND SENTENCE PATTERNS 1 AND 2

B9. RHODE2- BASED ON THE RHODE ISLAND CIRRICULUM FOR THE DEAF.
- ALSO APPLICABLE TO HEARING STUDENTS.
- DRILL IN SIMPLE PAST, PRESENT, AND FUTURE TENSES.
- SIMPLE EXPANSIONS
- SENTENCE PATTERNS 3, 4, AND 5.

B10. RHODE1A- BASED ON THE RHODE ISLAND CIRRICULUM FOR THE DEAF.
- ALSO APPLICABLE TO HEARING STUDENTS.
- DRILL IN 'IS A PERSON' : 'IS NOT A PERSON'
- TEACHER HAS OPTION OF USING NAMES OF HER CLASS IN THE DRILL

B11. MREAD1- DRILL IN CORRECT USE OF IRREGULAR
(OLD) VERBS.
- PROGRAM OFFERS 10 DRILLS WITH 9 QUESTIONS IN EACH.
- IRREGULAR VERBS: TO BE, TO GO, TO DO TO SEE AND TO COME.

B12. MREAD2- DRILL IN CORRECT USE OF IRREGULAR
(OLD) VERBS.
- PROGRAM OFFERS 10 DRILLS WITH 9 QUESTIONS IN EACH.
- IRREGULAR VERBS: TO HAVE, TO RIDE, TO FALL, TO RUN, AND TO SIT.

B13. MREAD3- DRILL IN THE CORRECT USE OF IRREGULAR
(OLD) VERBS.
- PROGRAM OFFERS 10 DRILLS WITH 9 QUESTIONS IN EACH.
- IRREGULAR VERBS: TO BEGIN, TO GIVE, TO WRITE, TO BREAK, AND TO SAY.

B14. BELONG- DRILL IN CLASSIFYING OBJECTS.
- STUDENT IS GIVEN A GROUP OF FOUR WORDS AND ASKED TO CHOOSE THE WORD THAT DOESN'T BELONG.
- 1 - 20 PROBLEMS BY SELECTION.

B15. SPELL20- SPELLING DRILL WHERE STUDENT HAS TO MAKE A CHOICE BETWEEN TWO SPELLINGS OF A CERTAIN WORD IN A SENTENCE.
- CHOICE OF SIMPLER WORDS OR HARDER WORDS.
- 1 TO 20 RANDOMLY GENERATED SENTENCES FOR EACH TOPIC - BY SELECTION.

B16. SPELL30- SPELLING DRILL WHERE THE STUDENT IS GIVEN FOUR RELATED WORDS AND MUST CHOOSE THE MIS-SPELLED ONE AND THEN SUPPLY THE CORRECT SPELLING OF THAT WORD.
- 1 TO 20 RANDOM QUESTIONS BY SELECTION.

B17. SPELB1- 10 DIFFERENT SPELLING TOPICS OF 5
(OLD) QUESTIONS EACH.
- REPORT CARD ISSUED AT END OF DRILL.
- INCLUDES TOPICS SUCH AS PLURALS, OPPOSITES, PROVINCES, ETC.

B18. SPELA1- EXPANSIONS OF SPELB1.
- EACH OF THE TEN TOPICS NOW HAS 10 QUESTIONS INSTEAD OF 5.
- TOPIC CALLED 'QUESTIONS' HAS BEEN REPLACED BY ONE CALLED 'ABBREVIATIONS'.
- HAS OPTION OF WHETHER THE ENTIRE LIST OF TOPICS WILL BE PRINTED.

B19. SYNANT- DRILL WHERE STUDENT DETERMINES SYNONYMS AND / OR ANTONYMS OF WORDS FROM THE CONTEXT OF A SENTENCE.
- 1 TO 20 RANDOM SENTENCES OF EACH BY SELECTION.

B20. HOMONYM- DRILL IN USING THE CORRECT HOMONYM FROM THE CONTEXT OF THE SENTENCE.
- 1 TO 20 RANDOMLY GENERATED QUESTIONS BY SELECTION.

B21. PRON3- SIX DRILLS ON NOMINATIVE AND OBJECTIVE FORMS OF PRONOUNS.
- DIVIDED ACCORDING TO SINGULAR OR PLURAL PRONOUNS.
- COMBINATION ALSO AVAILABLE.

B22. PRONOUN- DRILLS IN FIVE UNITS OF PRONOUNS.
- READABILITY APPROXIMATELY GRADE 2
- NOMINATIVE, OBJECTIVE, POSSESIVE, AND COMBINATIONS.
- PROGRESS TO NEXT UNIT ADVISED BY COMPUTER.

B23. PAIR1- DRILL IN CHOOSING THE CORRECT NEGATIVE VERB FORM (SINGULAR - PLURAL) FROM THE CONTEXT OF THE SENTENCE.
- SIX DIFFERENT DRILLS OF 10 QUESTIONS EACH - BY SELECTION.

B24. PAIR2- DRILL IN CHOOSING THE CORRECT OF COMMONLY MISUSED PAIR OF WORDS. EG. (LEND - BORROW)
- SEVEN DRILLS OF 10 QUESTONS EACH
- BY SELECTION.

B25. ROOTVB- DRILLS IN EXTRACTING ROOT WORDS IN ADDING ENDINGS TO ROOT WORDS.
- 'ING' AND 'ED' ENDINGS BY CHOICE.
- REGULAR AND IRREGULAR VERBS
- COMBINATION PROVIDED
- WRONG ANSWER GIVES CORRECTIVE FEEDBACK

B26. PREFIX- DIVIDING WORDS INTO ROOT WORDS AND PREFIXES AND/OR SUFFIXES.
- PROGRESSION IN SMALL STEPS.
- COMBINATION AVAILABLE.

B27. VERB1- DRILL IN CHOOSING THE CORRECT FORM OF THE VERB FROM THE CONTEXT OF THE SENTENCE IN WHICH IT APPEARS.
- FOUR DIFFERENT DRILLS OF 1 TO 15 RANDOMLY GENERATED QUESTIONS - BY SELECTION.
- INVOLVES REGULAR, IRREGULAR, SINGULAR AND PLURAL VERBS OR A COMBINATION OF ALL.

