The University of Manitoba

COMPUTER ASSISTED LEARNING FOR PUPILS WITH LEARNING DISORDERS

by

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A Thesis

Submitted to the Faculty of Graduate Studies

in Partial Fulfillment of the Requirements for the Degree

of Masters of Education

Department of Educational Psychology

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ABSTRACT

This thesis investigates computer-assisted learning (C.A.L.) as applied to junior high pupils that have a wide variety of learning disorders. Drill and practice programs were used as a means of teaching basic computation and spelling skills. Three random groups were randomly assigned to C.A.L. arithmetic, C.A.L. spelling, and Non-C.A.L. treatments. All three groups continued to receive regular classroom instruction. The experimental treatment continued for a three month period on an alternate day basis. The subjects were given the Stanford Achievement Test in Arithmetic and Spelling before (pretest 1 and pretest 2), after (post test), and three weeks after the treatment period.

The results of the study showed that there were no significant differences between the three groups. However, significant differences were found over time for both arithmetic and spelling. In arithmetic, differences were found between: 1) pretest 2 and both the post test and retention test ($p < .01$), and 2) pretest 1 and both the post test and retention test ($p < .05$). Similarly, in spelling, differences were found between: 1) pretest 2 and both the post test and retention test, and 2) pretest 1 and the post test, both at the .01 level of significance. An interaction effect was observed for arithmetic, but not for spelling. Further tests confirmed that the significant differences over time in arithmetic were attributable to the gains made by the C.A.L. arithmetic group. Similarly, in spelling the gains over time were analyzed for descriptive purposes and found to be attributable to the gains made by the C.A.L. spelling group.

The results of this study, therefore, indicated some statistical significance and were considered encouraging and significant in the context of special education. For example, in arithmetic from pretest 2 to the retention test, there was a 5.3 month gain for the C.A.L. arithmetic group compared to a 2.0 month gain for the C.A.L. spelling group, and a .5 month gain for the non-C.A.L. group. Similarly, in spelling, the C.A.L. spelling group gained 4.9 months compared to a 1.7 month gain for the C.A.L. arithmetic group and a 1.0 month gain for the non-C.A.L. group.

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CHAPTER I

INTRODUCTION

The computer is a powerful tool with the potential to improve many aspects of education. Instructional applications alone include simple monitoring tasks, tutorial interactions, drill and practice routines, simulations of real life situations, management of instructional sequences, testing, diagnosis, and prescription. Many of the above are included in a general application referred to as computer assisted learning (C.A.L.). Briefly stated, C.A.L. is the use of a computer to provide or assist the instructional process. C.A.L. as used in this study is an adjunct to regular classroom instruction.

Perhaps, one of the most promising uses of C.A.L. in schools is in helping to individualize instruction. In particular, its greatest potential may be in helping to meet the needs of exceptional children--especially those who have experienced difficulty learning under typical classroom conditions and methods. Indeed, a few recent studies indicate that C.A.L. may be a valuable remedial process for the developmentally handicapped. However, most C.A.L. research in the past has centered around normal populations of adults and children.

C.A.L. for pupils with learning handicaps seems to be a valid and logical application, but more research is needed to substantiate this claim. The cost factor of special education programs, combined with shortages of funds, facilities, resources, and well trained special education teachers, make it desirable that more efficient and effective instructional procedures be found.

Pupils with learning problems generally require more personal attention from their teachers than do normal pupils, often to the extent of being incapable of learning or studying on their own. As a result, teachers in these situations tend to perform a great deal of simple drill when their talents and creativity could be better used in higher level planning and interactions with pupils. If, through research, C.A.L. is proven to be an effective help in the learning process, then its use can be justified, and teachers could devote more time to the tasks which revolve around unique human interactions and capabilities.

In spite of many advances in our understandings of the learning process, we as teachers are still greatly puzzled as to how to optimize learning—especially for pupils with learning disabilities. Special education teachers continue to search for instructional methods which will prove to increase motivation and decrease frustration. This task is an even bigger challenge when facing pupils with learning disabilities. Traditionally, it has been this group of pupils which has been the most difficult group to manage, motivate, and assist in the learning process.

A minimum objective for most special education teachers would be to help their students upgrade their basic skills in the two core subjects of mathematics and language arts. However, accomplishing this task has proven to be the most elusive and seemingly the most distasteful for all types of pupils, especially in recent years. Although few educators would deny the importance of learning the basic skills, there seems to have been a decline in emphasis, or at least little advancement in the teaching of basic skills.

It is in the application of drill and practice that C.A.L. may be most helpful, especially pertaining to students who are very weak in these basic academic skills and at the same time "turned-off" from traditional teaching approaches.

Objectives of the Study

An overall objective of this study is to provide a novel learning experience for pupils with learning problems through the use of C.A.L. Another major goal is to evaluate the effectiveness of C.A.L. as a method of improving individualized instruction for pupils in special education programs.

Specific goals are as follows:

1. To provide a learning situation which may help the students remediate their weaknesses in the basic skills of addition, subtraction, multiplication, division, and spelling.
2. To provide greater individualization of instruction to allow the pupils to progress from their particular levels at their own rate.
3. To set up controlled learning situations to study the effects of the computer as an instructional tool in teaching basic academic skills to pupils with learning handicaps.

CHAPTER II

COMPUTER ASSISTED LEARNING AS RELATED TO LEARNING THEORY

An Overview of Computer Assisted Learning (C.A.L.) and Computer Managed Learning (C.M.L.)

The purpose of this section is to explain some of the terminology used in C.A.L. and other individualized instructional techniques.

A concise definition of C.A.L. is the following:

C.A.L. is a man-machine interaction in which the teaching function is accomplished by a computer without intervention by a human instructor. Both training material and instructional logic are stored in computer memory. (Adapted from Salisbury, 1971, p.48).

It should be noted that the term "assisted" in computer assisted learning implies that the instruction supplied by the computer serves only as an adjunct to the regular classroom instruction. Also, it should be mentioned that the terms C.A.L. and C.A.I. can be used and are used synonymously. (Salisbury preferred the term computer administered instruction.)

There are four basic ways of using computers to assist in teaching:

1. Drill and Practice

   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 basis to help in the job of rote memorization.

2. Tutorial

The computer can act as a tutor in presenting information, concepts, explanations, and questions in a running dialogue in an effort to help pupils achieve an understanding of the material being studied. If the questions are not answered correctly the computer could branch to additional explanations, reviews and examples. Thus many programs of this type have built in remedial features.

3. Simulation

In this type of program the pupils are provided with a model of real-life situations in which they are required to act spontaneously to make decisions regarding the problems with which they are faced. Thus, simulation is an active problem-solving situation in which the pupil will learn by trial and error without having the real consequences coming to pass. Under computer control, the pupil can experiment in ways which would be too costly or too impractical in real life. Learning about the problems involved in landing a rocket ship, learning to manage a farm wisely, or learning to manage money and bank accounts, are examples of situations which can be simulated by a computer to teach lessons that would otherwise be too impractical or too expensive to teach under real circumstances.

4. Games

Computerized puzzles in which the students match wits with the computer, or games in which the computer is the opponent, can stimulate interest and motivate pupils to exercise and strengthen their skills of logical reasoning.

Computer Managed Learning (C.M.L.) can be defined as:

A system for educational management that integrates student information, curriculum data, and information on resources in order to assist the teacher in individualizing instruction. (Finch, 1972, p.46)

Thus, C.M.L. is a comprehensive approach that guides the student through a series of curricular paths and experiences (computerized and non-computerized) depending on the needs, particular responses, and performances of the individual.

Thus, computerized techniques can go a long way in supplementing instructional conditions for the learning disabled. In addition to what has been mentioned, C.A.L. and C.M.L. could also be conducted in conjunction with other media such as audio tapes and video slides to accomplish a multi-media approach under the control of a central computer.

The Theoretical Foundations of C.A.L.

Modern examples of teaching machines and computerized instructional devices owe their theoretical roots to the behaviorist movement in psychology and trace back to the educational psychology of E.L. Thorndike.

In Thorndike's connectionism theory, the two main influential constructs were the law of effect and the law of exercise.

The "law of effect" stated that when a changeable connection between a situation and a response is made and followed by a satisfying situation, that connection's strength is increased; when made and followed by an annoying situation, its strength is decreased. (Thorndike 1913). Later, Thorndike's development of the "law of exercise" emphasized the importance of knowledge of results in learning. The mere repetition of the stimulus-response connection was not considered to be enough to ensure the learning of that connection. It was also necessary to confirm the appropriateness of the response. (Thorndike 1932).

More recently, B.F. Skinner presented his distinctions between classical (Pavlovian) conditioning and operant conditioning. This learning model assumes that the learner must be actively involved in the learning situation, and that the correct response must be reinforced or rewarded in order to strengthen the connection. This model of learning has been widely adopted and accepted on the basis of extensive experimentation, both with laboratory animals and human subjects.

Antecedents of C.A.L. and their relationship to learning theory

C.A.L. was also founded from advances in psychometrics and the need for a practical technology which could efficiently administer, score, and provide feedback from psychological tests. Out of this need grew the technologies of automatic testing devices, and later, teaching machines and programmed instruction.

Perhaps the three most influential ideas which have contributed to the development of C.A.L. were the advent of the simple teaching machine and programmed instruction, the concept of individualized instruction, and the instructional behaviorial objectives movement.

Teaching Machines and Programmed Instruction

The first teaching machine was developed by Sidney L. Pressey as early as 1926. However, Pressey's idea to use a simple machine to give tests, score tests, and teach simple drill materials did not become popular until the middle fifties when B.F. Skinner advanced the idea, using his work in operant conditioning as the theoretical foundation. Skinner developed a machine which differed from Pressey's in that the pupil did not have the option of choosing between alternatives. Instead, the pupil was asked to write his own response in a space provided. Also, the instructional sequences or programs were carefully designed so as to hint at what the correct responses should be. This was done to make the occurrence of the correct answer highly probable. Thus, Skinner's machines used programs which incorporated the operant learning principles of immediate reinforcement of original responses, shaping of desired responses, and of over-learning through repetition.

In "The Science of Learning and the Art of Teaching", Skinner (1954) presented his case that the science of behaviorism based on a reinterpretation of Thorndike's law of effect is all that is needed to set the conditions necessary for optimal learning in animals and in humans as well. Criticizing the prominent use of aversive controls in education, Skinner

contended that a better approach would be the consistent use of immediate positive reinforcement for desired behaviors and for the attainment of educational objectives. Also, he suggested that extrapolated findings from operant research have shown that:

1. Positive reinforcement should be immediate and should follow each correct response.
2. It is advantageous to proceed from the simple and familiar to the complex and less familiar through a gradual progression.

This type of program which moves step by step through a single set of material is known as a linear program.

Skinner consistently emphasized that the most important aspect was the arrangement of the instructional materials of the program and not necessarily the teaching machine itself. Also, Skinner (1958) draws a parallel between programmed instruction and individualized tutoring in pointing out the following similarities:

1. A good tutor begins where the pupil is and does not insist on moving beyond what the pupil can comprehend.
2. A good tutor moves at a rate consistent with the ability of the pupil to learn.
3. A good tutor does not permit false answers to remain uncorrected.
4. A good tutor does not lecture, instead by his hints and questioning, he helps the pupil to find and state answers for himself.

Similarly, a good program would include the following features:

1. A program would begin with small easy-to-take steps and gradually lead up to those which are either unfamiliar or too difficult prior to the instructional sequence.
2. Active participation in the learning sequences should take place through one's own reading, thinking, writing, or selecting of answers as opposed to the more passive process of listening to a lecture.
3. Immediate reinforcement of correct responses refers to knowldege of one's results and to continual feedback that one is learning the materials presented.
4. Individualization of instruction is provided for, in that the learner should be allowed to use as much time as necesaary to complete the program and attain the educational objectives stated in the program.
5. Subsequent modifications and improvements to programs are possible and may be desirable based on the results attained by learners going through the program. Thus, changes are to be made until it is highly probable that success will be attained by the learners for which the program was designed.

Individualized Instruction

Another influential factor in the development of C.A.L. has been the long standing issue in learning theory termed "individual differences". These individual differences include differences in learning rates, abilities,

backgrounds, styles, and behavioral characteristics. Based on the question of how individual differences affect learning, educators have again become interested in how to meet the individualized needs of pupils in a school system which is still geared largely to masses of students.

In a brief history of individualization, Blake and McPherson (1969) state that recognition of individual differences in learning dates back to ancient times. Also, it is suggested that in the one-room schools of the past, pupils proceeded on an individual basis rather than in uniform groups. Each child learned at his own rate, and he was allowed to learn as much as possible. As educational advantages were offered to a larger selection of growing population, it became necessary to deal with pupils in "grade-level" groups, and individualized instruction began to disappear. This marked the era of the textbook approach which dictated the lecture and uniform teaching to so-called homogeneous groups. The authors go on to define individualized instruction to mean:

> That the learning program for each curriculum area is organized in such a manner as to allow each child to move at his own pace under the guidance of his teacher. Instruction is non-graded, enabling each child to go so far in each subject as his ability permits. Careful records are kept on each child's progress. (Blake and McPherson, 1969, p.64).

Similarly, in support of individualized instruction, Burns (1971) states that no two living organisms are alike. People differ in learning rates, learning methods, problem solving approaches, repertoires of responses, patterns of interests, motivation to learn, goals, readiness

to learn, capacity to learn, and values. In summary, it is stated that individualized instruction is a natural way to learn--a concept of instruction which accounts for learner needs, habits of study, and time requirements.

In recent years, individualized instruction has come to mean meeting the educational needs of each learner by customizing curriculum and instructional strategies. Although the need for individualization seems to be accepted by a majority of educators, especially with respect to special education, very little is actually known on the basis of research about the interactions between learning and individual differences.

In the future, C.A.L. is expected to help in the job of researching the many questions raised by the interaction between learning and individual differences, optimizing the learning and instructional processes, and individualization of instruction. The computer is considered by many to be the most promising tool in the job of optimizing the learning, instructional, and research processes (Atkinson 1967), (Smallwood 1970), and (Fishman 1969).

Behavioral Objectives in Education

The main message of the behavioral objectives movement was that the goals of instruction must be stated as behaviors which can be objectively observed and measured under specified conditions at the end of a given learning experience (Bloom 1956) and (Mager 1962). This principle can be traced back to many sources including the programming and teaching machines movement, behavior modification, and individualized instruction,

Evaluation at the end of a learning sequence is usually done according to a given standard of time and/or margin of error. In short, educational objectives, where possible, should be stated in behavioral terms or operationally to facilitate evaluation.

Behavior Modification and Instructional Technology

What are the relationships between behavior modification, instructional theory, and the instructional technologies and principles mentioned above? Behavior modification instructional practices refers to the use of operant learning principles in the design and improvement of instruction. Programming, teaching machines, and individualized instruction, are examples of applications of the concepts of behavior modification methods and the operant learning theory. The principle of stating educational objectives in behavioral or operational terms is an example of the widespread application of an operant learning principle which is inherent in all of the above positions or procedures. It is noteworthy that the programmed instruction movement placed great emphasis on stating behavioral objectives as a first step in planning instruction.

Instructional Strategies of C.A.L. as Related to Learning and Instructional Theories

The instructional principles inherent in C.A.L. are, in part, the same as those which underlie programming and teaching machines, individualized instruction, and behaviorally stated instructional objectives. The present state of C.A.L. is based on and incorporates elements of all three of the above learning positions or strategies, both in a theoretical

and practical sense. Thus, the theoretical basis for C.A.L. is derived in part from operant learning principles and behavior modification instructional theory. But C.A.L. can and does go beyond these principles. This point will be expanded upon in a following section of this chapter.

Advantages of C.A.L. and the Principles of Learning and Instructional Theories

Many of the instructional advantages offered by C.A.L. are similar to those claimed for programmed instruction. For example, Gerard (1967) lists C.A.L. advantages as better and faster learning, learning at the student's own pace, better instruction because of expert authors, and eliminating routine drudgery for the teacher. Carpenter (1970) in reviewing general advantages, states that C.A.L. can regulate timing, duration, and types of materials used in learning. Also, it can assess learner responses and "branch" to remedial or enrichment routines within the same program when necessary. Crowder (1959) who developed the branching technique in programmed instruction, believed that pupils who are ill-prepared should be able to go back to similar materials, and if well-prepared, to by-pass some unrequired work. C.A.L. provides the maximum flexibility in the branching technique of providing alternative paths.

A further unique advantage of the computer is the prospect of testing, evaluating and researching the learning process, and in developing and testing instructional materials. Implied in the above is the ability to diagnose learner strengths and weaknesses in skills and aptitudes.

While branching is possible in programmed instruction, only C.A.L. can provide numerous tracks, utilizing various other media depending on

various parameters including recent response patterns, latency of responses, and individual learning characteristics.

C.A.L. and Other Learning Theories

A taxonomy as outlined by Bloom (1956), and the specification of behavioral objectives, can help teachers define more carefully the end results of an instructional sequence. However, they offer little prospect of determining how to get the pupil to do what is specified in the objectives. Can recent learning theory suggest how to best engineer learning experiences for learners?

C.A.L. is derived from programmed instruction and individualized instruction, and therefore has stimulus-response learning theory as part of its foundation. However, C.A.L. is related to other learning theory as well. The type of learning described as stimulus-response (S-R) learning in the operant model is far too simple to explain the complex behaviors which are learned even by young children. Thus, the operant model is probably more applicable during the early life of a child, or in cases of retardation. As a naive learner becomes more capable of verbal communication, simple S-R learning becomes less important in terms of adapting and adjusting to the social and physical environment, and in learning other complex behaviors.

The developmental theories of Piaget (1936), Ausubel (1968) and Gagne (1964) have helped to identify developmental variations in learners in perception, objectivity-subjectivity, the structure of ideas and the nature of the thinking process itself. Most promoters of C.A.L. have neglected relevant factors as they relate to the learning process. As a result, there has been no serious attempt to relate developmental principles

of cognitive growth to applications of C.A.L.

When we consider learners who are developmentally advanced, we would acknowledge that as maturity increases the individual perceives the world more in general, abstract, and categorical terms, and less in tangible, time bound, particularized contexts. (Piaget, 1958). In other words "there is an increase in the ability to comprehend and manipulate abstract verbal symbols and relationships without the benefit of direct tangible experience, concrete imagery, and empirical experience with particularized instances of a concept". (Edwards 1970).