B28. VERB2 DRILL WHERE THE STUDENT MUST TYPE IN THE CORRECT FORM OF THE GIVEN VERB FROM THE CONTEXT OF THE SENTENCE IN WHICH IT APPEARS. INVOLVES REGULAR AND IRREGULAR VERBS.
- 1 TO 15 RANDOMLY GENERATED QUESTIONS.
- BY SELECTION.

B29. STORY1- DRILL IN READING COMPREHENSION OF SHORT, SIMPLE 3-LINE STORIES.
- STUDENT IS GIVEN MULTIPLE-CHOICE QUESTION ABOUT THE MAIN IDEA OF THE STORY.
- 1 TO 15 RANDOMLY GENERATED STORIES BY SELECTION.

B30. STORY2- HIGH INTEREST, LOW LEVEL READING COMPREHENSION.
- EXTENSION OF STORY1
- 1 TO 10 RANDOMLY GENERATED STORIES.

B31. COMPARE- 4 DRILLS IN COMPARISONS OF ADVERBS AND ADJECTIVES, AND COMPARISONS USING 'MORE' AND 'MOST'.
- 1 TO 15 RANDOMLY GENERATED QUESTIONS FOR EACH TOPIC - BY SELECTION.

B32. POSSESS- 5 DRILLS IN POSSESSIVE SINGULAR AND PLURAL NOUNS, PRONOUNS, AND ADJECTIVES.
- 1 TO 15 RANDOMLY GENERATED QUESTIONS FOR EACH DRILL - BY SELECTION.

B33. COMP1- WORD DRILL IN IDENTIFYING WORD-PARTS AND FORMING COMPOUND WORDS.
- EACH TYPE OF DRILL IS AT THREE LEVELS: SIMPLE, INTERMEDIATE, AND HARDER WORDS.
- WORDS ARE KEPT CONSTANT FOR EACH LEVEL.

B34. PREP1- DRILL IN THE USE OF PREPOSITIONS.
- 1 TO 20 RANDOMLY GENERATED SENTENCES.
- PREPOSITIONS USED: IN, WITH, TO, ON,
- FOR, AND FROM.

SKILL SHEETS

NOTE: ALL SKILL SHEET PROGRAMS HAVE...
1. OPTIONS FOR NUMBER OF COPIES REQUESTED
2. OPTIONS FOR WORKSHEET CONSTRUCTION
3. BETWEEN 1 AND 20 RANDOMLY GENERATED QUESTIONS
4. ANSWER KEY PROVIDED

D1. ADDSKIL- ADDITION WORKSHEETS
- PARAMETERS FOR NUMBER AND COMPLEXITY OF ADDENDS (2 TO 5) BY SELECTION.

D2. SUBSKIL- SUBTRACTION WORKSHEETS
- PARAMETERS FOR COMPLEXITY OF BOTH SUBTRAHEND AND MINUEND BY SELECTION.

D3. MLTSKIL- MULTIPLICATION WORKSHEETS
- PARAMETERS FOR COMPLEXITY OF NUMBERS (DIGITS AND DECIMAL PLACES) BY SELECTION.

D4. DIVSKIL- DIVISION WORKSHEETS
- PARAMETERS FOR COMPLEXITY OF DIVISOR AND DIVIDEND (DIGITS & DECIMAL PLACES) BY SELECTION.

D5. FRSKIL1-
1) REDUCTION OF FRACTIONS
2) ADDITION OF FRACTIONS WITH DIFFERENT DENOMINATORS

D6. FRSKIL2-
1) SUBTRACTION OF FRACTIONS
2) MULTIPLICATION OF FRACTIONS
3) DIVISION OF FRACTIONS

D7. FRSKIL3-
1) ADDITION OF MIXED FRACTIONS
2) SUBTRACTION OF MIXED FRACTIONS
3) MULTIPLICATION OF MIXED FRACTIONS
4) DIVISION OF MIXED FRACTIONS

D8. FRSKIL4- EQUIVALENCE OF FRACTIONS
- RANDOMLY GENERATED BLANK IN EITHER NUMERATOR OR DENOMINATOR OF EITHER FRACTION.

D9. RPSKIL-
1) ROUNDING OFF DECIMAL PLACES
2) PERCENTAGE
- PARAMETERS FOR COMPLEXITY OF NUMBER AND FOR DECIMAL PLACE OF ROUND-OFF

D10. CVTSKIL-
1) CONVERSION OF DECIMALS TO FRACTIONS
2) CONVERSION OF FRACTIONS TO DECIMALS

EDUCATIONALLY-BASED GAMES

E1. GUESS- GUESSING OF A RANDOMLY CHOSEN NUMBER FROM 1 TO 100
- COMPUTER GIVES 'CLUES' SUCH AS 'TOO HIGH' OR 'TOO LOW'
- CONCEPT OF AVERAGES, QUICKEST METHOD OF ELIMINATION, ETC.

E2. BLACKM- OBJECT: TO LEAVE ONE PLAYER WITH THE TWENTY-FIRST MATCH.
- USEFUL DISCOVERY APPROACH TO UNUSUAL MATHEMATICAL PROBLEMS.
- PRIMARY AND UP.

E3. BMATCH- OBJECT: TO LEAVE ONE PLAYER WITH THE LAST MATCH FROM A STUDENT-CHOSEN LIMIT.
- PREDICTION OF NUMBER OF MATCHES THE COMPUTER WILL TAKE.
- DISCOVERY OF CORRECT NUMBER LIMITS NEEDED TO 'FOIL' THE COMPUTER.
- USE AFTER 'BLACKM'

E4. DICE- SIMULATED 'CRAP GAME'
- USEFUL FOR STUDY OF PROBABILITY AND STATISTICS.

E5. GUNNER- SIMULATED 'TARGET PRACTICE'
- USEFUL FOR STUDY OF CONCEPTS OF AVERAGE ANGLE, VECTOR, TRAJECTORY, AND TRIGONOMETRIC FUNCTIONS.

E6. PATTON- SIMULATED 'MAZE'
- USEFUL FOR DEVELOPMENT OF INTERNAL PERCEPTIONS OF A POSSIBLE TWO-DIMENSIONAL MOVEMENT.

E7. MOON- SIMULATED 'LUNAR LANDING'
- COMPLEX COORDINATION OF VARIABLES OF DISTANCE, FUEL CONSUMPTION, SPEED, TIME, ACCELERATION, DECELERATION, ETC.

SHORTENED DATA INSTRUCTIONS

'SHORTENED DATA' IS MERELY A FASTER WAY OF 'LOGGING INTO' A COMPUTER PROGRAM. INSTEAD OF WAITING FOR THE COMPUTER TO ASK EVERY QUESTION (HOW MANY PROBLEMS ?) OR TO RESPOND TO EVERY ANSWER (PLEASE CHOOSE BETWEEN 1 AND 20 PROBLEMS), THE USER ENTERS ALL PIECES OF DATA, SEPARATED BY COMMAS AT ONE TIME, AFTER ONE QUESTION, IE/ (PLEASE ENTER 4 VALUES (TYPE 8,8,F,D FOR FULL DATA)). THE VALUES ENTERED ARE THE SAME ONES, IN THE SAME ORDER

THE ONLY CRITERIA FOR USE OF 'SHORTENED DATA' IS FAMILIARITY WITH THE PROGRAM SO THAT ONE KNOWS THE MEANING OF EACH DATA PIECE. IT IS VERY IMPORTANT THAT THE DATA BE ENTERED IN THE RIGHT ORDER, AS THE COMPUTER IS PROGRAMMED TO EXPECT EITHER NUMBER OR WORDS AND GETS 'CONFUSED' (ILLEGAL INPUT) WHEN THE WRONG TYPE OF DATA IS ENTERED. IT IS ALSO IMPORTANT TO SEPARATE ALL DATA PIECES BY COMMAS, AS THIS IS THE ONLY WAY THE COMPUTER CAN TELL WHERE ONE PIECE OF DATA ENDS AND ANOTHER BEGINS.

SOME PROGRAMS INCLUDE THE NAME OF THE STUDENT WITHIN THE 'SHORTENED DATA'. SINCE THE NAME ALWAYS OCCURS LAST, THE STUDENT MAY BE LEFT TO ENTER IT HIMSELF WITHOUT SUPERVISION AS LONG AS THE INSTRUCTIONS CONCERNING THE USE OF THE COMMA ARE GIVEN (2,10,JOHN,SMITH). IF TOO LITTLE OR TOO MUCH DATA IS ENTERED, THE COMPUTER WILL RESPOND WITH (NOT ENOUGH DATA, TYPE IN MORE AT ---) OR WITH (TOO MUCH DATA -RETYPE AT ---) RESPECTIVELY. IN THE CASE OF TOO LITTLE DATA, THE COMPUTER WILL WAIT FOR YOU TO ENTER ADDITIONAL VALUES. IN THE CASE OF TOO MUCH DATA, THE COMPUTER WILL LET YOU ENTER AGAIN FROM THE BEGINNING. IF AT ANY TIME YOU BECOME CONFUSED YOURSELF,SIMPLY TYPE IN 'STOP' AFTER A '?' MARK AND THE PROGRAM WILL TERMINATE. YOU MAY THEN GO THROUGH THE PROGRAM UNDER 'FULL DATA'.

IF YOU ELECT 'SHORTENED DATA' AND THEN REALIZE THAT YOU REALLY DO NOT REMEMBER THE MEANING OF EACH ENTRY, YOU HAVE THE OPTION OF REVERTING AGAIN TO 'FULL DATA' BY TYPING THE VALUES INDICATED IN BRACKETS IE/ (PLEASE ENTER 4 VALUES (TYPE 8,8,F,D FOR FULL DATA). THE COMPUTER WOULD PRINT ? AND WAIT. WHEN YOU ENTERED 8,8,F,D YOU WOULD BE GIVEN FULL DATA.

STUDENT INFORMATION SYSTEM

OBJECT:

1. TO KEEP A RECORD OF ALL STUDENT PROGRAMS, AND ALL RELEVANT INFORMATION PERTAINING TO THAT PROGRAM.

   HERE IS AN EXAMPLE OF THE DATA REQUIRED FOR MULTSAN

   NUMBER OF DIGITS IN THE TOP NUMBER
   WHETHER THE MULTIPLIER IS CONSTANT OR RANDOM
   THE MULTIPLIER(IF IT IS CONSTANT)
   THE NUMBER OF QUESTIONS ATTEMPTED
   THE NUMBER OF CORRECT ANSWERS
   THE MARK

   THIS DATA IS STORED AND IS PRINTED WHEN THE TEACHER REQUESTS A LISTING OF THE STUDENT REPORT

2. TO ENABLE THE TEACHER TO OBTAIN A LISTING OF A REPORT FOR THE INDIVIDUAL STUDENTS THAT THEY MAY WANT, OR FOR THE ENTIRE SCHOOL.

STUDENT RESPONSIBILITIES

1. THE STUDENT MUST TYPE HIS/HER NAME CORRECTLY EACH TIME THEY LOG-ON TO THE COMPUTER.

NB. *** IF THE NAMES ARE NOT IDENTICAL FOR EACH
*** LOG-ON, THEN THE TEACHER WILL HAVE TO KEEP
*** TRACK OF THE DIFFERENT SPELLINGS OF THE
*** SAME NAME. THIS OF COURSE MAY LEAD TO MANY
*** INCONVENIENCES, SO PLEASE MAKE CERTAIN THAT
*** THE SUPERVISOR, OR MONITOR AT THE TERMINAL
*** CHECKS THE SPELLING OF STUDENTS NAMES CAREFULLY

NOTE THAT EACH PROGRAM HAS BEEN MODIFIED TO GIVE THE STUDENT THE OPPORTUNITY TO CORRECT HIS OR HER NAMES IF THEY HAVE BEEN MISPELLED.

HERE IS AN EXAMPLE OF THE QUESTIONS ASKED, AND THE RESPONSES THAT SHOULD FOLLOW.(THE STUDENT RESPONSES WILL BE UNDERLINED).