Typically, curriculum for C.A.L. is organized into topical units without regard to the hierarchical relations of those units on an abstract level, (Ausubel 1968). Usually, units are treated as though they are equivalent within the learner's cognitive framework.

Recently, Gagne (1965) has attempted to set down a hierarchy of types or levels of learning. The learning types as defined by Gagne, listed in order of increasing complexity, are as follows:

1. Response learning
2. Identification or multiple discrimination learning
3. Chain or sequence learning
4. Associative learning
5. Concept learning
6. Principle learning
7. Problem solving
8. Strategy learning

It is of primary importance that teachers or C.A.L. writers realize that there may be many forms of learning and that instruction should

reflect as many levels as possible—not just simple memorization of facts or response learning. For example, it is important in C.A.L. and other instruction that all prerequisite tasks and learning abilities have been developed prior to introducing new tasks or higher levels of learning. It has been suggested (Gagne, 1964), (Hicks and Hunka, 1972), that by following this model of types of learning combined with proper organization of subject matter and behavioral objectives, the instructor is much more likely to help a learner in the learning process.

In the writer's opinion, Gagne's model of learning and suggestions for instruction (C.A.L. or otherwise) are excellent guidelines to follow in planning instruction. Gagne outlines four aspects of the educational process for which ideas and guidelines can be derived from his taxonomy:

1. Planning behavioral objectives and delineating prerequisite capabilities before instructions.
2. Management of the learning situation to help insure motivation and involvement, as well as suggestions about content and necessary conditions.
3. Planning and testing instructional procedures to help optimize learning.
4. Selecting media which will provide greatest effectiveness in assisting the learning process.

Gagne's model of learning types and his instructional theory have received positive reviews and evaluations (Hilgard and Bower, 1966), (Snelbecker, 1974), (Hicks and Hunka, 1972). Hilgard and Bower suggest that his taxonomy may be "the beginning of a unified theory of learning"

(Hilgard and Bower, 1966, p.569). This writer believes that the strategies and instructional principles inherent in C.A.L. are supported theoretically in the framework of Gagne's model of learning and instructional principles, and conversely, that Gagne's theory is a good one to follow in planning and developing C.A.L.

Most of the eight types of learning seem well established and supported in previously developed learning theories and empirical studies (Snelbecker, 1974). Types one to four seem to be especially well documented, while types five to eight require further research. Also, Gagne's entire theory of instruction will require systematic research to test the value of this approach as an instructional theory per se.

However, the usefulness of Gagne's model as a theoretical and practical springboard seems rather tenuous. Ideally, in C.A.L. the inanimate computer should simulate the good educational practice of a teacher in planning and instruction. The computer can be programmed to show capabilities similar to those described by Gagne. In a sense, there exists a parallelism between learning in a human and what we must program a computer to do. Also, in executing a program, a computer will display many activities analogous to thinking and learning in humans, a field of study known as heuristics. For example, in C.A.L. the computer may branch to several different subroutines depending on the response of the learner and other pertinent factors. This procedure is akin to stimulus and discrimination learning in humans. Research in the uses of computers to simulate and externalize the human thought processes,

have resulted in studies in "artificial intelligence". From these studies have flowed new ways of looking at cognitive processes and theories of learning. It seems reasonable to suggest that as these and other new models of learning are developed, including mathematical or statistical learning theory, C.A.L. will receive further theoretical support and practical advancement.

CHAPTER III

REVIEW OF INDIVIDUALIZED INSTRUCTIONAL TECHNIQUES WITH EMPHASIS ON TECHNIQUES USED FOR PUPILS WITH LEARNING PROBLEMS

Description of Exceptionality and of Pupils with Learning Disabilities

The type of pupils involved in this study can be referred to as exceptional children in a very broad sense. The exceptional child has been defined as "the child who deviates from the average or normal child in mental, physical, or social characteristics to such an extent that he requires a modification of school practices, or special educational services, in order to develop to his maximum capacity."(Kirk,S.H., 1962,p.4-5).

Excluded from this study are pupils who deviate physically. The physically handicapped are usually trained under special facilities found at schools such as the Ellen Douglass School in Winnipeg, Manitoba. Also excluded are those exceptional pupils whose mental or intellectual abilities are at the higher than normal end of the scale of comparison.

Thus, the type of pupils involved in this study are those with emotional and learning disorders. This description is a broad classification which may be defined more specifically to include one or more of the following categories:

1. Children who are neurotic or psychotic, or who exhibit behavior disorders.
2. Children with an overall learning deficit—the slow learner or the borderline, educable retarded.

3. Children with specific learning disabilities or deficits (excluding the physically handicapped).
4. Children with sensory handicaps likely to lead to a secondary learning or emotional problem (excluding the deaf and the blind)
5. Children who are judged to be delinquent-children whose family or community experience leads to cultural or emotional deprivation (adapted from CELDIC report, 1970, p.19)

The terms: "slow learning pupils", "pupils with learning difficulties", "pupils with learning problems, "the learning disabled child", have all been used to describe the pupils of Central North School. The preferred terms to be used in this study will be "pupils with learning problems" or "children with learning disorders or disabilities". These terms will be used to refer to children included in this study who fit into one or more of the above mentioned categories.

Teaching Machines and Programmed Instruction

The advantages and features of C.A.L. generally follow the pattern provided by programmed instruction. Like programmed instruction, simple teaching machines and other related technologies have been used successfully as instructional aids in special education programs. Several examples of such programs are the following:

Malpass (1963) tested the effectiveness of automated instruction with E.M.H. (Educable Mentally Handicapped) and T.M.H. (Trainable Mentally Handicapped) institutionalized children. Significant results were obtained in the teaching of word recognition, spelling, and reading

skills. The results also showed that automated teaching methods were more effective when compared to traditional classroom instruction. Levels of retention were significantly higher after a period of sixty days for groups which received automated instructions.

A study by Olton (1967) investigated the extent to which increments in thinking and problem solving skills could be produced by the use of self-instructional programmed lessons. A program called "The Productive Thinking Program" was administered to forty-four of forty-seven fifth grade classes in Racine, Wisconsin with sixteen programmed lessons given one per day for four days per week. The teacher's role was kept to a minimum. Comparison of pre and post-test of a random sample of eight males and eight females (704 pupils) revealed significant increments on thirteen out of forty problem solving and divergent thinking criteria. These improvements occurred regardless of sex or level of intelligence.

Platt and others (1966) studied automation with mentally retarded and/or emotionally disturbed youths age 16 to 20 with I.Q. ranging from 70 to 90. Various audio-visual devices such as the Graflex Audio-graphic Instructor, were used to present programmed materials. Data analysis revealed that the automated method was usually more efficient than the conventional and programmed lecture method. However, the most effective method was one which integrated convential and automated instruction.

Malpass (1966) examined the effectiveness of programmed instructional materials in the teaching of basic reading skills to slow learning,

culturally deprived children aged six to nine. Forty-five children were divided into one control group receiving only traditional classroom instruction while one experimental group received programmed workbooks and another experimental group received instruction by means of a teaching machine. The results of comparison on post test vocabulary improvements showed significant gains for the machine-taught over the control and workbook-taught over the control group, but no significant difference between machine-taught and workbook-taught groups.

Oneaspect of an experiment conducted by Metzger (1966) was designed to determine theefficacy of a teaching machine to teach basic addition facts to Educable Mentally Handicapped (E.M.H.) pupils. Analysis of pre and post-measures indicated that teaching machines and programmed materials are successful with E.M.H. pupils. It was also found that E.M.H. children can learn arithmetic facts by rote if given enough time.

Most studies comparing P.I. to regular instruction have shown P.I. to be more effective or more advantageous. Contrary findings, however, are reported in a study by Bornstein (1964). In this study it was suggested that P.I. was no more effective than the lecture method in teaching high school mathematics to deaf students. Also, P.I. was found to require as much and often more time than the lecture method.

However, in 1966 Johnson conducted a study on teaching arithmetic to mentally retarded subjects and found that a group using a programmed sequence in combination with conventional classroom lessons showed significantly better results than the groups using:

1. A program designed by Johnson

2. T.M.I. Grollier's Elementary Arithmetic: Addition and subtraction Facts, and

3. Conventional classroom lessons.

The way in which programs are used often makes a difference. For example, in 1967, Higgins and Rusch showed that arithmetic concepts were effectively taught to E.M.H. children using a teaching device with audio-visual facilities and that going through the program twice produced higher post test scores than going through it once.

Steg (1968) and Bender (1968) studied the effectivenesss of various teaching machines that were designed to teach reading and other language skills to disadvantaged pre-kindergarten children. The machines reported on were called the Edison Responsive Talking Typewriter and the Story Telling Automated Reading Tutor. Both machines were effective in teaching some of the basic language skills. Results indicated that the automated techniques were in general more efficient than regular classroom instruction.

Warner (1967) researched the effectiveness of programmed instruction in phonic skills with three groups of exceptional children--seven mentally retarded, five neurologically impaired, and seven emotionally disturbed. An analysis of the results disclosed that the mentally retarded and the emotionally disturbed made significant gains between the beginning and terminal performance. Girls, and those below the mean age of eight, made better progress than those whose age was greater than eight.

In a large sample study using seventy retarded pupils in a treatment group, Dezelle (1971) compared programmed instruction in arithmetic to regular classroom methods taught by five teachers experienced in teaching the retarded. Although no significant differences were observed between pre and post test administrations of the California Achievement Test, the experimental group using programmed instruction showed the largest gains.

Rosen and Piper (1972) set up an individualized classroom for disruptive pupils. The classes were given individualized P.I. in all subject areas. All the pupils were between 12 and 17 years and were below average in ability. A token system was used and the tokens were redeemable for such rewards as vouchers to restaurants or tickets to sporting events. Comparison between achievement scores before and after the introductions to the tokens showed a gain in mean scores to be significant at the .01 level of confidence. Removal of the token system caused the mean scores to drop to the .1 level of significance. Re-introduction of the token caused the performance to rise even higher than at the first implementation of the token system.

This brief review tends to indicate that methods of individualized instruction such as programmed instruction and teaching machines have been beneficial for basic skills learning in children with learning disabilities. More comprehensive reviews of the literature in the area of programmed instruction and teaching machines can be found in Leith (1966), Malpass (1967), and in Sandals (1973) with respect to the

developmentally handicapped. The results of research clearly show that children can acquire and retain basic academic skills by means of programmed instruction.

C.A.L. in Mathematics with Emphasis on Pupils With Learning Problems

The advantages of C.A.L. for the disabled learner have been studied at an increasing rate in the last few years. Many of these studies have indicated that the instructional features of the computer can provide learning conditions which accommodate the needs of pupils with learning disabilities.

Most studies reviewed are studies in which effectiveness was measured by student achievement resulting from C.A.L. as compared to achievement resulting from other methods of instruction. Most studies have provided C.A.L. to pupils in addition to regular classroom instruction. As shown in Table 1, when that is the case, all studies reviewed have shown regular classroom instruction supplemented by C.A.L. to be more effective than or equal to classroom instruction alone. Examples of some of these are the following:

Sandals (1973) used C.A.L. as a means of teaching the social and mathematical skills involved in the process of banking and budgeting to developmentally handicapped young adults. Concepts such as budgeting, making deposits, and making withdrawals were taught by means of a slide presentation and teletype terminal. Significant differences were obtained between pre test and post test and between pre test and retention test administrations of criterion tests. It was concluded that a computer was an effective tool in teaching social skills

to retarded learners and that the material can be retained and transferred to new but similar conditions.

Knutson and Prochnow (1970) also showed that C.A.L. could effectively be used to teach money management skills to the retarded. The computer facilities included a teletype terminal with a keyboard overlay and slide presentations with corresponding audio instruction. Significant differences were found between pre and post test scores for children using this system.

Palmer (1973) reported on three separate studies on C.A.L. in the subject of mathematics. The mathematics programs were designed as a means of helping students improve in their basic skills and to help teachers manage diagnostic and prescriptive information. The California Test of Basic Skills and the California Achievement Tests were administered as pre and post tests to an experimental group receiving C.A.L. in mathematics and to control groups. In general the results showed that: 1) the mean test score for the experimental group exceeded those of the control group, 2) a higher percentage of experimental than control students exceeded their expected growth rates for the period, and 3) the students who received C.A.L. experienced growth rates substantially beyond normal expectations. Control group students did better on tests of reasoning ability than did C.A.L. students, possibly because the C.A.L. did not stress reasoning skills. It was concluded that the program proved economical, promoted student learning of basic skills, reduced the teacher's remedial work, and helped in diagnosis and prescription of student academic needs.

A study conducted by Davies (1972) was set up to determine if students using C.A.L. in the "STRANDS" mathematics program do significantly better than students not using the computer and if there may be significant changes in attitude towards self, mathematics, teachers, and machines on the part of the student using the C.A.L. Approximately 240 students from grades two through six were involved in the study and were generally in the low ability range. The Stanford Achievement Test and Semantic Differential were used. It was discovered that pupils using the C.A.L. performed significantly better in computational skills than those not using the computer. Also, no significant shift in attitudes, either positive or negative, took place.

However, on the question of the attitudes of pupils, parents, or educators toward the use of C.A.L., many other researchers report results in favor of C.A.L. Some of these studies cited later in this chapter include the works of: Golub (1974), Perry (1973), Morgan (1975), and King (1975).

Beech and others (1970), for example, reported an extensive survey of the feelings of both parents and pupils towards a Dial-a-Drill mathematics program used in New York City. The attitudes of both the pupils and parents were found to be quite positive—an interesting result considering that the sample was drawn from a population with a generally negative attitude towards education.

A comprehensive review dealing with the question of whether C.A.L. leads to feelings of "dehumanization" or "depersonalization" can be found in King (1975). Attitudes were explored towards various modes of C.A.L.

before, during, and after its use. It was found that computer-based instruction is not a threat to the process or spirit of humanization and that it can provide the opportunities for increasing personal interactions between educators and pupils.

Durward (1973) used C.A.L. in arithmetic, with sixth and seventh grade pupils. The samples consisted of three groups: a "C.A.L. group" receiving five minutes of C.A.L. in arithmetic per day in addition to regular classes; the "Help group" receiving five minutes of group instruction in addition to regular classroom instruction; and the "Zero group" receiving no additional instruction. The results indicated that the C.A.L. improved arithmetic skills and that it was superior to an equivalent amount of classroom instruction, although none of the results were statistically significant. It was also found through questionaires that teachers considered the project beneficial.

In an interim report Romans (1974) described a project which aimed at developing problem solving skills as well as teaching content—both at the same time. The project was successful in teaching math content through a sequence of problems in which the pupils induced rules and generalizations from examples. The experimenter reported that 88 percent of the students taught by this program reached the course objectives.

Many studies have also reported on the effectiveness of C.A.L. according to ability level. In general, these studies tend to indicate that C.A.L. is most effective when it is used by pupils who are below grade level or more effective for low ability pupils than for average or high ability pupils. Examples of such studies are cited below.

TABLE ONE - Studies That Involve C.A.L. in Mathematics

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	Maths (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.

Prince (1969) used C.A.L. effectively with disadvantaged children. Drill and practice mathematics programs were used in seventeen elementary schools. At the end of one year in the project, a significant educational difference was found between groups using C.A.L. compared to the control groups. Results of a more intensive study in the second year showed that there was no significant difference between groups of high I.Q., high income, pupils of C.A.L. and regular classroom instruction; but significant differences were found in favor of C.A.L. in Negro and low income groups as compared to the other groups.

Street (1972) also studied the use of C.A.L. to improve arithmetic basic skills of disadvantaged elementary school pupils. Results of this study did not show a significant difference between C.A.L. groups compared to control groups on the basis of standardized test scores. In some individuals minor increases were noticed. The lack of significant increases were attributed to: 1) Frequent computer breakdowns, 2) Programs that did not meet the instructional needs of the pupils, and 3) Lack of proper supervision of students and programs being used.

Crawford (1970) studied the role of C.A.L. as a method for presenting remedial programs in arithmetic for underachievers. The experimental group received C.A.L. in addition to the regular classroom instruction which was the only method used with the control group. The experimental group was found to have significant gains educationally although no statistical significance was attained between post test scores. It was suggested that this shortcoming was due to equipment failures, lack of sufficient staff training, absenteeism of students, and insufficient experimental time (eight weeks).

Suppes and Morningstar (1969) evaluated the use of drill and practice programs in mathematics for grades one through six in a Mississippi School. The results of the study showed that in each of the six grades, the improvement in grade levels achieved by pupils who were randomly assigned to C.A.L. was significantly greater ($p < .01$) than that gained by the control pupils. The difference in grade levels ranged from .41 to .88 in favor of the C.A.L. students.

In another report Suppes (1972) reported that third grade students in California and Mississippi whose regular instruction was supplemented by C.A.L. gained 2.28 and 2.03 in grade levels for computational ability in one year.

Martin (1973) and Suppes and Morningstar (1972) reported results according to ability level. Both studies found C.A.L. drill and practice in arithmetic to be more effective for low ability pupils than for pupils who were of average or above average ability.

Arnold (1970) and Scrivens (1970) found that after one year of C.A.L. in mathematics, the differences in achievement between pupils whose arithmetic instruction was supplemented by C.A.L. drill and practice and pupils who received regular classroom instruction were: 0.3 grade levels for grade two, 0.5 grade levels for grade three, 0.4 for grade four and 0.5 for grades five and six, all in favor of the C.A.L. groups.

In addition to the studies that have shown gains in achievement through the use of C.A.L., many studies also report that C.A.L. helps to save time in the instructional process. Some have also shown that, even

though C.A.L. does not always result in greater achievement, the time it takes pupils to learn is usually reduced. For example, Edwards (1975) cites nine studies that show reductions in time required to learn, compared to conventional methods. Six of these studies show equivalent achievement comparisons while three produced greater achievement in favor of the C.A.L. Following in this section are a few examples of some studies which show a reduction in learning time.

Student control of learning was studied by Jacobson (1975). The first step of the plan was self-management. Students were given a strategy for the curriculum decision making and the responsibility for applying that strategy. Two interactive computer programs were included as instructional alternatives within the self-management system on the rationale that computers are responsive, yet still under student control and are therefore uniquely adapted for self-controlled learning environments. Students in fourth and fifth grade were able to effectively manage their learning in elementary mathematics and apparently learned faster and retained material better than a comparative group of students.

Studies relating achievement in arithmetic to the amount of C.A.L. have been conducted by Jamison and others (1973). Involved were over 400 fifth and sixth grade pupils. Results have shown that boys, for example, who received 150 ten-minute C.A.L. sessions per year could expect a .58 grade level gain exclusive of any gain attributable to classoom instruction.