WHAT IS YOUR FIRST NAME ? CAPAIN

WHAT IS YOUR LAST NAME ? CANADA

IS THIS YOUR CORRECT NAME ? CAPAIN CANADA ? NO

CORRECT FIRST NAME ? CAPTAIN
CORRECT LAST NAME ? CANADA

IS THIS YOUR CORRECT NAME ? CAPTAIN CANADA ? YES

NOTE THAT THIS SECTION OF ASKING THE CORRECT NAME WILL CONTINUE UNTIL THE REPLY OF YES IS GIVEN. THUS THIS GIVES THE SUPERVISOR OR MONITOR AT THE TERMINAL NO EXCUSE TO LET AN INCORRECT NAME TO BE ENTERED INTO THE STUDENT RECORD.

APPENDIX G

Summary of Costs

APPENDIX G

Summary of Costs

Britannia 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%. The St. James-Assiniboia School Division paid $2,000 for a ten month period and the Department of Education contributed $3,000 to the Britannia School project.

A breakdown of monthly costs for the terminal at Britannia School was as follows:

Teletype rental - monthly	$ 67.00
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. Teacher time was not considered in this summary.

APPENDIX H

Hierarchy of Mathematics Levels

APPENDIX H

Name ____________________

Room # ________________

Computer Time Periods ________________________________

		DATE SCORE			
1	Add: one digit + one digit (under 10) ex: 4+5 Addsub 1				
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 H (cont'd.)

Name ________________

Room # ________________

Computer Time Periods ________________

		DATE SCORE			
11	Mult: one digit x 4 ex: 7 x 4 Multsan				
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 H

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 I

Learning Curves for Each Subject

Analysis of Group Data

APPENDIX I

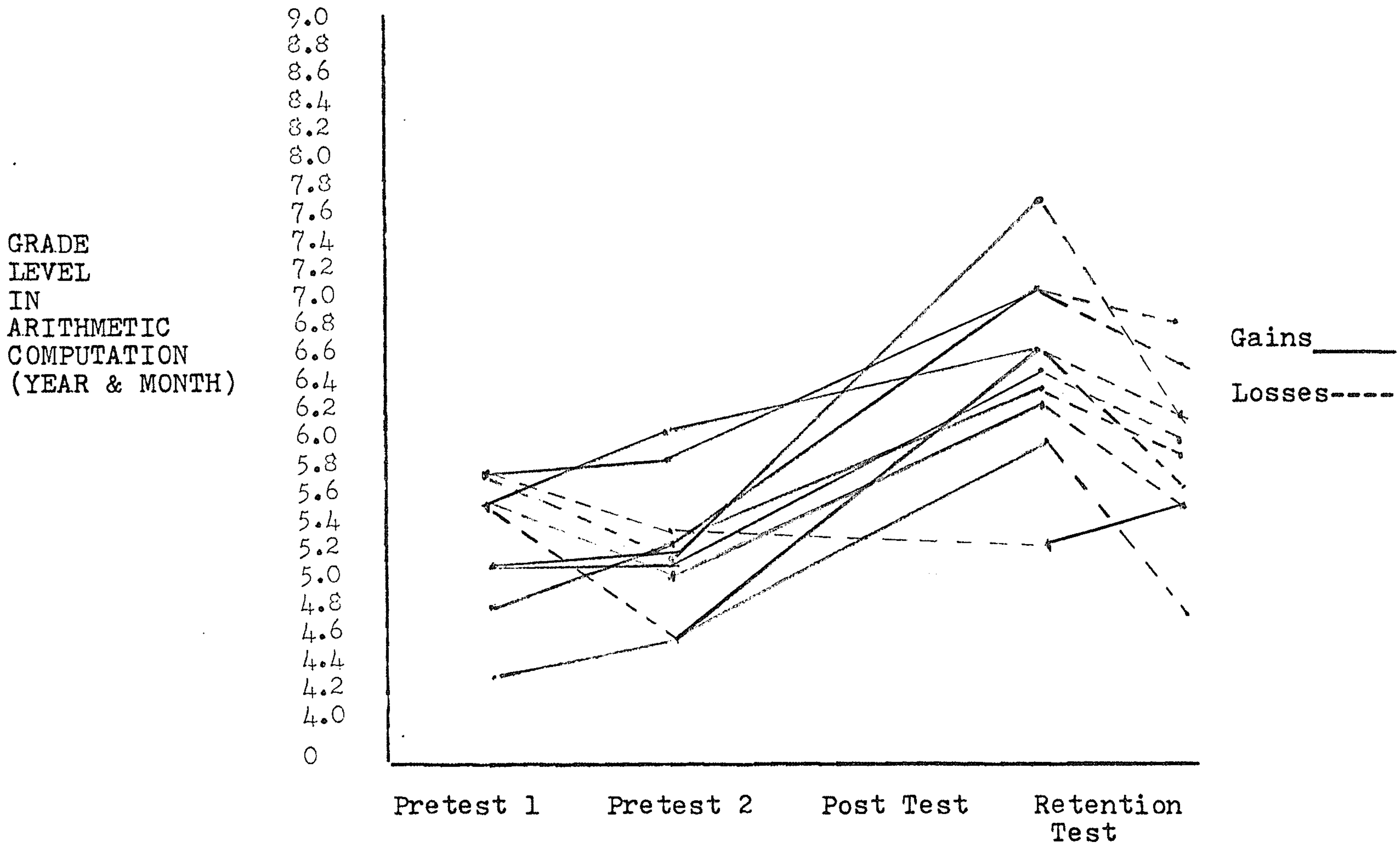
Learning Curves for Each Subject - Analysis of Group Data

The learning curves and individual data for each subject will be analyzed and discussed in this section. Graphs showing gains and losses can be found in Figures five, six, seven, eight, nine and ten.

Low-Achieving Students - C.A.L. Group

As shown in figure five, 9 pupils showed gains from pretest 2 to the retention test. Of the 10 pupils in this group, 5 showed an increase from pretest 1 to pretest 2, while 3 showed losses and 2 remained constant. During the treatment period 9 pupils showed gains and 1 showed a decline. During the retention period, 1 pupil showed a gain while 9 pupils showed a decline. In overall gain, from pretest 2 to the retention test, 9 pupils showed gains while one pupil remained constant. The greatest overall gain was 1.3 years. The mean gain was .66 years.

Figure Five - Learning Curves of the Low-Achieving Students in the C.A.L. Group



Low-Achieving Students - Tutorial Group

As shown in figure six, 8 pupils of the 10 in this group showed an overall gain from pretest 2 to the retention test. Of the 10 pupils, 4 showed a gain from pretest 1 to pretest 2, while five showed a decline and 1 remained constant. During the treatment period all 10 pupils showed gains. During the retention period 4 pupils showed gains, 5 showed declines and 1 remained constant. The greatest overall gain from pretest 2 to the retention test was 2.0 years. The mean gain was .87 years.

Low-Achieving Students - Control Group

As shown in figure seven, 8 pupils of the 10 in this group made an overall gain from pretest 2 to the retention test. Of the 10 pupils 5 showed a gain from pretest 1 to pretest 2, 4 showed a loss and 1 remained constant. During the treatment period 9 pupils showed gains while 1 remained constant. During the retention period 2 pupils showed gains and 7 showed losses. One pupil's score was not available at this point. The greatest overall gain from pretest 2 to the retention test was 1.6 years. The mean gain was .67.

Figure Six - Learning Curves of the Low-Achieving

Students in the Tutorial Group

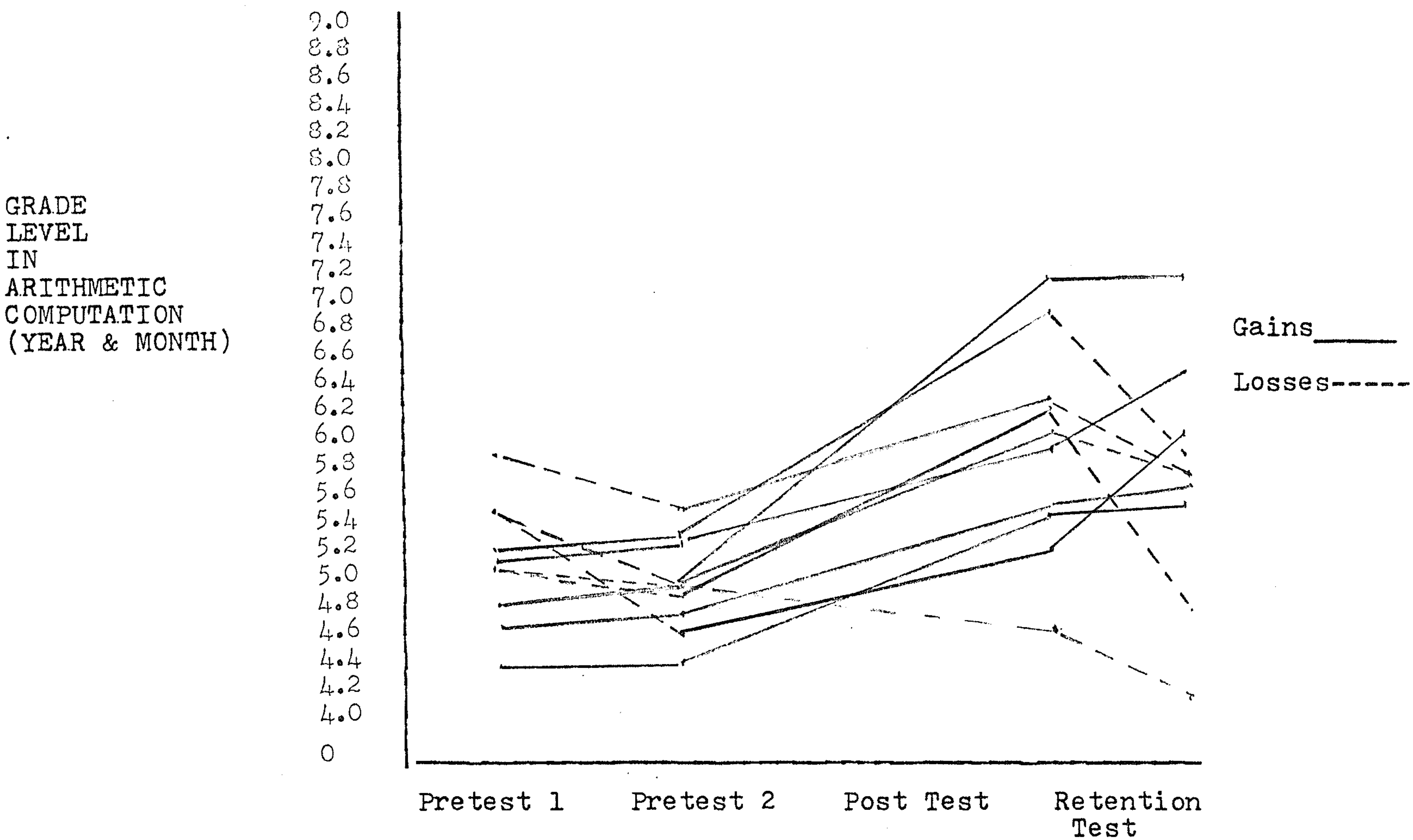
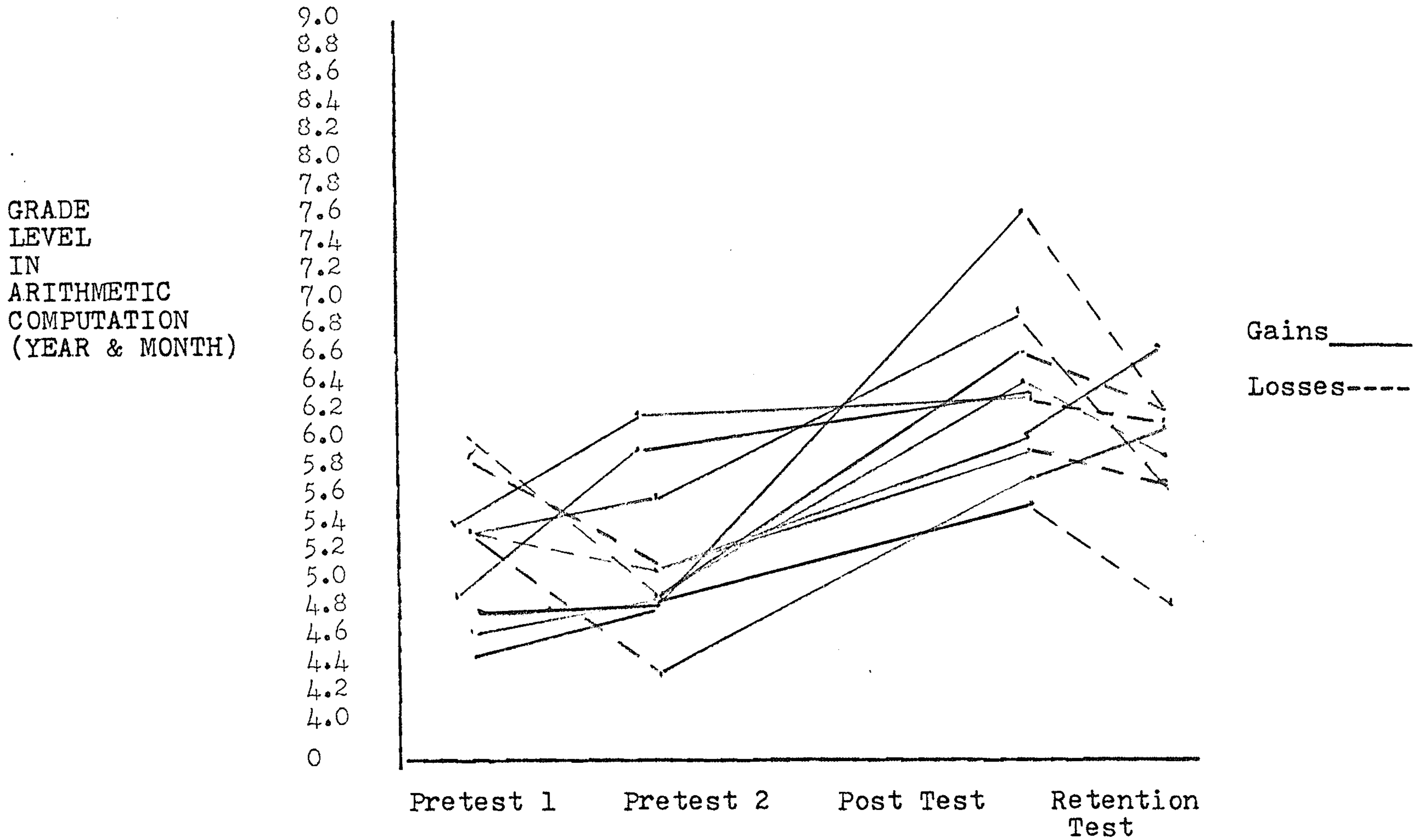