Suppes and others (1973) similarly reported a study that gave C.A.L. in mathematics to 312 deaf pupils who were below grade level in elementary

and secondary classes. These researchers demonstrated that, assuming 150 ten-minute C.A.L. sessions per year, a grade level increase of 1.26 years could be expected and attributed to the C.A.L. intervention.

Hill (1976) investigated the use of C.A.L. with physically handicapped children in the area of computational skills. The C.A.L. drill and practice programs used were essentially the same as those which were developed and adapted for use in this study. One of two randomly selected groups received C.A.L. in addition to the regular classroom instruction, which was given to both groups. Although the results showed no statistically significant differences between the two groups, some results were considered educationally significant. The experimental group for example, showed an increase of seven months during a four month period compared to a three month gain for the control group during the same amount of time.

C.A.L. in Language Arts

Studies involving language skills are not as common as those involving mathematics skills. This may be because of the difficulty of writing effective programs to teach the basics by C.A.L. There are limitations inherent in C.A.L. programs that use the visual instructional sequences only. For example, spelling programs are difficult to construct without the use of an audio component. However, programmers and resourceful teachers have combined to develop some excellent language skills programs in the last few years. Table Two shows a summary of the studies reviewed using C.A.L. in language skills. Following are examples of some studies that have been based on language skills programs:

TABLE TWO - Studies That Involve C.A.L. in Language Skills

STUDY	MODE	SUBJECT	GRADE/AGE LEVEL	RESULTS
Atkinson (1968)	Mixed	Reading	Intermediate	+
Brebner & Others (1975)	Mixed	Remedial Reading	Grade 6	+
Bubba & Thorhallson (1973)	Drill & Practice	Spelling	College	+
Caldwell (1973)	Mixed	Reading	14-18 (yrs)	+
Dunwell (1972)	Drill & Practice	Spelling	5-8 (yrs)	+
Elfner (1973)	Drill & Practice	Reading	E.M.R.*	+
Fletcher & Atkinson (1972)	Tutorial	Reading	Grade 1	+
Golub (1974)	Mixed (tutorial)	Reading	14-24 (yrs)	+
Green (1968)	Drill & Practice	Word & Letter Recognition	4 yrs (disadvantaged)	+
McEwan (1975) and Robinson	Mixed	French	Secondary Grade 10	=
Nelon (1972)	Tutorial	Vocabulary	Elementary (E.M.R.)	+
Perry (1973)	Mixed	Reading	Secondary	+
Wilson & Fitzgibbon (1970)	Drill & Practice	English	4 - 5	

Caldwell (1973) devised a study to compare the usefulness of C.A.L. compared to programmed instruction. The same program was delivered to two groups of subjects between the ages of 14 and 18 with reading levels below fifth grade. The reading programs were designed to teach semi-literate adolescents through the use of occupational information. Significant differences were found between pretest and post test achievement scores for both groups using a criterion-referenced reading test. This was an indication that each method was successful in enhancing the achievement of the pupils. However, a comparison of pretest and post-test means for both groups revealed no significant advantage of one method over the other.

The concepts of mastery learning and the use of criterion referenced testing is increasingly being used in C.A.L. for both the management of the curricular sequence and also for post test evaluation. Thus an important effect may be that C.A.L. may help a majority of pupils improve to a minimal level of competence, compared to the traditional approach where perhaps only a minority may reach a minimal level of mastery.

Elfner (1973) reported on a three year reading development program for forty mentally handicapped children. The project offered C.A.L. in a programmed format in the first year. The second year involved a conversion from C.A.L. to computer managed instruction. In the third year a system of supplementary instruction was presented without the computer. Some of the conclusions were: 1) the E.M.R. pupils required more drill and practice than originally thought 2) significant gains were made by the forty pupils, and 3) those who took more time to respond to test questions on the computer

showed more gains in objectives successfully passed on the post-test.

In spelling, Dunwell and others used a C.A.L. course called "WRITE" to help fifth to eighth grade pupils with spelling and word usage. The course used an IBM 360 computer and the Coursewriter III language. Pupils received self-paced drills at a typewriter terminal. The stress was placed on spelling rules and patterns and the teaching was through the use of examples. Results on the Lincoln Intermediate spelling test using an experimental-control, pre and post-test design, showed that the experimental group made significantly greater gains. It was concluded that C.A.L. was an effective means of teaching spelling, that it was sensitive to individual needs, and helpful in remedial work with weaker students. (Dunwell and others, 1972).

In Red Deer College (Alberta) a C.A.L. program is being used to examine the ability of the computer to drill students in spelling. The program called "Spelling Clues" runs in Fortran IV on an IBM 360/67 computer and covers a list of 100 frequently misspelled words. Students are asked via audio-tapes to spell the words; the accompanying dialogue responds to both the correct and incorrect answer, analyzes errors, provides examples of usage, and reminds students of basic spelling rules. Students control the sequence and pace of their individual programs and work in an atmosphere of privacy and anonymity. Formal evaluations have not yet been conducted, but preliminary indications are that the program is successful. (Bubba and Thorhallson, 1973).

At a major Canadian centre for C.A.L. in Calgary, Alberta, research is progressing in the fields of C.A.L. for the developmentally handicapped

(Hallworth and Brebner, 1975), individualized remedial reading (Brebner and others, 1975), and computer based vocational counselling systems (Hallworth and others, 1975), all of which are showing positive results and signs of gaining acceptance and wider application.

In the individualized remedial reading program, for example, a controlled experiment was carried out to determine the effect the project was having on pupil achievement. Two groups were set up—the first group contained the thirty-five poorest readers from the sixth grade as measured by the Canadian Test of Basic Skills, while the other group consisted of another sixty-five pupils. The first group used the C.A.L. system entirely, while the second group continued with a traditional program. A statistical analysis revealed a significant difference in favor of the first group.

"Students enjoyed using the terminals. For a period of two years, the use of the management system has provided a strong motivation to improve reading and it continues to do so. This may be a Hawthorne effect, but can hardly be objected to if it becomes permanent." (Brebner and others, 1975, p.562)

In Edmonton, Alberta a study was designed to determine the effectiveness of implementing a C.A.L. project entitled "FRAND", as a part of a regular course of study in secondary school French. (McEwan & Robinson, 1975). The purpose of FRAND was to teach reading and writing skills by means of a linguistically structured progression using the instructional principles associated with mastery learning theory. C.A.L. pupils were matched to

control pupils on the basis of aptitude and attitude scores, [Modern Language Aptitude Test, (Carroll and Sapon, 1959) and selected scales of the National Test Battery (Gardner and Smythe, 1975)]. At the conclusion of C.A.L., achievement scores were compared for both groups. No significant differences between groups on mean achievement scores were found.

Fishman and others (1969) wanted to find the optimum methods of spelling instruction through the use of C.A.L. Most previous experimental evidence showed that for the same amount of practice, learning is better when practice is distributed rather than massed. However, their investigations found that the massed condition is better for short term performance, while distributed repetitions produces better long term learning.

Wilson and Fitzgibbon (1970) discovered that a group of fourth and fifth grade children made an average of seven months growth in reading skills during a four month period, as a result of having their normal instruction supplemented with C.A.L. drill and practice routines.

Green (1968) used slides, a teletype terminal, and a tape recorder to teach disadvantaged four yearolds to recognize words and letters. C.A.L. was tested with middle class and disadvantaged children. Most programs were reported to be more suitable for the middle class. However, it was felt that a C.A.L. approach, which provided increased gross motor responses in lieu of verbal ones, was well suited to disadvantaged children, especially males.

Golub (1974) developed a project to validate a C.A.L. literacy development program for job-oriented youth ages fourteen to twenty-four. The end product of this program was to provide diagnosis of reading levels, an occupational interest inventory, and instruction in literacy and occupational information. Evaluation of the program showed that pupils made considerable gains in their literacy development, and outstanding gains in their knowledge of career information. The attitude of C.A.L. pupils was significantly better than the attitude of students taking a programmed text version of the program, as measured by the Semantic Differential Test.

Atkinson (1968), using an elaborate computer terminal, studied the field of initial reading programs. The evaluation revealed that pupils assigned to C.A.L. groups achieved significantly greater gains in reading grade placement on the California Achievement Test, and on a test developed for the project, than did students receiving classroom instruction alone.

A more recent evaluation of a newer C.A.L. program in initial reading using a teletype terminal by Fletcher and Atkinson (1972), yielded statistically significant results. The study used fifty matched pairs of first grade students with one member of each pair assigned to a C.A.L. treatment. After one year, the C.A.L. group achieved an average reading grade level of 2.3 on the Stanford Achievement Test and 2.6 on the California Cooperative Primary Test, compared to 1.9 and 2.1 achieved respectively by the non C.A.L. group.

Nelon (1972) studied the feasibility of C.A.L. for elementary school children, twelve of whom were educable mentally retarded and twelve of whom

were mentally normal. The children were matched with equivalence in mental age and developmental levals. The experimental group consisting of both types of subjects was given a programmed vocabulary curriculum. For subjects of comparable mental age there were no significant differences between E.M.R's and normals in learning, error rate, or time needed for completion. (In the experimental group, the amount of learning was found to be greater for those of lower mental age, but error rate was not related to mental age.) However, there were significant differences on post test scores between experimental and control groups in favor of the experimental group.

C.A.L. In Both Mathematics and Language Skills

Table Three provides a summary of some of the studies done in both mathematics and language skills. Out of five studies cited, four showed C.A.L. superior to traditional instruction, while one study presented mixed results. Following are brief reviews of these studies, some of which produced impressive results.

A computer-assisted instructional project was implemented in twenty-one Chicago elementary schools. The instructional programs used were those of the "STRANDS" series in reading, language arts, and mathematics drill and practice, developed by the Computer Curriculum Corporation. All students involved were achieving at least one year below grade level upon entering the program. Results of the project after one year showed it to be highly successful in providing individualized instruction, and in freeing teachers for more creative work. In addition, the students showed

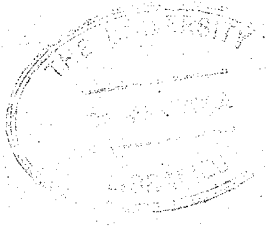
TABLE THREE - (a) Mixed Studies in Both Maths and Language

STUDY	MODE	SUBJECTS	GRADE/AGE LEVEL	RESULTS
Berthold (1974)	Tutorial	Maths & Spelling	Brain damaged children	*
Litman (1973)	Tutorial & Drill & Practice	Maths, Reading	Elementary weak students (special ed.)	+
Morgan (1975)	Drill & Practice	Reading & Maths	Visually & aurally handicapped	+
Perry (1973)	Drill & Practice & Simulation	Consumer Math	17 mean age	+
Suppes & Fletcher (1974)	Drill & Practice	Basic Math & Language	Elementary (deaf)	+

*Mixed results, teacher alone was shown to be superior to C.A.L. alone. Also, teacher plus C.A.L. was shown to be superior to C.A.L. alone.

(b) C.A.L. in Other Subjects

STUDY	MODE	SUBJECTS	GRADE/AGE LEVEL	RESULTS
Adams (1969)	Mixed	German (Introductory)	College	+
Bitzer & Boudreaux (1969)	—	Nursing	College	+
Edwards & Judd (1972)	—	Special Ed. Teacher Training	College	+
Ellenbogen (1975)	Mixed	Music	University	+
Ford (1972)	Drill & Practice	Technical vocational	Post High School	+
Hansen & Others (1968)	Drill	Physics	College	+
Lagowski (1970)	Mixed	Chemistry	College	+
Morrison & Adams (1969)	Mixed	German (Introductory)	College	=
Suppes & Morningstar (1970)	—	Russian	College	+



gains in achievement to almost one month for every month of C.A.L. instruction. This can be compared to the expected gains of 5.6 months for every 8 months in other special educational programs. (Litman, 1973)

Suppes and Fletcher (1974) conducted a three year study which involved 5,000 pupils in fifteen schools for the deaf. Both elementary language arts and mathematics were studied. The results of the mathematics STRANDS experiment showed that: 1) C.A.L. math. STRANDS programs lead to substantial gains in computational skills when used by hearing impaired pupils, 2) gains can be made by pupils who work intensely for only six to ten minutes per day on drill and practice programs, and 3) gains were significantly greater (two or three times greater) than those attained from regular classroom instruction.

Berthold (1974) researched the teaching of mathematics and spelling to eleven minimally brain damaged children. Compared in the study were the effectiveness of 1) computer alone, 2) teacher alone, and 3) the teacher and computer combined. Gains in achievement were obtained in the case of the teacher alone, and the teacher-computer combination. Some of the possible reasons for the poorer performance of the computer alone were: 1) the teacher was more adaptable and had more instructional methods than the computer programs, and 2) the full adaptability of the computer program was not used between sessions to meet the individual needs of the pupils.

Perry (1973) reported on a project which in part delivered C.A.L. in math, science, and reading to low ability students in secondary schools. The consumer arithmetic and reading programs consisted of drill and practice

routines and simulations of sales clerk and customer responses. Twenty-five special education students with mean chronological age of 17, mean I.Q. of 67, and reading level of 3.6 years, showed gains of 5.55 months in mathematics and 4.6 months in reading after a period of five months as measured by pre and post test scores on the Wide Range Achievement Test. The reading gain was noted in part because of the controlled reading effect of the teletype terminal. In the regular mathematics and science course, pre and post tests of selected units showed a 40% improvement in student performance after five hours of C.A.L. instruction.

Morgan (1975) developed a C.A.L. program in mathematics and reading for approximately 400 visually or aurally handicapped students in Cincinnati. Students were identified and given pretests to determine their needs. Their special education teachers were trained to prepare appropriate C.A.L. lesson material and to monitor student progress. During the first year, the achievement of deaf students was analyzed, and attitude scales were administered to teachers, students and parents. Preliminary results showed that teachers were able to implement the C.A.L. system with deaf students, that C.A.L. was beneficial for the hearing-impaired, that students, teachers, and parents reacted favorably toward C.A.L. use, and that further hardware and software development will be necessary before C.A.L. can be fully implemented and tested with visually impaired students.

Other Types of C.A.L. Research

At Concordia University in Montreal, a C.A.L. program was developed whereby pupils listened to cassette-tapes on music and responded to questions

presented through C.A.L. Explanatory material (in tutorial style) preceded each question and immediate feedback followed pupil response, directing him to one of a number of remedial or enrichment paths. Each experimental pupil spent three sessions at a terminal to complete two units and a test. The control group which received the test only, spent one session at the terminal. The pre specified objectives were attained by 80% of the experimental group which also showed a significant gain in achievement in musical style in post test scores (Ellenbogen, 1975).

Other Canadian activity in C.A.L. includes the work of the National Research Council of Canada (N.R.C.), (Brahan and Brown, 1972). In 1967 the National Research Council began an initial study of computers as aids to learning which led to the establishment of a central facility. Other research organizations also make use of these facilities on a co-operative basis. The facilities include a medium scale time-sharing computer accessible to the participating organizations through remote terminals. Some of the research organizations involved include: The University of Calgary, the Ontario Institute of Studies in Education in Toronto, Algonquin College in Ottawa, McMaster University in Hamilton, and the University of Montreal.

A main goal of the project is to co-ordinate research efforts and to seek improvements in specialized hardware and software equipment. In this way the project provides a means of co-operation between the researcher and systems designer.

Recent innovations being investigated and developed include:

1) a touch sensitive input tablet, used to transmit data to the computer when the surface is touched,
2) audio tape and disc storage units,
3) alphanumeric and graphic display devices,
4) line concentrator systems and supporting system programs,
5) instantaneous response audio units,
6) software techniques to help improve the quality of student operation of input devices,
7) research concerned with achieving voice input into computers, and
8) mass storage methods for use with library and curriculum materials.

In addition, an in house project at N.R.C. is underway to identify and design the necessary facilities in a C.A.L. system aimed at satisfying the special requirements of students with learning disabilities. Initially, this project investigated the use of automated assessment of human abilities. Original work centred on computerized implementation of the Peabody Picture Vocabulary Test in co-operation with Carleton University. It has been reported that this automated technique has been shown to be feasible when used with retarded children and adolescents. (Knights, 1973)

At the University of Alberta, Edmonton, exists another research centre for computer applications in education. An IBM 1500 C.A.L. system has been used for the teaching of: reading to young deaf children, statistical laboratories, coursewriter programming to university students, and for enrichment programs for secondary school students. Problems in linguistics

and intelligence measurement through a simulation of the Wechsler Intelligence Scale for Children have also been investigated.

The most widely publicized research activity in Edmonton is the application of C.A.L. to the field of teaching and testing in medicine. C.A.L. has been successfully used in cardiology instruction and in the area of medical patient simulation. Another project is concerned with the study of eye movement and pupil dilation by using a mini-computer to monitor the video output of a video oculometer. These projects have been successful and prospects for future developments and improvements remain bright. (Hunka, 1972)

Table Three summarizes the results of a few studies done using C.A.L. in various other subject areas and levels of instruction. Following are brief descriptions of these studies.

Ford (1972) investigated the feasibility of C.A.L. for Navy technical training. Five C.A.L. units were developed to replace 92 hours of the classroom curriculum. The study showed that C.A.L. pupils scored higher and learned faster. Forty-five percent less training time was required. This was attributed in part to innovative branching strategies for remediation.

Hansen, Dick, and Lippert (1968) implemented a college level physics program using C.A.L. Three groups of pupils were compared: A) pupils who received most of their instruction through C.A.L., B) those receiving partial C.A.L. and partial classroom instruction and C) those who received only classroom instruction. Cumulative results from midterm and final examinations revealed significantly better performance by the C.A.L. group.

Adams and Morrison (1968) reported the results of a two year experiment which used C.A.L. to teach introductory German. Pupils were matched, based on the results of a pre test in the Modern Language Aptitude Test. One pupil from each matched pair was randomly assigned to a C.A.L. version of a German course and the other pupil was assigned to a control group. The C.A.L. group did significantly better on tests of reading and writing achievement. Also, performance of the C.A.L. group did not suffer as far as conversational German was concerned.

Bitzer and Boudreaux (1969) found that a C.A.L. course in maternity nursing provided a substantial saving in time. When delivered by C.A.L., the course required a maximum of fifty hours compared to the standard eighty-four hours needed by the regular lecture presentation.