Figure Seven - Learning Curves of the Low-Achieving

Students in the Control Group



Average-Achieving Students - C.A.L. Group

As shown in figure eight, 6 pupils of the 10 in this group made an overall gain from the pretest 2 to the retention test. Of the 10 pupils 6 showed a gain from pretest 1 to pretest 2, 3 showed a decline and 1 remained constant. During the treatment period 9 showed gains and 1 remained constant. During the retention period 3 showed gains while 7 declined. In overall gains, from pretest 2 to the retention test, 6 pupils showed gains while 2 declined and 2 remained constant. The greatest overall gain was 2.1 years. The mean gain was .47 years.

Average-Achieving Students - Tutorial Group

As shown in figure nine, 7 pupils of the 10 in this group made an overall gain. Of the 10 pupils 5 showed a gain from pretest 1 to pretest 2 while 3 declined and 2 remained constant. During the treatment period, 5 pupils showed gains, 4 showed declines and 1 remained constant. During the retention period 4 showed gains, 5 showed declines and 1 remained constant. In overall gains, from pretest 2 to the retention test, 7 pupils showed gains and 3 pupils showed declines. The greatest gain was 3.2 years. The mean gain was .72 years.

Figure Eight - Learning Curves of the Average-Achieving Students in the C.A.L. Group