Castleberry and Logoswski (1970) reported on an evaluation of a course in chemistry. The C.A.L. subjects achieved significantly higher scores on the portions of the final examination that covered material presented by C.A.L. There was no difference between C.A.L. and non C.A.L. groups on those portions of the examination that covered material presented to groups using classroom instruction.

Even though there is strong evidence that C.A.L. helps pupils learn more, or learn more quickly, the effect of C.A.L. on the retention of learning is not as clearly established. Edwards (1975) for example, cites two cases of studies showing C.A.L. as having a negative effect on retention and one study reporting equal effects when compared to traditional methods. However, a more comprehensive review including more recent studies tends to

support the contention that C.A.L. will help to produce equal or better retention compared to traditional approaches. For example, three studies cited in this review reported better retention through the use of C.A.L. [(Sandals (1973), Jacobson (1975), Hill (1976)]. Although more research is needed to clear up this issue, the key to better retention through C.A.L. would seem to be effective planning and writing of C.A.L. programs suitable to the needs of the learner for which they are designed. A sometimes arbitrary, or unwarranted decision may also make the difference between high or low levels of retention. The selection of a criterion score to determine proficiency and thus, promotion, through a C.A.L. curriculum sequence is an example of such an important decision which may affect the outcome of a study.

Edwards and Judd (1972) described the findings of a C.A.L. course in special education teaching for undergraduates. Students were randomly selected for placement in one of three groups. The first group received a course handbook and took part in discussion classes; a second group received only discussion classes, and the third group received C.A.L. and the course handbook. The analysis of the data revealed that the C.A.L. group did better than the discussion groups on post test scores in achievement.

Suppes and Morningstar (1970) described the study of a C.A.L. course in college level Russian. First, the C.A.L. course was found to be more motivating than the classroom instruction of the same course. Of the original enrollment in the C.A.L. course, 73 percent finished all three

parts of the first year compared to 32 percent of the pupils who enrolled in the classroom presentation. Secondly, it was found that C.A.L. pupils made significantly fewer mistakes on the final examination than did students who received regular classroom instruction.

Reviews of the literature clearly show that when C.A.L. is used as an adjunct to regular classroom instruction, educational benefits accrue, including gains in learning, particularly for pupils with special needs.

However, when C.A.L. is used as a substitute for traditional instruction the results of research are not as clear. For example, Edwards (1975) in a review of studies which substituted C.A.L. in whole or in part for regular instruction, nine studies showed that the C.A.L. pupils achieved more than the non-C.A.L. pupils, while eight studies found little or no difference. The results of using C.A.L. as a replacement for traditional instruction are therefore inconclusive.

Advantages of C.A.L.

Butman (1973) argues that C.A.L. is most economical and most effective when used in a market where a "decrease in training time or an increase in student-teacher ratio" can be obtained as in special education programs. C.A.L. can reduce the overall training time by permitting each pupil to move at his or her own best pace. Also, C.A.L. provides a necessary "student support system" which helps regulate and keep records of a student's progress, areas of difficulty, and skills that have been mastered.

Also, C.A.L. can help increase student-teacher contact time by taking over some of the mechanical time-consuming drill activities. In his study, Butman used subjects from both the top 20 percent and bottom 80 percent of the class. It was concluded that about half of the control group who did not have the benefit of the C.A.L., did not have the motivation or the skills to move ahead at their own best pace without the monitoring and reinforcement features provided by the C.A.L. Also, significant reductions in training time were observed in both experimental groups.

In an article entitled: A Note on the Effectiveness of Computer Assisted Instruction, Fletcher and others argue that there are strong and consistent achievement gains by students when they are given C.A.L. over a reasonable fraction of a school year. Supporting this claim is a list of sixteen studies that deal with C.A.L. programs that have been used beneficially and effectively. The review includes a wide range of subject areas and multi-levels of instruction in such subjects as mathematics, science, nursing, and different languages. The authors conclude that current reports in the literature on C.A.L. reveal practically no negative findings in the area of C.A.L. applications. (Fletcher and others, 1972).

Edwards and others (1975), reviewed the empirical studies that had been done in order to evaluate the effectiveness of C.A.I. Studies reviewed were divided into four main areas of computer applications: drill and practice, problem solving, tutorial and simulation. In brief

the conclusions drawn were: 1) that C.A.L. can be an effective tool to assist in the instruction process, 2) that students generally learn more rapidly but may retain less with C.A.L. than with regular methods, 3) that C.A.L. is more effective with low ability students than for middle or high ability students, and 4) that both the students and teachers are enthusiastic about C.A.L. as an instructional aid.

Advantages of C.A.L. Pertaining Specifically to the Field of Special Education

An analysis of the educational features of C.A.L. suggests many positive factors that could facilitate learning—especially for pupils with learning difficulties. In addition, the learning histories and characteristics common to disabled learners imply that such pupils may benefit from the special features that C.A.L. can offer. A summary of some of the advantages include the following points. (Adapted from Sandals, 1973 and Faford, 1973)

1. The use of small logical steps helps the slow pupil to assimilate information.
2. The pupil learns to pace himself according to his own speed.
3. There is active participation provided by the one-to-one relationship between pupil and interactive terminal.
4. Immediate feedback for pupil responses is given. Personalized positive reinforcement for correct response is provided automatically when it is most advantageous, (i.e., for slow learners at least).
5. The programs may help increase the pupil's attention span by focussing the attention and by reducing distractions.

6. The immediate feedback and necessary interaction with the computer may facilitate emotional and academic independence.
7. The program is infinitely patient regarding pupil mistakes. It is consistent in never scolding, and in providing positive reinforcement.
8. The teacher is freed from scoring tests and routine presentations and spends more time with learners who are having difficulty.
9. Higher motivation for learning may result from C.A.L. and this may carry over into other course areas where improved behavior may be observed.
10. Record keeping and evaluation may be done automatically. This may facilitate diagnosis and the prescription of specific learning disabilities and may eventually lead to curriculum and instructional improvements for slow learners.
11. It can provide individualized instruction to a large number of pupils daily.

As can be seen, the first four points are derived from programmed instruction and operant learning principles. Point number five refers to a motivational factor and possibly a "controlled reading effect" in the constant rate of word printing, and a blocking out of distractions due to the sound of the automatic printing. Point number six traces back to operant learning as well as suggesting that less dependence on the teacher may result. Points seven and nine refer to motivational and interest states being kept at a high level because

of the consistent treatment of the learner with respect to the computer. Points eight, ten, and eleven are basically items of convenience and efficiency available through the use of C.A.L.

Many of these advantages would also be valid for the general population as well, although they have been compiled with special educational students in mind.

SUMMARY

It has been stated (Atkinson and Wilson, 1969) that the great potential of C.A.L. is its capacity to individualize instruction. This is considered true, especially when applied to special education, wherein special considerations and factors make C.A.L. more feasible and justified. These special factors include special learning, and instructional needs of disabled learners, lack of sufficiently trained special education teachers, lack of facilities and equal opportunities (Butman, 1973; Sandals, 1973; Faford, 1973). In any case, it should be emphasized that appropriate use of the computer should involve fulfilling instructional tasks that cannot be performed as well using other approaches.

In summary, a review of the literature supports the contentions that:

1. C.A.L. is an effective educational tool when used wisely.
2. Attitudes of pupils, parents and educators are, in general, favorable towards C.A.L.
3. C.A.L. seems to be effective generally, but most effective when used for pupils with special needs.

4. C.A.L. helps to reduce the amount of time needed for instruction compared to traditional methods.
5. C.A.L. helps to increase achievement across many subject areas. It is most effective for pupils working under special circumstances.
6. The issue of the relationship between C.A.L. and retention of learning is not clearly resolved. There is recent evidence, however, to suggest that if carefully planned and applied, C.A.L. will promote high levels of retention.
7. Careful application of C.A.L. will lead to cost-effectiveness. C.A.L. is most cost effective in special education programs.

It has been shown, therefore, that C.A.L. is a viable method of instruction in both the upgrading of basic mathematics and language skills through the mode of drill and practice. It is also clear that C.A.L. is a useful teaching aid suitable for use with pupils who suffer from learning disorders because the unique instructional and motivational features help to meet the special needs of pupils with learning problems. In the past, very few studies have investigated the use of C.A.L. in both mathematics and language skills directly in a school setting with a sample of pupils who exhibit an extremely wide range of learning problems. It seems reasonable and desirable, therefore, to undertake such a study.

CHAPTER IV

METHOD

The Problem

The literature shows only a few studies concerned with the application of C.A.L. in basic arithmetic and spelling skills for pupils with learning difficulties. Only a small number of these studies have involved a population with as wide a range of learning problems as the population of Central North School. In general these pupils have experienced difficulty learning basic facts, concepts, rules, and procedures in one or both core subjects of spelling and arithmetic. Their arithmetic and reading levels are generally two or more years below their expected levels according to their age. Therefore, it seemes both practical and reasonable to investigate whether C.A.L. could help these pupils in the learning of their basic skills of addition, subtraction, multiplication, division, fractions, decimals, and spelling.

A main objective of this study was to evaluate the effectiveness of C.A.L. as a way of improving the individualization of instruction. Computerized drill and practice exercises were used in an attempt to help pupils strengthen and upgrade the above-mentioned basic skills. It is important to note that the concepts and skills in question had been introduced and taught in previous grades and classes by classroom instruction, but the pupils had not been able to gain mastery of them.

Specifically this study attempted to answer the following questions:

1) What conclusions can be drawn from previous research in C.A.L., and for pupils with learning disabilities?
2) Can C.A.L. help pupils with learning disabilities improve their learning of basic computational and spelling skills?
3) Can these skills be retained by these pupils over a period of time, after the experimental treatment has ended?

Research Hypothesis

If three randomly selected groups of pupils with learning problems received regular classroom instruction in arithmetic and language arts and if two of the groups received additional help via C.A.L., one doing basic arithmetic skills, the other doing spelling through C.A.L., then there will be significant differences between the three groups in achievement over time in favor of the C.A.L. groups for both arithmetic and spelling as measured by standardized achievement tests.

Specifically the following null hypotheses will be tested for both arithmetic and spelling achievement scores:

Null Hypothesis (1)

There will be no significant differences between the treatment effects (mean scores) of the levels of factor A (experimental versus control group means).

Null Hypothesis (2)

There will be no significant differences between the treatment effects (means) and the levels of factor B (over time).

Null Hypothesis (3)

There will be no significant differences between the experimental and control treatment effects (means) with respect to a) arithmetic and b) spelling achievement scores over time.

The Sample

Description of the Research Setting—Central North Upgrading School

Central North Upgrading School is a special education program for pupils who have wide varieties of learning problems. The school provides a modified curriculum concentrating primarily on the two core subjects of arithmetic and language arts. Intensive remedial work is undertaken by the pupils in the two core subject areas under the guidance and supervision of highly skilled teachers who spend much time diagnosing weaknesses, prescribing individualized remedial exercises, and interacting with the pupils frequently on an individual basis. The groups are kept as small as possible (the maximum group size being 20 pupils) to help ensure a high degree of teacher-pupil interaction. The classes are mixed—male and female.

A key objective of the program is to help the pupils improve in the area of social skills and interactions with others. Another main objective is to help students upgrade their basic academic skills so that they may be better prepared to re-enter the mainstream of regular academic or vocational education. To accomplish these goals, much effort is put into helping pupils improve their attitude towards themselves and others, and their motivation to learning and self-improvement. A key method in accomplishing these goals is to allow (as much as possible) each pupil to gain a measure of success in the learning process. C.A.L. with its capacity to meet specific educational needs of individuals through intricate remediation procedures, a high degree of individualized instruction and highly motivational activities, may provide great help to disabled learners in gaining positive and successful learning experiences.

Description of the Pupils Involved in the Study

As previously mentioned, the sample of this study was drawn from the population of pupils from Central North Upgrading School. In general, the population consists of approximately 150 pupils who have a lengthy history of learning difficulties. Included are pupils who have specific learning disabilities, low mental abilities, social difficulties, behavior disorders, and emotional and psychological problems. Typically these pupils are one or more years behind in regular academic development and often have a poor attitude towards themselves, others, school, and learning in general. Functioning in regular school programs has been difficult if not impossible for these pupils. In general, these pupils come from families of the middle or lower socio-economic classes. Many of these families receive some form of social assistance. A large number of these pupils are juvenile offenders—many of them coming from broken homes or single parent families. The ratio of boys to girls in the school population is approximately two to one.

The sample was set up in the following manner:

From the total population of approximately 150 pupils, approximately ten were screened out of the study previous to the random selection of pupils according to the following criteria:

1) Pupils who were 18 years old or older.
2) Pupils whose I.Q. scores were in the higher than normal range (i.e. higher than the 90-109 I.Q. range).
3) Pupils who were excessively truant.

Included in the sample were pupils who fulfilled the following criteria:

1) Male or female between the ages of 10 to 17 years, 11 months.

2) Minimum reading level of grade II as determined by the Canadian Tests of Basic Skills and the reading tests administered by the Reading Resource Teacher.

3) Minimum arithmetic level of grade II (familiarized with the concepts of addition, subtraction, multiplication and division) as determined by the Canadian Test of Basic Skills and various other tests as administered by the arithmetic resource teacher.

4) History of past failure or difficulties in previous grades.

From the remaining 140 students, a total sample of 75 subjects was randomly chosen. Originally, there were 46 boys and 29 girls in the sample. Their ages ranged from 12 to 17 with a mean age of 14.9 years. Their I.Q.'s ranged from 64 to 108 with a mean I.Q. of 86.8, although some of the scores may have been outdated or doubted as to their accuracy. Each subject was randomly assigned to one of three groups. The groups were then randomly selected as a non-C.A.L. group and two experimental groups. Descriptive data for each treatment group is summarized in Table Four.

A T-test was calculated to ensure that the means of the three groups were not significantly different ($p < .05$). The treatment for experimental group 1 consisted of C.A.L. in basic computational skills of addition, subtraction, multiplication, division, fractions and decimals. The treatment for experimental group 2 consisted of C.A.L. in simple spelling drills. All three groups continued to receive regular classroom instruction in order not to interfere with the regular day-to-day routine of the school. During regular classroom time, the two experimental groups received computer assisted drills in spelling and arithmetic on an individual basis. The C.A.L. spelling group received spelling drills only and the C.A.L. arithmetic group received arithmetic drills only. A summary profile for each subject is provided in Appendix A.

TABLE FOUR - Descriptive Data for Each Treatment Group

GROUP	SEX M/F	AGES RANGE/MEAN	MEAN ACHIEVEMENT SCORES ARITH./SPELLING	I.Q. RANGE/MEAN
1. C.A.L. Arithmetic	13/11	12-17/14.8	4.950/5.142	67-105/84.3
2. C.A.L. Spelling	14/10	12-17/15.0	4.792/4.829	64-105/86.2
3. Non-C.A.L.	16/8	13-17/15.2	4.888/4.929	64-108/89.9

Limitations of the Sample

Since the purpose of this study was to evaluate the merits of C.A.L. for pupils with various learning problems, it was necessary to have large groups in order to ensure the validity of comparisons between groups. A total sample size of 75 was chosen representing approximately 50% of the total school population. This meant that two groups of 25 pupils or 50 pupils received C.A.L. Since we were equipped with only one computer terminal it was impossible to allow each pupil to receive daily instruction using C.A.L. in a regular school day. Therefore, because of the large sample, it was only possible to schedule individualized computer drills for each subject on an every second day basis. This factor greatly limited the amount of computer contact time per pupil per week.

Other factors such as variability in amount of instruction received in classroom instruction and the quality of instruction as varied from one teacher to another could not be controlled for directly, since this would disrupt the regular schedule and normal procedure of the existing school program. However, it is believed that the random selection procedures used in choosing and grouping the subjects would sufficiently control these variables.

Other limitations were imposed by the prerequisites of a minimum reading level and arithmetic level of grade two, and the restriction of some pupils whose I.Q. scores fell in the higher than normal range. Fortunately, only a few pupils were screened out because of these factors. Thus, although the sample cannot be considered as typical of the pupil population, it can be considered to be more typical of the general population of those pupils who have learning problems.

Instructional Programs

Four arithmetic and two spelling programs were used for C.A.L. in this study. Examples and detailed descriptions of these programs can be found in Appendix B. All of these programs were written in a high level computer language called BASIC. These programs were either written or adapted by the experimenter or other special education teachers. All of the programs were introduced, used and refined during the demonstration stage of the project for five months prior to this study. The readability of the programs were kept suitably low for even the weakest readers. In fact very little reading was necessary except for the instructions to the student. Once familiar with the programs and their instructions, the pupils experienced few problems in the use of the drills.

The programs used a highly personalized format by storing the pupil's name and using it in dialogue with the subject at every opportunity. Reinforcement of correct responses were made with light or sometimes amusing comments often addressing the pupil by name, for example: "Right on Johnny, keep up the good work!"

As mentioned earlier, the entering behavior expected for pupils doing arithmetic drills was approximately a grade two arithmetic level. This basically entails a familiarity with the concepts of addition, subtraction, multiplication and division. For the beginning programs in spelling, a reading level of approximately grade two was required to ensure that the pupils could recognize most of the words and understand their meanings.

Addsan, Subtsan, and Multsan are simple branching programs in the basic skills of addition, subtraction, and multiplication. These drills are "self-constructed" in the sense that the pupil or the supervisor at the terminal could choose the appropriate level of difficulty and complexity of the questions attempted. For example, in Multsan it was possible to choose the number of questions to be done in the drill up to a maximum of ten, the number of digits in the top number up to a maximum of five, and the number by which to multiply from one to nine.

In each of these drills the proper method of carrying, borrowing, or regrouping in the adjacent columns was emphasized and reinforced by the printing of a question mark for each column. Each problem was randomly generated, and the reinforcers delivered after successful completion of each question was also randomly chosen from a pool of six carefully worded encouraging statements for satisfactory performance. Hierarchies of math (Hill, 1976) and spelling skills were developed and used to help pinpoint the particular skill and level of difficulty upon which each C.A.L. pupil would start. The hierarchy made it very simple to keep track of where each pupil was working and to check on individual progress. A copy of these hierarchies can be found in Appendix C.

Divide is a program in long division which offers practice in the division of whole numbers. Pupils are offered up to 15 randomly generated questions with the option of whether decimals are to be involved. Another option allows the pupil to choose the number of digits in the divisor and dividend within the limits of one and nine. In this drill it is usually necessary to use paper and pencil or chalk and chalkboard to

carry out the steps entailed in the division algorithm.