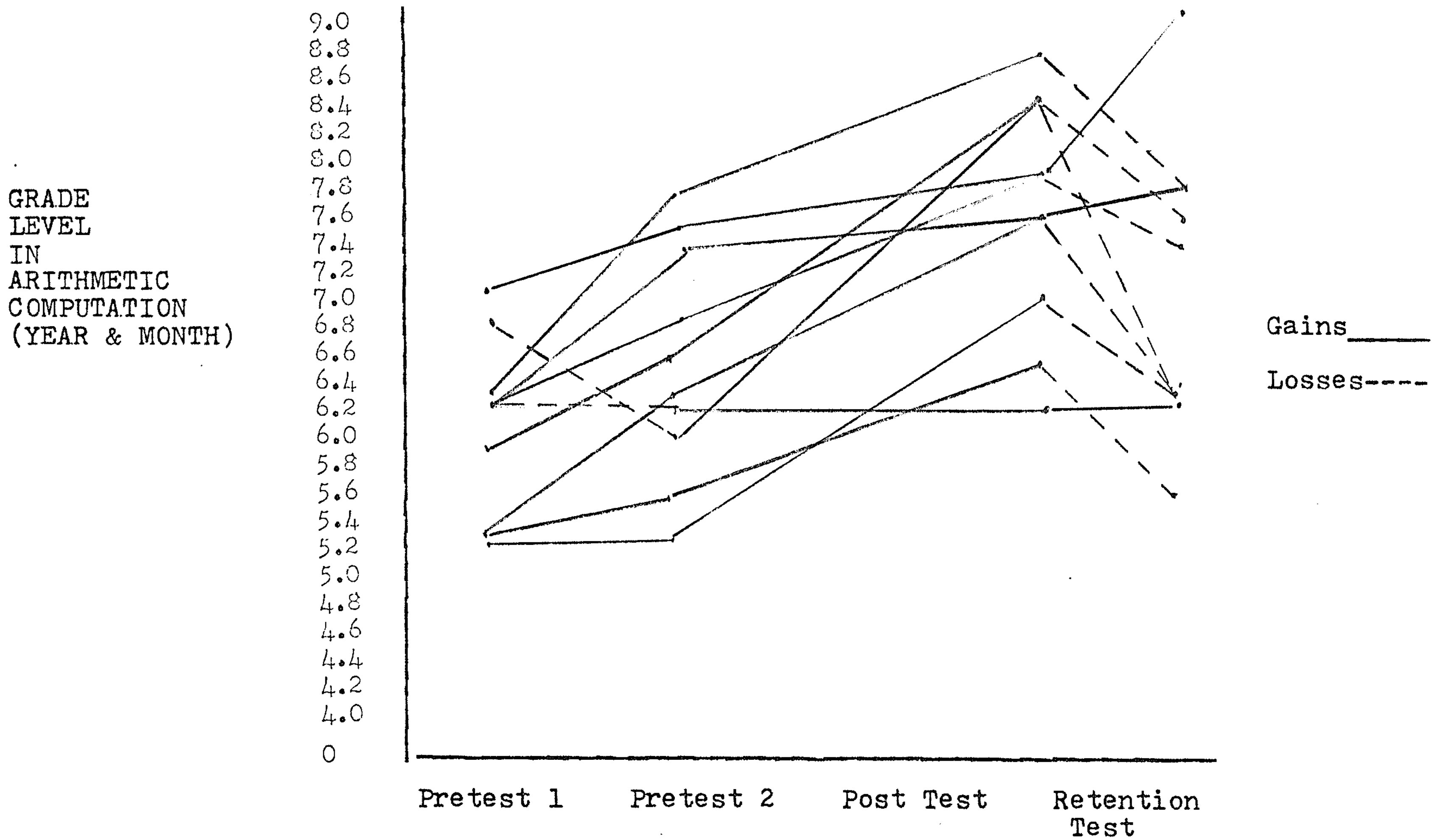
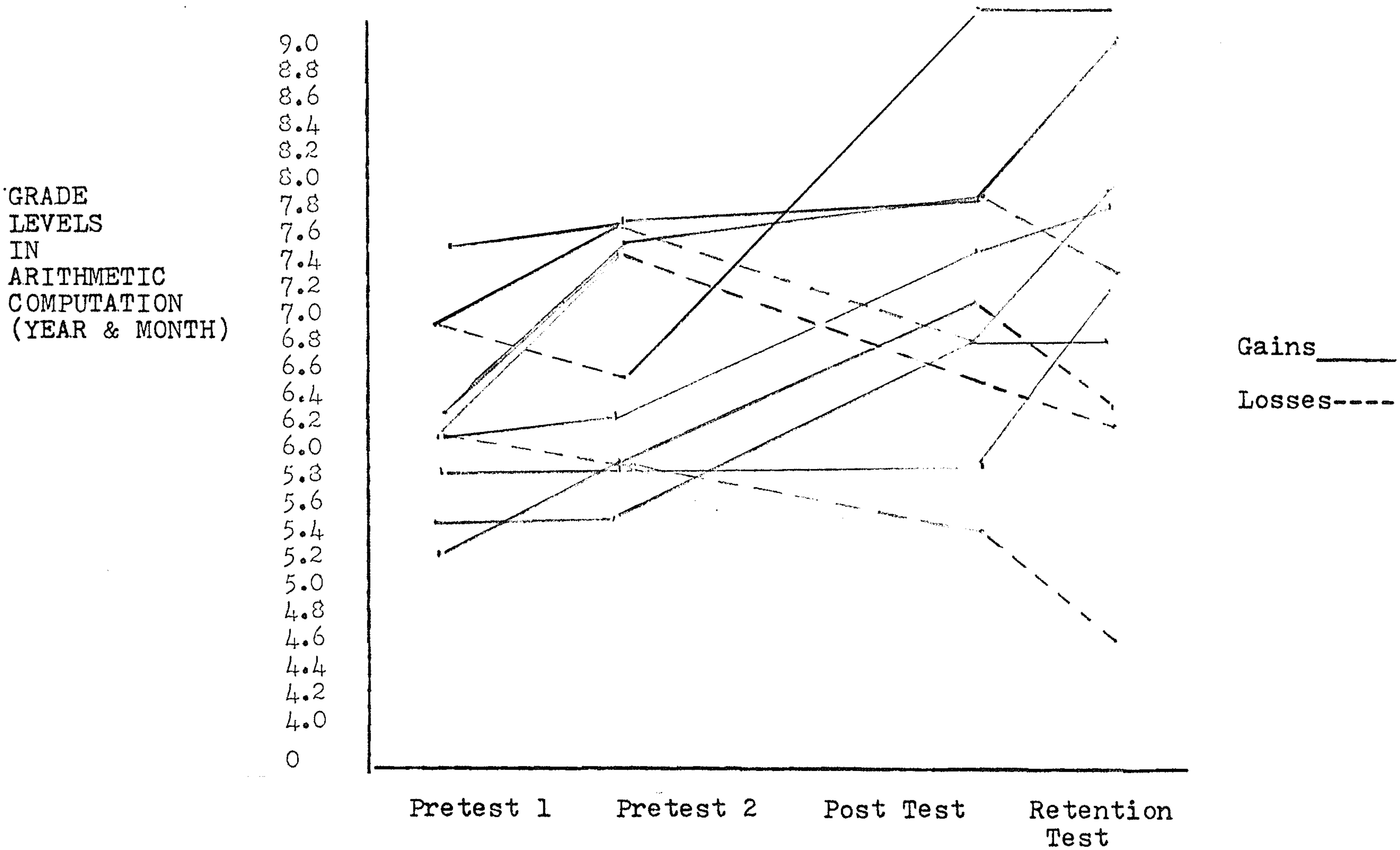