In "Spel 128" a set of four words were presented to the pupils. Originally, there was one drill consisting of twenty questions, each containing four word items. The words were selected from a list of spelling words called the Dolch Basic 2000 which were graded from grade two up to the grade six level. Each set of four words had either one or no misspelled words in the set.

The pupils were asked to identify by number the misspelled word if one existed in the set. If the first response was incorrect, the pupil received a second chance. If he made a mistake on the second response, the number of the misspelled words was given at the teletype terminal. After identifying the word by number the pupil was asked to spell it correctly. The pupil's input was then checked for accuracy and randomly selected reinforcements were provided if the pupil had spelled the word correctly. If not, the computer would then give the correct spelling.

Spel B1 is a spelling drill in which the pupil is offered ten drills. Each drill deals with a set of common everyday words which are often misspelled. Each drill consists of five questions. At the end of each drill a report is given on the results of the drill including the number of words attempted, the number of words spelled correctly, the percentage, and a message to the parents. Also, provided is a list of words with which the pupil had difficulty.

Measuring Instruments

Criterion scores on standardized reading tests and arithmetic tests which had been administered previous to the study were used to determine which pupils had the reading and arithmetic levels necessary to take part in the study. These test results were available in school cumulative files of pupil progress and through classroom teacher's records. In our school the reading resource teacher and arithmetic-lab teacher maintain an on-going testing program throughout the school year. In addition, the Canadian Tests of Basic Skills is administered by the school division to all elementary and junior high aged pupils at the end of each school year. Therefore, the students are familiar with the practice of taking standardized tests, and there are usually as many as four or five test scores per school year upon which to make a grade level assessment.

The Stanford Achievement Test (S.A.T. 1964) and (S.A.T. 1973) were chosen as the criterion tests to measure the grade levels attained on pretests, post tests, and retention test administrations during the course of this study. Specifically the arithmetic subtest of computational skills from (S.A.T 1964) and the subtest for spelling (S.A.T. 1973), were used mainly because these two subtests most closely resemble the actual skills and concepts practiced in the computerized drills. A second advantage in using the S.A.T. was its availability in four parallel forms for S.A.T. 1964 and two forms for 1973, thus facilitating retesting as desired, using one form each for pretest 1, pretest 2, post test, and retention test. A third advantage of the

S.A.T. is the range of five choices for levels of difficulty from primary to advanced, thus allowing a choice of test level appropriate to the ages and achievement levels found in our sample. A fourth advantage of the S.A.T. is the fact that its design and format are age and maturity level appropriate. This helps to guard against negative feelings arising in the pupils during the test situation. In other words, the appearance of the test can be controlled according to the age and maturity of the pupil so that it does not have the appearance of being "too hard", "too easy", "too advanced", or "too infantile".

Reliability and Validity

Concerning the reliability and validity of the S.A.T., few studies and data are available regarding the 1964 edition. However, in response to some criticism, the authors have provided more information in the 1973 edition. In general, because of the advantages mentioned above, this researcher considers the S.A.T. to be the most suitable for the content and type of pupils being taught through C.A.L.

Content validity, that is the extent to which the content of the tests constitutes a representative sample of the skills and concepts that are the goals of instruction, was judged to be extremely high. In the 1973 edition in particular, instructional objectives for each subtest are provided in the manual. Using this information to compare the tests' content with the school's curriculum for both spelling and arithmetic computation, accurate judgements regarding content validity can be made.

In general, the format is excellent in its presentation of basic computational skills. Several reviewers were impressed by these tests, and by supporting material that the publishers provide. [Harold C. Trimble and Peter F. Merenda in Buros (1972)].

"In providing a measure of that phase of the traditional mathematics curriculum known by the general term arithmetic, the 1964 Stanford Achievement tests continues to be outstanding among tests of its kind." [Miriam M. Bryan, in Buros (1972)].

Apparatus

The computer used in this study was a Control Data Corporation computer-model number 6500. This computer is owned by the Province of Manitoba and operated by Cybershare Ltd., formerly Phoenix Data Ltd. The instructional terminal consists of a model 33 hardcopy teletype terminal. This type of terminal has the advantage of supplying a hardcopy printout of the instructional sequence. Two copy telex paper was used in order to obtain the printout of each drill in duplicate.

In addition, this type of terminal seems to have the added advantage of helping the pupils to concentrate on the lesson because the left to right printing activity seems to imitate the effect of a controlled reader. The terminal was placed in a small room constructed especially for the computer. The computer room was built away from the regular classroom at the end of a hallway.

Computer software, used in this study, were the drill and practice programs which have been described and documented earlier in this section. As mentioned previously, these programs were written in a powerful high level computer language called BASIC.

Administration and Procedure

(1) Procedure

The study began on February 21, 1975 and continued until June 10, 1975. The duration of the experiment was 15 weeks. A timetable outlining the main events and procedure of this study can be found in the flowchart in Figure 1.

(2) Pretest Administrations

Pretest 1 was administered on Friday, February 21, 1975 from 1:00 p.m. to 3:00 p.m. One week later on Friday, February 28, 1975, pretest 2 was administered between the same two times. The tests consisted of the Stanford Achievement computation and spelling subtests. For pretest 1, Form X was used while for pretest 2 a parallel form, Form W was used. The tests were administered by the experimenter while three school paraprofessionals served as proctors for each test session. The entire sample of 75 pupils was tested all at one sitting, as was the case during the three subsequent test administrations. All testing was conducted in the same location, a large three classroom sized open area which normally serves as the school's reading lab. Four subjects who missed the pretest 1 were tested the following Monday, February 24,1975

from 1:00 p.m. to 3:00 p.m. While six subjects who missed the pretest 2 session were tested on Monday, March 3, 1975 during the same time slot as for the regular session.

All the tests were divided into two equal groups at random. The experimenter scored one half of the tests while a paraprofessional scored the other half. All raw scores were converted to grade score equivalents by means of a table of conversion supplied in the test's administration manual. (All raw scores and conversions were rechecked by the experimenter for all four sets of tests. After all scores and conversions were rechecked, the statistical analyses were computed.)

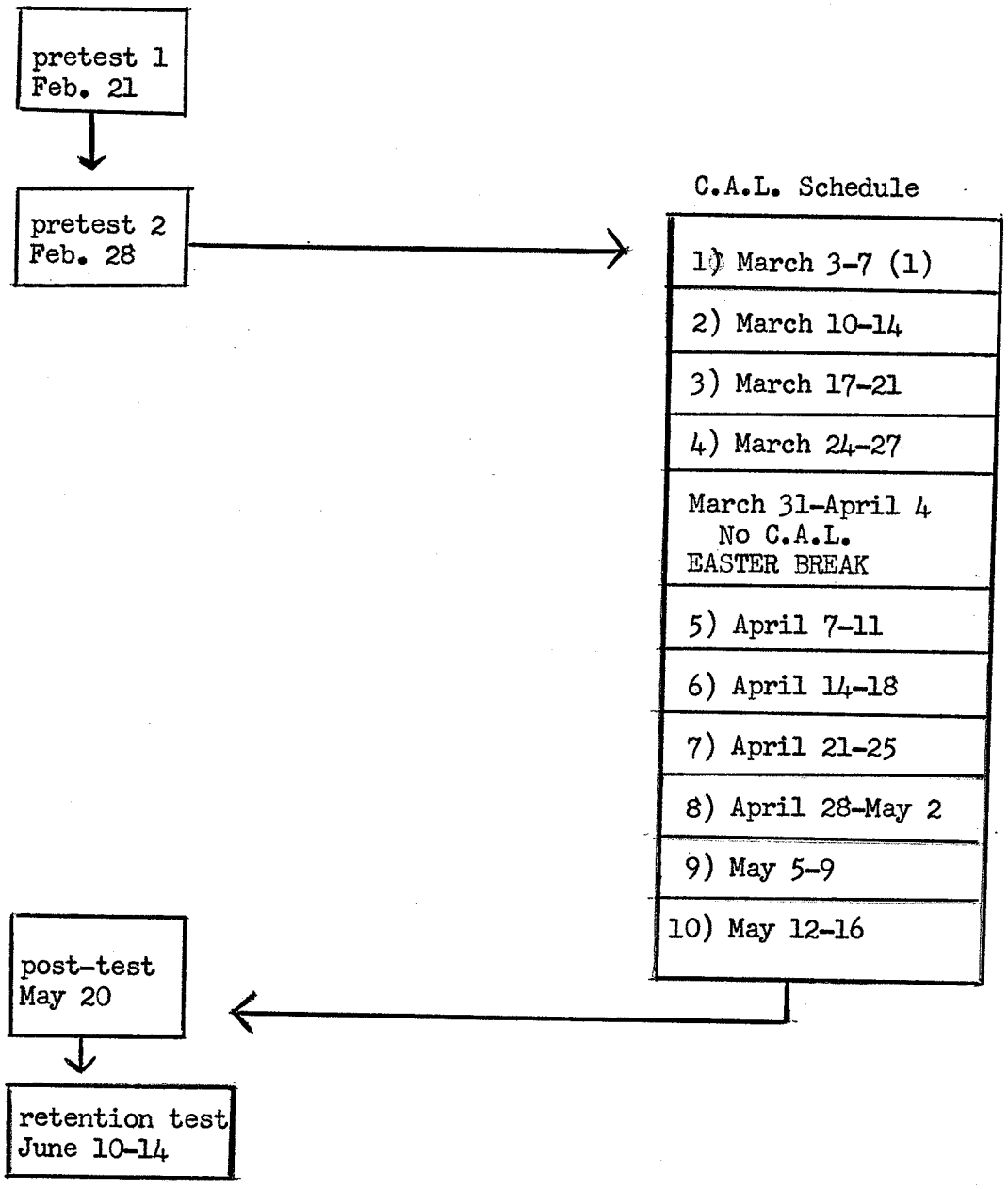
(3) Scheduling of Computerized Drills

Each pupil receiving C.A.L. drills was scheduled for a ten minute session on the teletype terminal every other day on a six-day school cycle. These drill sessions were given between 9:00 to 12:00 a.m. and from 1:00 to 3:30 p.m. As mentioned earlier, the C.A.L. was a supplement to the regular classroom instruction for the two C.A.L. treatment groups: C.A.L. arithmetic and C.A.L. spelling. Pupils in these two treatments were scheduled for C.A.L. at random throughout the school day so as to minimize the extra time devoted to one of these subjects. Pupils in the third treatment group received only regular classroom instruction in both arithmetic and spelling.

The non-C.A.L. group was used as a control for the C.A.L. arithmetic group and the C.A.L. spelling group. Also, the C.A.L. arithmetic group served as an additional control for the C.A.L. spelling group on spelling achievement scores and vice versa. By this means, the study controlled for some Hawthorne Effect.

FIGURE 1

Flowchart of Procedure



Also, with the Hawthorne Effect in mind, all the pupils who were possible candidates for the study had been desensitized to the novelty of C.A.L. by their previous exposure and practice for a period of five months before the experimental study began.

An examination of results of previous C.A.L. arithmetic and spelling drills, plus analyses of pretest scores and other diagnostic measures helped to establish the level of difficulty upon which to begin each subject. This procedure helped eliminate unnecessary drill on skills already mastered.

A criterion of 80% achievement was established for advancement to a higher level of drill difficulty. This criterion score was chosen mainly to stay consistent with criteria used elsewhere (arithmetic lab and other remedial programs) within the school.

A criterion score used to determine proficiency can be considered as an informal test situation. Some experts have stated that with regards to informal testing of reading comprehension, 85% accuracy can be considered as good comprehension (Bond and Tinker, 1967). It is reasonable, therefore, to generalize this criterion from reading comprehension to mastery of spelling and of concepts and skills in arithmetic. Keeping in mind that this criterion is set for the general population it would be reasonable, therefore, to adjust it down slightly to 80% for pupils with learning problems.

Although others (Johnson & Kress, 1972) consider that criterion scores used to determine independent levels of proficiency should be no less than 90%, it can be argued that a downward adjustment should be made

in consideration of the special needs or problems encountered by pupils in special education. The teachers at Central North consider the 90% level too rigorous an expectation. A pupil with special needs can and often does make "careless" mistakes due in part to a slip, often understandable in light of his disability, while also making "honest" mistakes due to insufficient knowledge. An expectation of 90% does not allow for more than one error of any type since most of our drills consisted of ten items or less. It was felt that such a high expectation would probably lead to high incidence of frustration and failure to progress, and thus adversely effect learning.

All subjects were asked to graph their own daily achievement scores. Since the hard copy print-out was made in duplicate, one copy was filed and the other copy was kept and used by the student. In this way the teachers, pupils, and this researcher were supplied with two daily checks as to the progress of each pupil.

4) Daily Management by Student Volunteers

During the five month demonstration stage of this project, a group of our older students, ages 15, 16, 17 had been trained and gained valuable experience in supervision of pupils at the computer terminal. Their main functions were: to manage the pupil drill sessions with the computer terminal, to ensure that a subject was ready and waiting to take his or her turn as soon as the previous subject was finished, to help keep records of pupil attendance and progress, and to help answer questions regarding

the use of the computer terminal. During this time these supervisors were allowed to sit at the terminal with the pupil. This was permitted to allow the pupils to become familiar and comfortable with the use of the terminal.

During the experimental study two older students continued to be present in a managerial and supervisory role. However, during this time they were not allowed to sit with the pupils on a continuous basis. Pupils were allowed to consult these supervisors as to which drill or level of difficulty was to be attempted, but no prompting within the drill was allowed on the part of the supervisors. The main reason for this was to ensure independent thinking so that maximum benefits would accrue to the subjects taking the drills.

5) Post Test and Retention Test Administrations

The same testing procedure and location was used for the post test and retention test as was used for the two pretests. The post test was given on Tuesday, May 20, 1975 from 1:00 p.m. to 3:00 p.m. and the retention test was given three weeks later on June 10, 1975 during the same time period. During the retention period of three weeks no subjects were allowed to take any C.A.L.; however, many of them asked why they could not continue. These subjects were told that they had finished their turn and that other pupils who had been waiting were being given a chance to try C.A.L. As in pretest 1 and pretest 2 the tests were divided into two groups at random so that the experimenter scored half of the tests while a paraprofessional scored the other half. All raw scores were

converted to grade score equivalents by means of the table of conversion, supplied by the test's administration manual. All raw scores and conversions were rechecked by the experimenter for all four sets of tests. After all scores and conversions were rechecked and recorded, the statistical analyses were computed.

Statistical Procedure

Statistical analyses were performed on the data obtained from seventy-two subjects. Since two subjects dropped out of the study, one from each treatment group, one subject was subsequently dropped at random from the control group in order to keep the three groups equal at twenty-four subjects per group.

Analyses of Variance for Repeated Measures Over Time

The tests for significant differences over time using the repeated measures of pretest 1, pretest 2, post test, and retention test mean scores for both arithmetic computation and spelling were performed using the Analyses of Variance for Mixed Designs Program. The computer at the University of Manitoba was used for this purpose.

The statistical analysis consisted of two separate 3x4 analysis of variance designs for repeated measures over time. One analysis of variance dealt with achievement in arithmetic as a dependent variable, and the second analysis of variance examined achievement in spelling as a dependent variable of achievement. Three completely randomized groups were randomly assigned to C.A.L. arithmetic, C.A.L. spelling and non-C.A.L.

group treatments. A diagram of the data treatment design can be found in Appendix D.

The following are the hypotheses for the two-way ANOVAS for repeated measures over time for both arithmetic and spelling:

If three groups of pupils with learning problems are administered standardized achievement tests in arithmetic and spelling before and after a ten week treatment period during which group 1 received C.A.L. in arithmetic, group 2 received C.A.L. in spelling, and group 3 received regular classroom instruction only, then there will be significant differences in achievement mean scores between:

1) Treatment effects over levels of factor A, (significant mean differences between groups, i.e. between i) the C.A.L. arithmetic group and the C.A.L. spelling group, ii) between the C.A.L. arithmetic group and the non-C.A.L. group, and iii) between the C.A.L. spelling and the non-C.A.L. group).

2) Treatment effects over levels of factor B (significant mean differences over time between i) pretests and post tests and ii) between pretests and retention tests).

3) Experimental and control group treatment effects with respect to arithmetic and spelling scores over time.

The following are the statistical hypotheses for both spelling and arithmetic using the analysis of variance for repeated measures (3X4 design). Complete discussions of derivations and formulae can be found in Winer (1971) Chapter 4.

1) Null Hypotheses Ho: $\alpha_1 = \alpha_2 = \alpha_3 = 0$

There will be no significant differences between the treatment effects (mean scores) of the levels of factor A (experimental versus control group means).

Alternative Hypotheses H1: not Ho

There will be a significant difference between the treatment effects of the levels of factor A.

2) Null Hypotheses Ho: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$

There will be no significant differences between the treatment effects (means) of the levels of factor B (over time).

Alternative Hypotheses H1: not Ho

There will be significant differences between the treatment effects and the levels of factor B.

3) Null Hypotheses H1: $\alpha_1\beta_1 = \alpha_1\beta_2 = \alpha_1\beta_3 = \alpha_1\beta_4 = \alpha_2\beta_1 = \cdots = \alpha_3\beta_4 = 0$

There will be no significant differences between the experimental and control group treatment effect (means) with respect to a) arithmetic and b) spelling scores over a period of time.

Alternative Hypotheses: H1: not Ho

There will be significant difference between the experimental and control group treatment effects with respect to a) arithmetic and b) spelling scores over a period of time.

The results of the Analyses of Variance were examined and the Newman-Keuls aposteriori probing technique was used to determine whether significant differences existed between pretests, post test and/or retention

test. According to Winer (1971), with equal sample sizes it is best to use treatment means rather than treatment totals.

Thus, using the Neuman-Keuls method, the following treatment means were compared:

	Ho:		Hi:
(pre 1)	$\bar{X}_1 = \bar{X}_2$ (pre 2)	or	$\bar{X}_1 \neq \bar{X}_2$
	$\bar{X}_1 = \bar{X}_3$ (post)	or	$\bar{X}_1 \neq \bar{X}_3$
	$\bar{X}_1 = \bar{X}_4$ (ret)	or	$\bar{X}_1 \neq \bar{X}_4$
	$\bar{X}_2 = \bar{X}_3$	or	$\bar{X}_2 \neq \bar{X}_3$
	$\bar{X}_2 = \bar{X}_4$	or	$\bar{X}_2 \neq \bar{X}_4$
	$\bar{X}_3 = \bar{X}_4$	or	$\bar{X}_3 \neq \bar{X}_4$

Comparisons were made between pre tests (1 and 2), post test, and retention tests at .05 and .01 levels of significances.

Further analyses of the results were made by means of the test for simple main effects. If the interaction of factors A (treatments) and B (time) is significant, it is normal procedure to test for simple main effects. Since this investigation showed significant interaction in arithmetic at the .01 level and a lesser significant interaction for spelling at the .10 level, tests for simple main effects for both arithmetic and spelling were performed. For spelling the results of

these tests will serve for descriptive purposes only.

Intercorrelations between: 1) pretest 1, pretest 2, and post test, 2) pretest 1, pretest 2, and retention test were determined for descriptive purposes for both arithmetic and spelling. These intercorrelations were computed for experimental and control groups. Results of these intercorrelations may help to account for increases in scores between pretests and post tests, and pretests and retention tests. Specifically, this correlational data may help to indicate if increases in scores between pretests and post test, and pretests and retention tests, may be due to overall treatment effects.

Also, correlations between arithmetic and spelling scores for each of the three groups are presented for the following comparisons: pretest 2 in arithmetic versus pretest 2 in spelling, post test in arithmetic versus post test in spelling, and retention test in arithmetic versus retention test in spelling. These results are presented and discussed for descriptive purposes in Appendix E.

CHAPTER V

RESULTS

The results of this study are presented in this chapter. A detailed discussion of the results relating to the hypotheses will follow in the discussion section of this thesis.

Tables of raw data can be found in Appendix F. The test scores are presented in the form of grade scores(years/months). The means, variances, and standard deviations are also presented in Appendix F. As stated previously (in Chapter IV), the three main null hypotheses for the Analyses of Variance for both arithmetic and spelling are:

1) There will be no significant differences between the treatment effects for the levels of factor A (experimental versus control means).

2) There will be no significant differences between the treatment effects for the levels of factor B (over time).

3) There will be no significant differences between the experimental and control group treatment effects over a period of time (interaction of factor A with factor B over time).

Analysis of Variance for Arithmetic

The summary table for the Analysis of Variance for arithmetic can be found in Table Five. The critical value for hypothesis 1 was 4.95 at the .01 level of significance (df = 2, 69). Therefore, since the observed F ratio was 0.37, there were no significant differences between the experimental and control group means. Thus, Null Hypothesis 1 was accepted.

The critical value for Null Hypothesis 2 at the .01 level of significance was 3.88 (df = 3,207). The obtained F ratio was 7.03 indicating significant differences between the means of the levels of factor B. Aposteriori probing techniques are needed to determine where the difference(s) lies. Null Hypothesis 2 was therefore rejected and the Alternative Hypothesis accepted.

For Null Hypothesis 3, the critical value needed for significance at the .01 level was 2.89 (df = 6,207). The F ratio obtained was 4.10 and thus showed a significant interaction effect at the .01 level. Null Hypothesis 3 was therefore rejected and the Alternative Hypothesis was accepted.

Analysis of Variance for Spelling

The summary tables for the Analysis of Variance for Spelling are presented in Table Six. The results for spelling are similar to the results for arithmetic. Since the number of subjects per group was the same for both spelling and arithmetic the critical values for all three spelling hypotheses are the same as those for arithmetic.

For hypothesis 1, the obtained F ratio was 0.11. Since this is smaller than the critical value, the Null Hypothesis was accepted.

For hypothesis 2, the observed F ratio was 10.24 which was significant at the .01 level. The Null Hypothesis was rejected and the Alternative Hypotheses was therefore accepted.

For Hypothesis 3, the observed F ratio was 1.86 which was significant at the .10 level only. Since it was not significant at the .05 or .01 levels, Null Hypothesis was therefore accepted.

TABLE FIVE

Analysis of Variances Summary Table for Repeated Measures Design (Arithmetic)

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (treatment)	6.23	2	3.11	0.37
Subj. W groups	588.91	69	8.54	
B (math scores)	3.79	3	1.26	7.03 *
AB	4.42	6	0.74	4.10 *
BX subj. w. groups	37.21	207	0.18	
TOTALS	640.56	287		

* $p < .01$

TABLE SIX

Analysis of Variances Summary Table for Repeated Measures Design (Spelling)

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (treatment)	1.91	2	0.95	0.11
Subj. W. groups	617.73	69	8.95	
B (spelling scores)	5.88	3	1.96	10.24 *
AB	2.13	6	0.36	1.86 **
BX Subj. W. groups	39.62	207	0.19	
TOTALS	667.27	287		

* $p < .01$

** $p < .10$

Post Hoc Tests

Significant differences were found between the levels of factor B (over time) for both arithmetic mean scores and spelling mean scores. The Neuman-Keuls probing technique was used to determine where the differences occurred. The data for this test can be found in Table Seven for arithmetic and Table Eight for spelling.

In this technique the computed values in part (iii) (the critical values for the ordered differences between pairs) are compared to a difference in ordered means (i). If (i) is greater than or equal to (iii) then there is a significant difference indicated. In Table Seven for arithmetic, significance was observed between pretest 2 and both post test and retention test—all at the .01 level of significance. A lesser degree of significant difference at the .05 level was found between pretest 1 and post test and between pretest 1 and retention test.

For spelling in Table Eight, significance was observed between: pretest 1 and post test 2, pretest 2 and post test, and pretest 2 and retention test—all at the .01 level of significance.

Tests for simple main effects were performed in order to answer the following questions:

(1) are there differences 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) b_1, b_2, b_3 and b_4 at a_1 or

b_1, b_2, b_3 and b_4 at a_2 or

b_1, b_2, b_3 and b_4 at a_3.

TABLE SEVEN

Newman-Keuls Test for Differences Over Time Using Treatment Means (Arithmetic)

		b_2	b_1	b_4	b_3
Ordered Means		4.88	4.98	5.14	5.16
		b_2	b_1	b_4	b_3
(i)	b_2	-	.10	.26	.28
	b_1		-	.16	.18
	b_4			-	.02
(ii)	q.95 (r,207)		2.77	3.31	3.63
	q.99 (r,207)		3.64	4.12	4.40
(iii)	$S_{\bar{B}}$ q.95 (r,207)		.14	.16	.18
	$S_{\bar{B}}$ q.99 (r,207)		.18	.21	.27
		b_2 pre 2	b_1 pre 1	b_4 (ret)	b_3 (post)
(iv)	b_2 (pre 2)			**	**
	b_1 (pre 1)			*	*
	b_4 (ret)				

* $p < .05$
** $p < .01$

TABLE EIGHT

Newman-Keuls Test for Differences Over Time Using Treatment Means (Spelling)

		b_2	b_1	b_4	b_3
Ordered Means		4.97	5.09	5.22	5.35
		b_2	b_1	b_4	b_3
(i)	b_2	-	.12	.25	.38
	b_1		-	.13	.26
	b_4			-	.13
(ii)	q.95 (r,207)		2.77	3.31	3.63
	q.99 (r,207)		3.64	4.12	4.40
(iii)	$S_{\bar{B}}$ q.95 (r,207)		.14	.17	.19
	$S_{\bar{B}}$ q.99 (r,207)		.19	.21	.23
		b_2 pre 2	b_1 pre 1	b_4 ret	b_3 post
(iv)	b_2 (pre 2)			**	**
	b_1 (pre 1)				**
	b_4 (ret)				

* $p < .05$
** $p < .01$

The results are shown in Table Nine for arithmetic and Table Ten for spelling. An analysis of the data in Table Nine shows a significant difference over time in favor of the C.A.L. math group and a significant interaction at the .01 level. Hence the experimental data tends to reject the hypothesis that there are no differences in the effects of factor B (time) when observations are made at level a_1 (i.e. treatment 1, C.A.L. mathematics).

The results shown in Table Ten for spelling indicate a significant difference over time at the .01 level and a significant interaction effect at the .10 level. Therefore, the hypothesis that there is no significant difference in the effects of factor B (time) when observations are made at level a_2 (i.e. treatment 2, C.A.L. spelling) is rejected.

For descriptive purposes, the intercorrelations were calculated for each of the three groups for both arithmetic and spelling scores. The correlational data obtained indicated that pretests to post test and retention test were highly correlated and significant at the .05 and .01 levels for both arithmetic and spelling. Results are presented in Table Eleven for arithmetic and Table Twelve for spelling.

Group mean scores are presented graphically in Figure Two for arithmetic and Figure Three for spelling for all three treatment groups. In addition, the individual learning curves for each subject are presented in Appendix G.

TABLE NINE

Analysis of Variance for Simple Main Effects (Arithmetic Scores)

Source	SS	df	MS	F
1. Between subjects				
2. Between A at b_1	.02	2	0.01	$\frac{2}{6}$ = .004
3. Between A at b_2	.30	2	0.15	$\frac{3}{6}$ = .07
4. Between A at b_3	5.96	2	2.98	$\frac{4}{6}$ = 1.31
5. Between A at b_4	4.36	2	2.19	$\frac{5}{6}$ = .96
6. Within cell	626.12	276	2.27	
7. Within subjects				
8. Between B at a_1 (arithmetic group)	7.40	3	2.47	$\frac{8}{12}$ =13.72 **
9. Between B at a_2	.56	3	0.19	$\frac{9}{12}$ = 1.06
10. Between B at a_3	.24	3	0.08	$\frac{10}{12}$ = .44
11. AB	4.42	6	0.74	$\frac{11}{12}$ = 4.11 **
12. BX Subj. W. groups	37.21	207	0.18	

* $p < .05$; F critical = 2.60 (df = 3,207); 3.00 (2,276)

** $p < .01$; F critical = 3.78 (df = 3,207); 2.80 (6,207)

TABLE TEN

Analysis of Variance Table for Simple Main Effects (Spelling Scores)

Source	SS	df	MS	F
1. Between Subjects				
2. Between A at b_1	.46	2	.23	$(\frac{2}{6})$ = .096
3. Between A at b_2	1.22	2	.61	$(\frac{3}{6})$ = .256
4. Between A at b_3	1.01	2	.505	$(\frac{4}{6})$ = .212
5. Between A at b_4	1.34	2	.67	$(\frac{5}{6})$ = .281
6. Within cell	657.35	276	2.38	
7. Within Subjects				
8. Between B at a_1	.994	3	.331	$(\frac{8}{12})$ =1.742
9. Between B at a_2 (Spelling group)	6.142	3	2.047	$(\frac{9}{12})$ =10.773**
10. Between B at a_3	.868	3	.289	$(\frac{10}{12})$ =1.521
11. AB	2.13	6	.36	$(\frac{11}{12})$ =1.894***
12. Bx subj. w. groups	39.62	207	.19	

* $p < .05$; F critical = 2.60 (df = 3,207); 3.00 (df = 2,276); 2.10 (df = 6,207)

** $p < .01$; F critical = 3.78 (df = 3,207); 2.80 (df = 6,207)

*** $p < .10$; F critical = 1.77 (df = 6,207)

TABLE ELEVEN

Correlation Matrices for the Three Treatment Groups (Arithmetic)

Treatment 1	C.A.L. group 1 (math)			
	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1. pre 1	1.00			
2. pre 2	0.90**	1.00		
3. post	0.94**	0.90**	1.00	
4. ret	0.87**	0.82**	0.94**	1.00

* $p < .05$ r critical = .38 df (24)
** $p < .01$ r critical = .49 df (24)

Treatment 2	C.A.L. group 2 (spelling)			
	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1. pre 1	1.00			
2. pre 2	0.91**	1.00		
3. post	0.91**	0.92**	1.00	
4. ret	0.90**	0.85**	0.91**	1.00

* $p < .05$ r critical = .38 (df = 24)
** $p < .01$ r critical = .49 (df = 24)

Treatment 3	Non C.A.L. group			
	1 (prel)	2 (pre 2)	3 (post)	4 (ret)
1. pre 1	1.00			
2. pre 2	0.94**	1.00		
3. post	0.95**	0.96**	1.00	
4. ret	0.95**	0.97**	.99**	1.00

* $p < .05$ r critical = .38 (df = 24)
** $p < .01$ r critical = .49 (df =24)

TABLE TWELVE

Correlation Matrices for The Three Treatment Groups (Spelling Scores)

Treatment 1	C.A.L. group 1 (math)			
	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1. pre 1	1.00			
2. pre 2	0.97**	1.00		
3. post	0.87**	0.88**	1.00	
4. ret	0.87**	0.87**	0.93**	1.00

* $p < .05$ r critical = .38 df (24)
** $p < .01$ r critical = .49 df (24)

Treatment 2	C.A.L. group 2 (spelling)			
	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1. pre 1	1.00			
2. pre 2	0.94**	1.00		
3. post	0.93**	0.91**	1.00	
4. ret	0.94**	0.92**	0.98**	1.00

* $p < .05$ r critical = .38 (df = 24)

** $p < .01$ r critical = .49 (df = 24)

Treatment 3	Non C.A.L. group			
	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1. pre 1	1.00			
2. pre 2	0.94**	1.00		
3. post	0.90**	0.92**	1.00	
4. ret	0.92**	0.95**	0.96**	1.00

* $p < .05$ r critical = .38 (df = 24)

** $p < .01$ r critical = .49 (df = 24)

FIGURE TWO - GROUP MEAN CURVES FOR ARITHMETIC

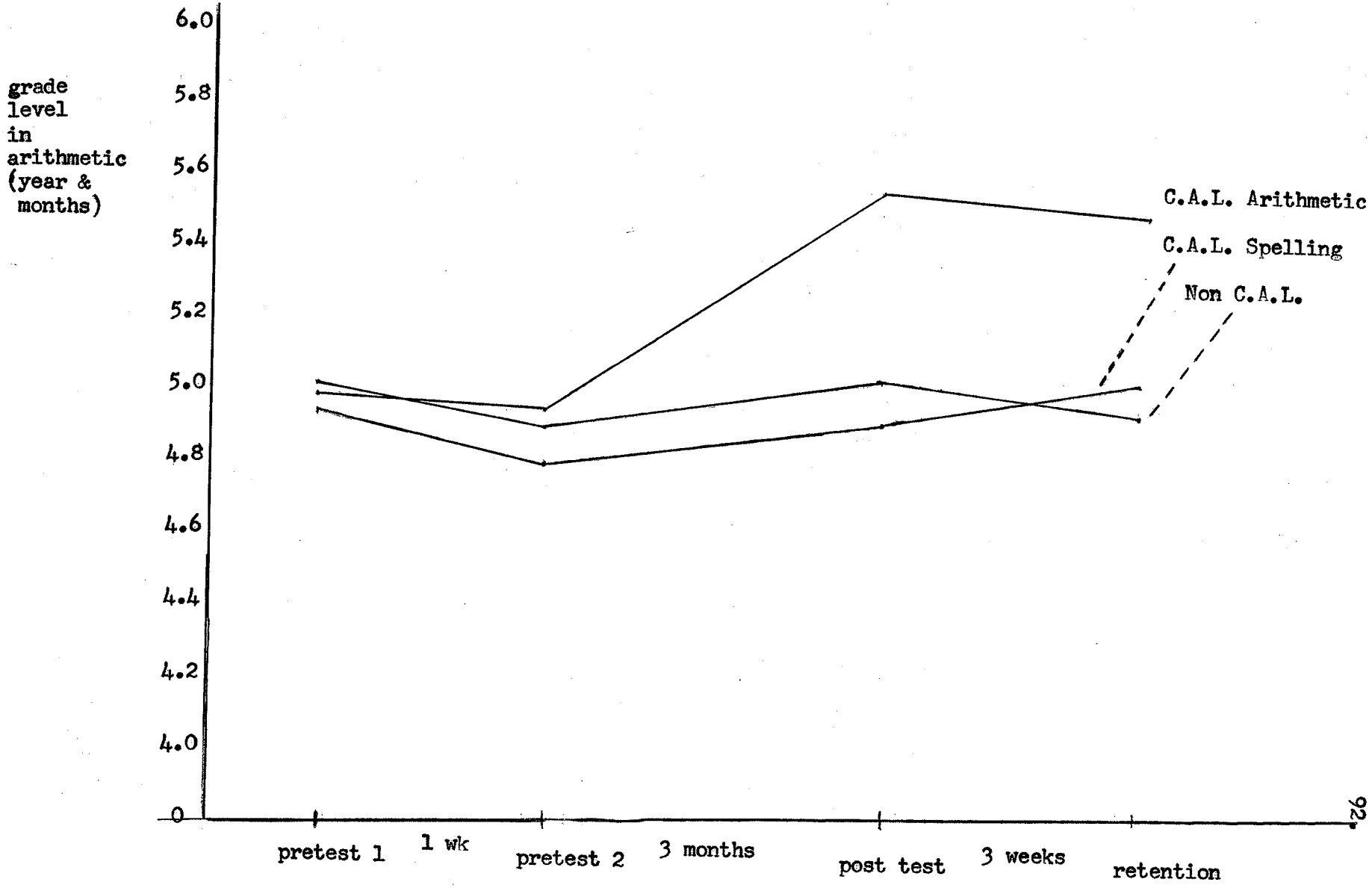
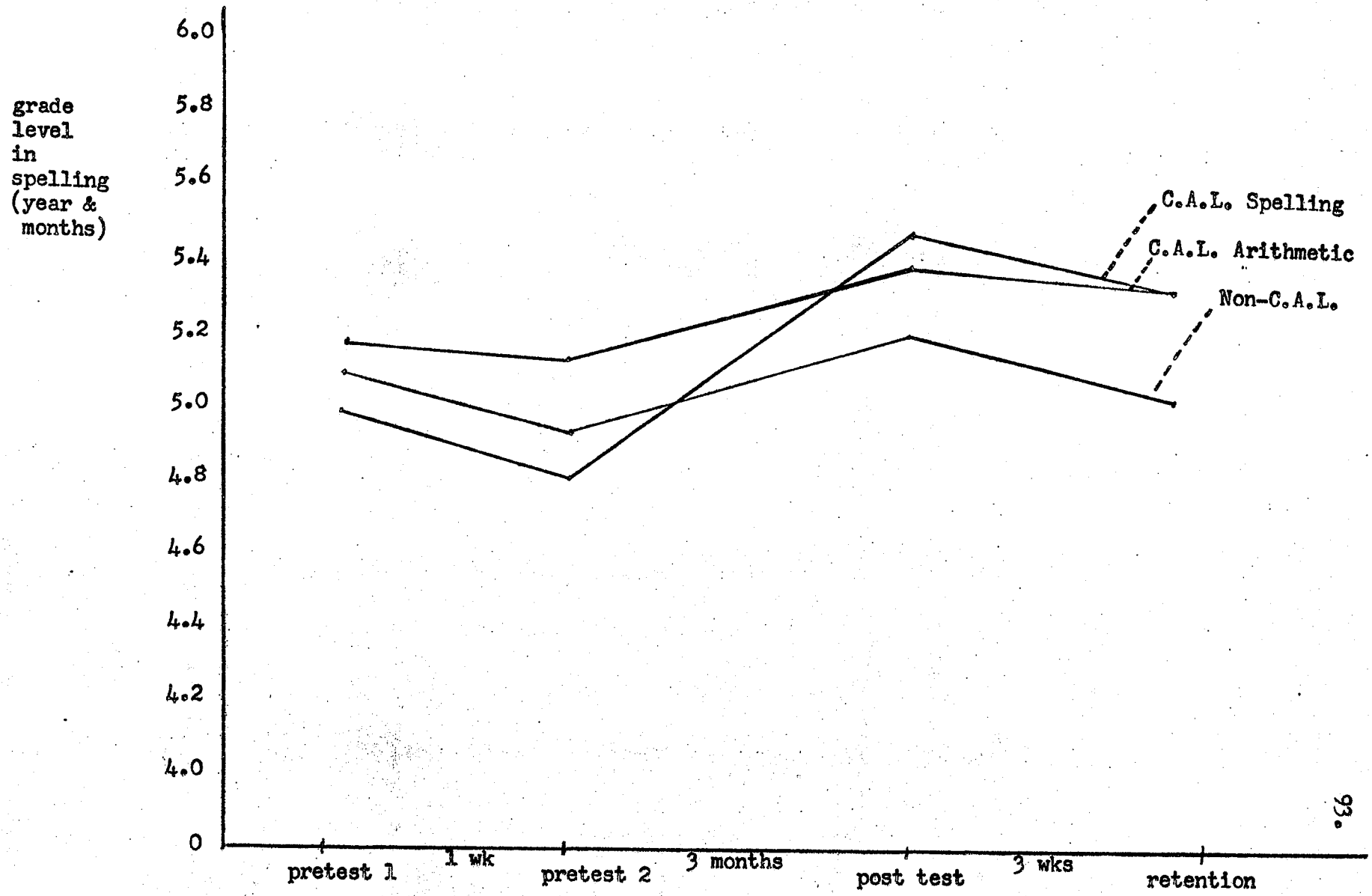