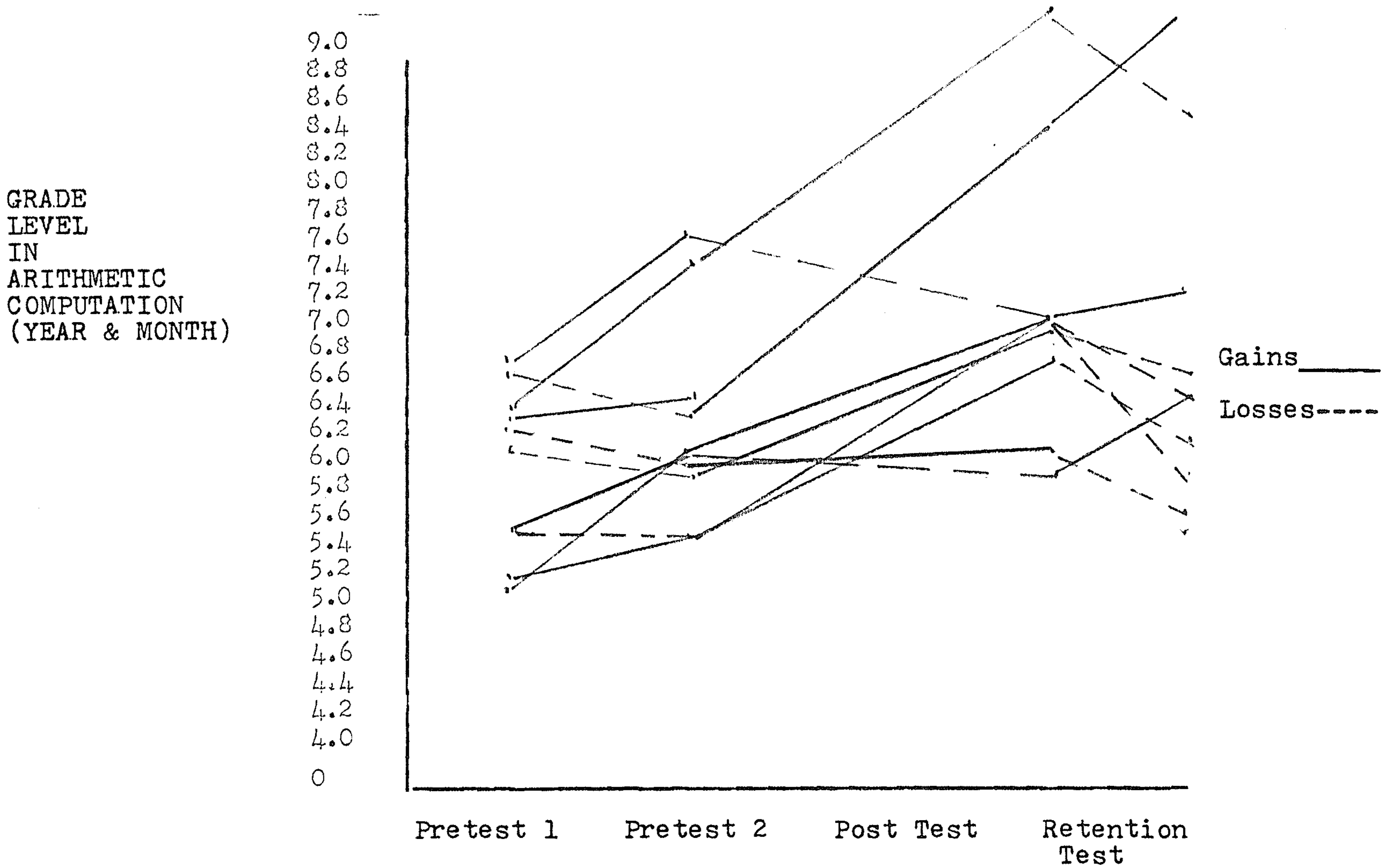
Figure Nine - Learning Curves of the Average-Achieving Students in the Tutorial Group



Average-Achieving Students - Control Group

As shown in figure 10, 7 pupils showed gains from pretest 2 to the retention test. Of the 10 pupils in this group, 6 showed an increase from pretest 1 to pretest 2 while 4 showed a decline. In the treatment period, 7 pupils showed gains while 2 pupils showed declines. One pupil's score was not available at this point. During the retention period 3 pupils showed gains while 6 pupils showed losses. In overall gains, 7 pupils gained while 2 declined and 1 pupil remained constant. The greatest gain was 2.0 years. The mean gain was .58 years.

Figure Ten - Learning Curves of the Average-Achieving Students in the Control Group



APPENDIX J

Summary of Group Data

APPENDIX J

TABLE 13

Summary of Group Data

Low-Achievers

	Gains	Decline	Constant
C.A.L. Group (Figure Five)			
1) from pretest 1 to pretest 2	5	3	2
2) treatment period	9	1	0
3) retention period	1	9	0
4) overall from pretest 2 to retention test	9	0	1
Tutorial Group (Figure Six)			
1) from pretest 1 to pretest 2	4	5	1
2) treatment period	10	0	0
3) retention period	4	5	1
4) overall from pretest 2 to retention test	8	1	1
Control Group (Figure Seven)			
1) from pretest 1 to pretest 2	5	4	1
2) treatment period	9	0	1
3) retention period	2	7	0(-1)
4) overall from pretest 2 to retention test	8	1	0(-1)

APPENDIX J

TABLE 14

Summary of Group Data

Average-Achievers

	Gains	Decline	Constant
C.A.L. Group (Figure Eight)			
1) from pretest 1 to pretest 2	6	3	1
2) treatment period	9	0	1
3) retention period	3	7	0
4) overall from pretest 2 to retention test	6	2	2
Tutorial Group (Figure Nine)			
1) from pretest 1 to pretest 2	5	3	2
2) treatment period	5	4	1
3) retention period	4	5	1
4) overall from pretest 2 to retention test	7	3	0
Control Group (Figure Ten)			
1) from pretest 1 to pretest 2	6	4	0
2) treatment period	7	2	0(-1)
3) retention period	3	6	0(-1)
4) overall from pretest 2 to retention test	7	2	0(-1)