FIGURE THREE - GROUP MEAN CURVES FOR SPELLING



CHAPTER VI

DISCUSSION AND CONCLUSIONS

The findings presented in this study have shown that: 1) pupils with learning problems can manage the use of the computer terminal and C.A.L. with very little help from others, 2) C.A.L. is a promising means of individualizing instruction, and 3) pupils with learning problems were able to improve their basic skills in both arithmetic and spelling through the use of C.A.L.

For easy reference the research hypothesis is restated below:

If three randomly selected groups of pupils with learning problems received a regular classroom instruction in mathematics and language arts, and if two of the groups received additional help via C.A.L., one doing basic arithmetic skills and the other doing spelling through C.A.L., then there will be significant differences between the three groups in achievement over time in favor of the C.A.L. groups for both arithmetic and spelling as measured by standardized achievement tests.

Analysis of Variance for Arithmetic

Since no significant differences were found between the experimental and control group means, (between the means of the levels of factor A) Null Hypothesis (1) was accepted for arithmetic.

Because of the significant differences observed over time (between the means of the levels of factor B), Null Hypothesis (2) was rejected and the Alternative Hypothesis was accepted at the .01 level of significance.

The Newman-Keuls probing technique was used to find where the significant differences occurred. Results from this test indicated significant differences between pretest 2 and both the post test and retention test at the .01 level. Also found was a lesser degree of significant difference between pretest 1 and both the post test and retention test (i.e. at the .05 level). These results indicate that learning (and retention of learning) took place in arithmetic over the four month experimental period.

The results obtained with respect to Null Hypothesis (3) showed a significant interaction effect at the .01 level. Therefore, Null Hypothesis (3) was rejected and the Alternative Hypothesis, that there were significant differences between the experimental and control group treatment effects over time, was accepted. Accordingly, tests for simple main effects were performed.

The results from the tests for simple main effects showed significant differences over time at the .01 level of significance. On arithmetic scores, neither the C.A.L. spelling group nor the non-C.A.L. group showed any significance at the .05 level. Therefore, the C.A.L. arithmetic group showed significantly greater gains on arithmetic measures than did the other two comparison groups (C.A.L. spelling and non-C.A.L. groups). The significant difference over time was, therefore, attributable to the gains made by the C.A.L. arithmetic group.

Analysis of Variance for Spelling

The results obtained for the spelling analysis are the same as those for arithmetic except in the case of hypothesis (3).

Since no significant differences were found between the experimental and control group means, Null Hypothesis (1) was accepted for spelling.

Because of the significant differences observed over time, Null Hypothesis (2) was rejected and the Alternative Hypothesis was accepted at the .01 level of significance. This result indicates that learning took place but does not indicate where the differences occurred. The Newman-Keuls probing technique revealed that differences existed between pretest 2 and both the post test and retention test at the .01 level of significance. Also, the same degree of significant difference was shown between pre test 1 and the post test. These results indicate that learning (and some retention learning) took place in spelling over the four month experimental period.

The results obtained for Hypothesis (3) did not show significance at the .01 or .05 level. Therefore, Null Hypothesis (3) was accepted. However, since a difference was observed at the .10 level, the tests for simple main effects were performed for descriptive purposes only. Results obtained revealed that neither the C.A.L. arithmetic, nor the non-C.A.L. group attained any significant gains over time. Therefore, the C.A.L. spelling group attained greater gains on spelling scores than did the other two comparison groups (C.A.L. arithmetic and non-C.A.L. group). The difference over time was therefore attributable to the gains made by the C.A.L. spelling group.

It is interesting to note that in spelling, the spelling group dropped .13 months, while in arithmetic, the arithmetic group dropped only .02 months during the retention period. This is an indication that retention of learning was greater for the C.A.L. arithmetic group in arithmetic compared to that of the C.A.L. spelling group in spelling. This may be explained, in part, by the fact that the arithmetic drills were of better quality than the spelling drills.

Results of the correlational data showed that the gains in achievement were consistent within all three groups over the four month experimental period. The intercorrelations between pretest 1 and post test and retention test for both arithmetic and spelling scores were not significantly different. This is indicative of the equality of predicability and reliability of both pretest 1 and pretest 2. The scores in both arithmetic and spelling tended to decline slightly from pretest 1 to pretest 2. This result was expected because the subjects seemed to be more anxious for pretest 1 than for pretest 2, which may have caused slightly inflated scores for pretest 1. Since they were observed to be less anxious during pretest 2, the results of this test would be more reliable.

Overall, the study has indicated that pupils with learning problems can make significant gains in learning in the basic skills of arithmetic and spelling. A comparison of group mean scores from pretest 2 to retention test shows an overall increase of 5.3 months for the arithmetic group on arithmetic scores compared to a 2 month increase for the spelling

group, and an 0.5 increase for the non-C.A.L. group. Similarly, on spelling scores, the C.A.L. spelling group increased 4.8 months while the C.A.L. arithmetic group increased 1.8 months, and the non-C.A.L. group increased 1 month. Analysis of these figures indicates both educationally and statistically significant gains in learning.

General Comment

For pupils with special needs, many studies have shown that C.A.L. can effectively and significantly increase the amount of learning compared to regular classroom instruction alone. The present study provides more positive evidence in this regard and implies several conclusions relevant to the education of pupils with learning problems. Elaboration of this point will follow in this section.

The use of C.A.L. in arithmetic and spelling provided many "spin-off" effects. The pupils seemed to find the C.A.L. drills more interesting and enjoyable than other type of drills. Many students would often check in the computer room to make sure they would not be denied their turn on the computer.

Some teachers commented on the improved attitudes of many of the C.A.L. pupils, both in terms of improved behavior in class and also in terms of better performance in other subject areas as well. A descriptive indication of this is provided by the fact that the arithmetic group did better in spelling than the non-C.A.L. group (1.8 months increase compared to 1 month), and the spelling group did much better in arithmetic achievement than did the non-C.A.L. group, (2 months increase compared to a 0.5 month increase).

Also, C.A.L. pupils showed signs of improved abilities to attend and to concentrate in other subject areas compared to non C.A.L. pupils. Many C.A.L. pupils improved in arithmetic and spelling beyond expectations. For example, 17 C.A.L. pupils showed increases in arithmetic achievement compared to 11 from the non C.A.L. group. Similarly, in spelling 21 pupils made gains compared to 14 in non C.A.L. group. Graphs and tables showing these comparisons can be found in Appendix G.

C.A.L. pupils also increased their efficiency in terms of time needed to complete their work. In general these pupils were able to work much faster and with greater accuracy on the computer as compared to other forms of drill (paper and pencil - worksheet drills). On the average, ten to twelve minutes were used on C.A.L. compared to about twenty minutes needed to do a similar amount of work in the classroom.

C.A.L. provided a convenient means of increasing the attention given to the individual needs of pupils for drill and practice. Probably more could have been gained in pupil achievement if the teachers would have taken advantage of the C.A.L. drills to analyze where the problems were occurring. Unfortunately, the opportunity to use the results of C.A.L. as an information system re pupils' specific weaknesses was not always used to maximum advantage. This was mainly because of inexperience with the system and lack of coordination with other teachers.

Coincidently, the pupil supervisors may have been helped in terms of their job assignments. Many were observed to develop better attitudes to their own school work and responsibilities.

Also, it should be noted that the "regular instruction" available at Central North School is not really regular in the traditional sense. A high degree of individualization and remedial instruction is carried out using innovative methods and sophisticated technologies in the mathematics and reading labs and in the classroom as well. These techniques are considered to be quite effective in their own right. On a yearly basis many pupils make achievement gains in excess of one year—a result which is contrary to their past performances in previous schools. Therefore, this factor, coupled with the successful use of C.A.L., combined in some cases to produce very dramatic increases in achievement scores.

Implications and Future Considerations

The present study has shown significant benefits of C.A.L. in the subject areas of arithmetic and spelling for pupils with special educational needs. Although drill and practice is considered as essential in the process of the mastery of basic skills, it has been suggested that it no longer needs to be boring or unmotivating. With the aid of C.A.L. mastery of these important basic skills is no longer a major stumbling block for special-need pupils.

This study has also helped to point out some areas where improvements were needed. In arithmetic more programs were needed in the topics of fractions, decimals, equivalent fractions, fraction and decimal equivalents, word problems, money problems, percentage problems, and measurement.

In the area of language arts, much more work was needed to develop and refine existing programs not only in spelling, but in grammar, punctuation, and other topics. Most of these improvements have been made since the time of the experiment and presently exist on the computer system. Manuals documenting these programs are now available (see Appendix H). Programs could also be expanded in order to offer basic skills curriculum to at least the eighth grade level.

Studies of C.A.L. in the future should be conducted to compare C.A.L. to other types of instruction not usually included in regular classroom instruction. For example, studies using control groups engaged in an activity approach to mathematics or computational skills taught via television, or hand caluculators would further our understanding of the effectiveness of other newer technologies as well as C.A.L.

Other future directions might include some of the following recommendations for C.A.L. studies involving pupils with learning problems:

1) Simulation, game, and tutorial programs in other subject areas such as social studies, health, science and guidance should be developed. Provided that the readability of the program is carefully controlled, there is tremendous potential to teach concepts which at one time were considered too difficult for pupils with learning difficulties.

2) A more comprehensive C.A.L. project would be the development of a multi-media approach using audio-visual techniques in conjunction with and under direct control of the C.A.L. This could also include the use of a sophisticated information storage and retrieval system to aid the teachers in maintaining and using pertinent student records. Student data could be made available daily, or whenever necessary. Automatic record keeping would

then assist in the continuous re-evaluation of student progress for the purpose of systematic diagnosis, prescription, and remedial branching strategies. Equipment to implement this is presently available but lack of funds prevents development in this area.

3) Research is needed to look into the relationship between motivation, behavior, learning, and C.A.L.

4) C.A.L. studies could be devised to compare the effectiveness of C.A.L. using curriculum based on learning hierarchies, such as that of Gagne, compared to C.A.L. using other strategies.

5) High powered tutorials, or tutorials in combination with other types of programs, are necessary to help pupils increase their comprehension abilities—particularly in both key subjects of mathematics and language arts.

6) The concept of C.A.L. could be expanded to include the idea of computer assisted diagnositic testing. Included in this type of application would be tests to determine grade level in specific subject areas and entering behaviors previous to instruction. Also included would be diagnostics into different types of learning deficits or disabilities. Development and study in this field may pay dividends in the future.

Limitations of the Study

As has been mentioned earlier, a closer supervision of the pupils' progress and drill problems being used might have increased the effectiveness of their C.A.L. experience. No attempt was made to co-ordinate classroom topics with the topics being drilled using the C.A.L. Further efficiency was sometimes sacrificed due to lack of supervision and contingency planning on the part of the experimenter. The jobs done by student volunteers in getting the subjects from their classes to logging procedures, were extremely important, and on the whole were carried out well. However, even better

results may have been obtained with more consistent and careful supervision, preferably by a teacher or adult who could carry out such a function on a full time basis.

It can not be over emphasized that the job of proctoring and supervising, performed by the student volunteers, was extremely critical. This indicates the necessity of providing and maintaining a positive human component in C.A.L. projects. The process of carefully regulating, supervising, and monitoring the system is absolutely essential to the attainment of positive effects through C.A.L. It is therefore a limitation of this study that no data was collected on what effects the supervising had on the student supervisors themselves. It is also an implication for future C.A.L. research that human factors such as involvement and planning on the part of the experimenter, supervision by proctors, and careful study and control of human interactions during the course of C.A.L., are of prime importance and have a definite effect on the outcome of experimental research.

Another limitation of the overall study was the failure to involve a fourth group which could have performed an operant task unrelated to C.A.L., such as drill and practice provided by peer tutors. Such an extension would have supplied valuable comparative data and helped to control more fully for the Hawthorne effect.

Summary and Conclusions

The data provided by the Analyses of Variance for both arithmetic and spelling indicated that Null Hypothesis (1) should be accepted. Therefore, it was accepted that there were no significant differences between the two experimental groups and control group means for both arithmetic and spelling.

Significant differences were found over time between pretests and post test, and retention tests. Therefore, Null Hypothesis (2) was rejected for both arithmetic and spelling. Post hoc analyses using Newman-Keuls probing technique revealed differences between: pretest (2) and the post test and retention tests for both arithmetic and spelling at the .01 level of significance. Also found were differences between pretest (1) and post test for spelling at the same level. Lesser differences were found between pretest (1) and post test and retention test for arithmetic at the .05 level of significance.

Null Hypothesis (3) was rejected for arithmetic but accepted for spelling. Results of tests for simple main effects indicated a significant treatment effect for the C.A.L. arithmetic group on arithmetic scores. It was therefore inferred that there were significant gains in achievement scores over time in favor of the C.A.L. arithmetic group compared to the C.A.L. spelling and non-C.A.L. groups.

Results obtained from the correlations indicated that the gains in achievement were consistent within all three groups and that pretest 1 and pretest 2 were equally reliable since they were highly correlated.

The main objectives of this study have been realized. A computer assisted learning system has been established and has proven to be successful in the remediation of the basic skills of addition, subtraction, multiplication, division, and spelling. A greater degree of individualization of instruction is presently being enjoyed by the most needy pupils, thanks to the expansion of the instructional programs in this project.

Also, it was found through this study that C.A.L. is an effective aid in drill and practice routines in both arithmetic and spelling for pupils with learning problems. Economically, this application of C.A.L. has proven to be feasible (see Appendix I). Educationally, the data supports the

contention that our C.A.L. helped to produce significant gains in achievement in both arithmetic and spelling. It is believed that because of the sustained enjoyment and high levels of interest and motivation to learn via the computer, and because of the continuous feedback of positive results, many of the pupils who received C.A.L. were able to gain feelings of accomplishment and success and therefore, gained benefits of a highly personal nature related to increased feeling of their own self worth.

The future of computers in education seems to be filled with promise. Some people, however, have argued that with the advent of the computer, the school will become less humane and more impersonal. Also, some critics have charged that schools are becoming increasingly ineffective in the job of teaching. If, in the future, the computer can be made to take over some non-productive aspects of teaching, then the teacher may be freed to interact more often and more usefully with pupils. By allowing teachers to spend more time discussing, explaining, answering questions, diagnosing and prescribing, the computer will, in all probability, be a tremendous aid to improve all aspects of education for teachers, administrators, and pupils. The human elements of providing an overview, making decisions, and sharing emotions such as enthusiasm, encouragement, and caring, can never be replaced or eliminated from the learning process and can be enhanced by the careful application of computers to education.

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APPENDICES

APPENDIX A

SUMMARY PROFILES OF SUBJECTS

APPENDIX A

TABLE THIRTEEN - Summary Profiles of Subjects - Group 1

SUBJECT	SEX	AGE	TEST/ DATE/IQ	GRADE LEVEL MATH/SPELLING	TYPE OF DISABILITY
1	F	14	Wisc 67/103	4.3 / 5.0	E.P. *
2	F	14	Otis 69/95	5.6 / 5.0	E.P./L.D.*
3	M	15	Otis 68/85-89	6.3 / 5.5	L.D./S.L.*
4	F	16	Wisc 69/67	3.0 / 4.0	E.M.R./E.P
5	M	14	Wisc 69/70	3.9 / 3.6	E.M.R./L.D.
6	M	14	Wisc 71/90	4.3 / 2.2	L.D./S.L.
7	F	14	Otis 70/73	5.1 / 6.0	E.P. / S.L.
8	M	16	-	5.3 / 4.0	H.I.
9	M	15	70/67	3.8 / 4.8	E.M.R.
10	F	16	Wisc 71/90	4.5 / 5.9	E.P./L.D./S.L.
11	M	16	Otis 67/88	5.2 / 5.8	L.D./S.L.
12	M	14	Wisc 69/103	6.0 / 5.5	E.P./L.D.
13	M	12	Wisc 70/73	2.1 / 3.4	E.P./S.L.
14	F	14	Otis 69/105	4.6 / 5.0	E.P.
15	F	15	Wisc 72/81	5.9 / 7.1	S.L./L.D.
16	M	14	71/95	5.6 / 6.6	E.P.
17	F	15	Wisc 72/83	6.4 / 7.1	S.L. / L.D.
18	M	16	Wisc 72/79	7.7 / 5.6	S.L. / L.D.
19	F	15	Wisc 72/82	5.9 / 5.8	S.L. / L.D.
20	F	17	Wisc 70/69	1.8 / 1.8	E.M.R./E.P.
21	M	15	Otis 72/82	4.9 / 6.7	L.D.

APPENDIX A (cont'd)

Summary Profiles of Subjects - Group 1 (cont'd)

SUBJECT	SEX	AGE	TEST/ DATE/IQ	GRADE LEVEL MATH/SPELLING	TYPE OF DISABILITY
22	M	14	Otis 69/97	6.6 / 7.0	L.D.
23	M	15	L-T 72/77	5.3 / 5.7	S.L./L.D./E.P.
24	F	16	Otis 72/80-84	4.7 / 4.3	L.D. / E.P.

APPENDIX A (cont'd)

Summary Profiles of Subjects - Group 2

SUBJECT	SEX	AGE	TEST/ DATE/IQ	GRADE LEVEL MATH/SPELLING	TYPE OF DISABILITY
1	M	17	Wisc 70/105	8.0/7.0	E.P.
2	F	15	Otis 68/92	4.2/5.8	L.D.
3	M	15	Wisc 72/85	3.9/5.4	S.L./L.D./E.P./H.I.
4	F	15	Otis 70/80	3.5/5.5	S.L./L.D./E.P.
5	F	14	Otis 71/91	5.7/6.1	L.D./E.P.
6	M	16	Otis 67/98	5.9/5.0	E.P.
7	M	16	Wisc 68/95	7.7/3.4	S.I./L.D.
8	M	16	Wisc 68/83	5.1/4.0	S.L./L.D./V.D.
9	F	14	Otis 70/84	4.9/3.9	S.L./L.D.
10	M	16	Wisc 68/64	3.1/3.6	E.M.R.
11	F	17	Wisc 65/77	3.8/4.8	E.M.R./DYS
12	M	13	Otis 66/70	2.9/3.0	E.M.R./E.P.
13	F	15	Wisc 66/78	3.8/2.7	E.M.R./E.P.
14	M	14	S.B. 67/90	3.0/4.0	S.L./E.P.
15	M	14	Otis 69/105	4.8/5.7	L.D./DYS
16	F	14	Wisc 68/97	6.1/5.6	L.D./E.P.
17	M	12	Wisc 73/83	5.3/6.3	S.L./E.P.
18	F	16	Otis 74/81-94	5.2/4.7	S.L./L.D.
19	F	15	Otis 68/81-94	5.8/6.1	S.L./E.P.
20	M	16	Otis 68/76	4.4/3.9	S.L./E.P.

APPENDIX A (cont'd)

Summary Profiles of Subjects - Group 2 (cont'd)

SUBJECT	SEX	AGE	TEST/ DATE/IQ	*GRADE LEVEL MATH/SPELLING	TYPE OF DISABILITY
21	M	14	Wisc 70/68	3.8/4.3	E.M.R.
22	M	15	-	4.9/5.3	S.L.
23	M	16	Wisc 71/98	5.3/70	L.D./E.P.
24	F	14	Otis 72/90	3.9/2.8	S.L./L.D./E.P.

Summary Profiles of Subjects - Group 3

SUBJECT	SEX	AGE	TEST/ DATE/IQ	GRADE LEVEL MATHS/SPELLING	TYPE OF DISABILITY
1	M	16	Otis 70/95-104	7.1/5.7	L.D./E.P.
2	M	16	Otis 68/100	7.4/5.5	E.P.
3	M	15	L.T. 72/87	3.5/4.8	S.L./L.D./E.P.
4	F	14	Otis 69/95-105	7.1/6.8	L.D.
5	M	15	Wisc 68/70	5.6/7.8	E.M.R.
6	M	16	Wisc 67/80	4.2/4.4	E.M.R./L.D.
7	M	14	L-T 71/95	5.4/4.7	E.P.
8	F	15	Otis 68/81-94	6.4/7.0	E.P.
9	F	16	Otis 67/80	3.9/5.2	C.P.*/E.P.
10	M	17	Wisc 68/72	3.1/6.0	E.M.R./E.P.
11	F	16	Wisc 71/64	1.8/1.8	E.M.R.
12	M	13	Wisc 70/96	2.9/2.4	L.D./E.P.
13	M	14	S.B. 66/65	2.9/3.0	E.M.R./E.P.
14	M	17	L-T 72/92	3.0/2.4	S.L./E.P./L.D.
15	M	16	Otis 68/90-99	5.0/3.6	L.D./E.P.
16	M	15	Wisc 68/101	2.9/3.2	L.D./E.P.
17	F	15	Wisc 70/105	3.6/2.5	L.D./DYS
18	F	16	Wisc 67/84	4.6/5.3	S.L./L.D.
19	F	16	Otis 69/95	6.4/5.5	L.D./E.P.
20	M	15	Wisc 70/108	5.6/7.6	E.P.

APPENDIX A (Cont'd.)

Summary Profiles of Subjects - Group 3 (Cont'd.)

SUBJECT	SEX	AGE	TEST/ DATE/IQ	GRADE LEVEL MATHS/SPELLING	TYPE OF DISABILITY
21	M	15	Otis 68/90-99	7.4/6.6	E.P./S.I.
22	M	14	Otis 69/81-94	6.4/5.0	S.L.
23	M	14	Wisc 68/104	5.8/5.1	E.P.
24	M	14	69/100	5.3/6.4	E.P.

APPENDIX A (Cont'd.)

LEGEND:

E.P. - emotional problem - C.G.C. referred

L.D. - specific learning disability

S.L. - slow learner

Dys - Dyslexia

A.D. - auditory perceptual dysfunction

V.D. - visual perceptual dysfunction

S.I. - speech impairment

H.I. - hearing impairment

V.I. - visual impairment

E.M.R.- educable mentally retarded

APPENDIX B

SAMPLE COMPUTER PROGRAMS

PROGRAM ADDSAN

DESCRIPTION:

Drill in addition for remediation. Student can do 1-10 randomly-generated problems. There is a choice of how many digits (from 1-5) in each number and how many numbers (from 1-5) the student needs practice in. Students must enter the answer to only one column at a time. This answer is immediately checked and another try or a new problem is given if the answer is not correct. The number of problems wanted at the beginning of the program is the number of problems the student must answer correctly. If the student gets one problem wrong then he will be given one extra problem etcetera.

OBJECTIVES:

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 column.

INSTRUCTIONAL CONSIDERATIONS:

For students at the elementary level. Time required to do 10 problems is approximately 20 minutes.

Student should know how to add within the range given to him (her). The student should also be familiar with the concept of "carrying". If more than two numbers are given then the student should be familiar with adding columns of numbers.

```
 77/02/28. 11.22.44.
CYBERGRAPE LIMITED.
USER NUMBER:  76HANDI                    KRONOS 2.1/397AE0
PASSWORD
[redacted]
TERMINAL:      70.TTY
RECOVER /SYSTEM:BASIC
OLD, NEW, OR LIB FILE:  OLD
FILE NAME:  ADDSAN
READY.

RUN

 77/02/28. 11.24.18.
PROGRAM   ADDSAN

SELF CONSTRUCTED DRILLS IN ADDITION FOR REMEDIATION

HOW MANY PROBLEMS (FROM 1 TO 10) DO YOU WANT TO DO? 4

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

HOW MANY DIGITS (FROM 1 TO 5 )DO YOU WANT IN EACH NUMBER? 2
DO YOU WANT AN EXTRA TRY ('T') OR NO EXTRA TRY ('NT') ? T


WHAT IS YOUR FIRST NAME ? NORF
WHAT IS YOUR LAST NAME? FIORENTINO

IS THIS YOUR CORRECT NAME ?    NORF  FIORENTINO   ? YES

HELLO NORF HOW ARE YOU TODAY?

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

OK LET'S BEGIN...




      0    5
      0    3
(+) ----------
     ? 8
   ? 0
VERY GOOD NORF

 0  0  8   IS THE CORRECT ANSWER
```

```
      7    7
      5    2
(+) ----------
     ? 9
   ? 2
? 1
```
RIGHT ON NORF KEEP UP THE GOOD WORK

1 2 9 IS THE CORRECT ANSWER

```
      9    7
      4    1
(+) ----------
     ? 8
   ? 7
```
SORRY TRY AGAIN
```
   ? 3
? 1
```
YES THAT IS GOOD NORF

1 3 8 IS THE CORRECT ANSWER

```
      5    9
      8    5
(+) ----------
     ? 4
   ? 2
```
SORRY TRY AGAIN
```
   ? 2
```
NO NORF YOU ANSWERED THIS COLUMN WRONG. THE CORRECT ANSWER SHOULD HAVE BEEN 4 . TRY A NEW PROBLEM.

```
      0    0
      9    9
(+) ----------
     ? 9
   ? 9
```
RIGHT YOU ARE DOING FINE NORF

0 9 9 IS THE CORRECT ANSWER

THE DRILL IS OVER NORF . YOU HAD 4 CORRECT ANSWER(S)
AND 1 WRONG ANSWER(S).
WITH 2 EXTRA TRIES.
THAT GIVES YOU 80. PERCENT CORRECT.

DO YOU WANT TO DO ANY MORE PROBLEMS TODAY? ANSWER 'YES' OR 'NO'.? NO

THANK YOU FOR COMING TO PRACTICE TODAY NORF.
I HOPE THAT I WILL HEAR FROM YOU AGAIN SOON.

```
RUN

 77/02/28. 11.32.14.
PROGRAM    ADDSAN

SELF CONSTRUCTED DRILLS IN ADDITION FOR REMEDIATION

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

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

HOW MANY DIGITS (FROM 1 TO 5 ) DO YOU WANT IN EACH NUMBER? 3
DO YOU WANT AN EXTRA TRY ('T') OR NO EXTRA TRY ('NT') ? NT


WHAT IS YOUR FIRST NAME ? JAMIE

WHAT IS YOUR LAST NAME? FIORENTINO

IS THIS YOUR CORRECT NAME ?    JAMIE  FIORENTINO  ? YES

HELLO JAMIE HOW ARE YOU TODAY?

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

OK LET'S BEGIN...



      1    9    6
      4    3    0
      4    7    1
(+) ---------------
     ..............
                ? 7
          ? 9
     ? 0
? 1
RIGHT YOU ARE DOING FINE JAMIE

 1  0  9  7   IS THE CORRECT ANSWER
```

```
      7    5    6
      2    5    Ø
      2    3    9
(+) : ---------------
      ..............? 5
         ? 4
    ? 2
? 1
```

RIGHT ON JAMIE KEEP UP THE GOOD WORK

1 2 4 5 IS THE CORRECT ANSWER

```
      8    8    8
      1    8    3
      5    8    Ø
(+) : ---------------
      ..............? 1
         ? 4
```

NO JAMIE YOU ANSWERED THIS COLUMN WRONG. THE CORRECT ANSWER SHOULD HAVE BEEN 5 . TRY A NEW PROBLEM.

```
      5    8    9
      9    Ø    Ø
      4    4    1
(+) : ---------------
      ..............? Ø
         ? 3
    ? 9
? 1
```

RIGHT ON JAMIE KEEP UP THE GOOD WORK

1 9 3 Ø IS THE CORRECT ANSWER

THE DRILL IS OVER JAMIE . YOU HAD 3 CORRECT ANSWER(S)
AND 1 WRONG ANSWER(S).
THAT GIVES YOU 75 PERCENT CORRECT.

DO YOU WANT TO DO ANY MORE PROBLEMS TODAY? ANSWER
'YES' OR 'NO'.? NO

THANK YOU FOR COMING TO PRACTICE TODAY JAMIE.
I HOPE THAT I WILL HEAR FROM YOU AGAIN SOON.

PROGRAM SUBTSAN

DESCRIPTION:

This program provides drill in subtraction for remediation. The program randomly generates problems up to 5 digits in the top number. The columns of numerals are actioned singly so that improper carrying is diagnosed immediately. The student continues on the program until he has done correctly the number of problems requested. The number of correct answers is given as a percentage of the total number of problems attempted.

OBJECTIVES:

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

INSTRUCTIONAL CONSIDERATIONS:

Instruction level: Grade 1 to Grade 9.

Time required to do 15 problems is approximately 10 to 15 minutes.

At the beginning of the program the pupil is allowed to choose to by-pass the directions.

```
@

 77/02/28. 20.52.13.
 CYBERSHARE LIMITED.                          KRONOS 2.1/397AE0
USER NUMBER:  76HANDI
PASSWORD
[redacted]
TERMINAL:      77,TTY
RECOVER /SYSTEM:BASIC,OLD,SUBTSAN
READY.

RUN

 77/02/28. 20.54.00.
PROGRAM    SUBTSAN

SELF CONSTRUCTED DRILLS IN SUBTRACTION FOR REMEDIATION

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

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

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


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

WHAT IS YOUR FIRST NAME ? JON

WHAT IS YOUR LAST NAME? FIORENTINO

IS THIS YOUR CORRECT NAME ?    JON  FIORENTINO  ? YES

HELLO JON,HOW ARE YOU TODAY?

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

OK,LETS GET STARTED...
```

```
      2    4
      0    3
(-) ----------
        ? 1
    ? 2
```

RIGHT ON JON YOU ARE DOING FINE

2 1 IS THE CORRECT ANSWER.

```
      9    6
      4    2
(-) ----------
        ? 4
    ? 5
```

YES THAT'S GOOD JON KEEP UP THE GOOD WORK...

5 4 IS THE CORRECT ANSWER.

```
      8    6
      1    0
(-) ----------
        ? 6
    ? 8
```

NO JON YOUR ANSWER IS NOT CORRECT. THE ANSWER
SHOULD HAVE BEEN 7 . WE WILL TRY A NEW PROBLEM

```
      2    3
      0    2
(-) ----------
        ? 1
    ? 2
```

RIGHT ON JON YOU ARE DOING FINE

2 1 IS THE CORRECT ANSWER.

THE DRILL IS OVER JON FIORENTINO. YOU HAD 3 CORRECT
1 WRONG AND HAD 0 EXTRA TRIES.
THAT GIVES YOU 75 PERCENT CORRECT

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

PROGRAM MULTSAN

DESCRIPTION:

MULTSAN is a drill in multiplication. The student can do from 1 to 10 randomly-generated problems. There is an option for the number of digits (from 1 to 5) in the number to be multiplied. Also, the student has the choice of multiplying by a fixed constant (a single-digit number between 1 and 9). In each problem the answer is to be entered one column at a time, from right to left, just as if the student were working it out on paper. His answer is checked after each answer. Also, for every question that the student answers wrong, an extra question is given, i.e. if you asked for 3 questions and got 1 wrong, you would be given 4 questions altogether. At the end of the drill, the student's score is listed: number of correct and wrong answers, and percentage correct. Then the student may do some more problems, if he so chooses.

OBJECTIVES:

1. To give the student practice in multiplication.
2. To progress along with the student, i.e. the difficulty of the problems is based on the student's level of knowledge. If he only knows up to the 5 times-table, he can be drilled on just that.
3. If so specified by the number of digits in the top number, the drill can be used to give the student practice in "carrying".

PROGRAM MULTSAN (cont'd.)

INSTRUCTIONAL CONSIDERATIONS:

- For students at the elementary level (Grades 2-4).
- Student should be familiar with multiplying numbers within the specified range, i.e. if a 1-digit number is to be multiplied by the constant "4", then the student should have been taught the 4 times table.
- If the top number has 2 or more digits, then the student should know about the concept of "carrying".
- Approximate run time: 20 minutes for 10 problems.

```
PROGRAM    MULTSAN

SELF-CONSTRUCTED DRILL IN MULTIPLICATION

HOW MANY PROBLEMS (FROM 1 TO 10) DO YOU WANT TO DO? 2

HOW MANY DIGITS (FROM 1 TO 5) DO YOU WANT IN TOP NUM? 3

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

WHAT NUMBER (FROM 1 TO 9) DO YOU WANT TO MULTIPLY BY? 3

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

WHAT IS YOUR FIRST NAME ? CHERYL

WHAT IS YOUR LAST NAME? FIORENTINO

IS THIS YOUR CORRECT NAME ?    CHERYL  FIORENTINO   ? YES

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

OK, LET'S BEGIN...


     8    2    6
                3
(X) ---------------
     ? 8
          ? 7
     ? 4
? 2
YES THAT IS GOOD CHERYL

 2  4  7  8   IS THE CORRECT ANSWER


     3    1    9
                3
(X) ---------------
          ? 7
     ? 5
? 8
NO, CHERYL. YOUR ANSWER IS WRONG.
THE ANSWER SHOULD HAVE BEEN  9 .
TRY THIS ONE...


     9    8    0
                3
(X) ---------------
          ? 0
     ? 4
? 9
? 2
TERRIFIC CHERYL YOU ARE DOING WELL

 2  9  4  0   IS THE CORRECT ANSWER

THE DRILL IS OVER, CHERYL. YOU HAD  2  CORRECT ANSWERS
AND YOU HAD  1  WRONG ANSWER(S). THAT GIVES YOU
  66.6667  PERCENT.
```

DIVIDE

DESCRIPTION:

DIVIDE is a drill in division. The student can do from 1 to 15 randomly-generated problems. There is an option of whether or not decimals are to be involved. If the choice is not to work with decimals, then the student is asked to input the number of digits (from 1 to 9) in the number that you divide into, say X. This is followed by asking the number of digits (from 1 to X) in the number that you divide by. In working with decimals, there are options for the number of digits and the decimal places in both the divisor and dividend. The student will probably use paper and pencil to help him solve the problems. The student gets one try at each problem; if he gives an incorrect answer, an error message is printed, followed by the correct answer. At the end of the drill, the student's score is listed: number of problems attempted, number of problems correct, and percentage. He may then do some more problems, if he so chooses.

OBJECTIVES:

1. To give the student practice in the division of integers.
2. To give the student practice in the division of decimal numbers.
3. The drill can be used for testing purposes since the student has only one try at each problem. Also, the problems are different at every RUN.
4. To help the student in dealing with proper decimal alignment, i.e. in the problem, $1.5 \overline{)\ 4.5}$, the student must move the decimal places in order to solve the problem, i.e. $15. \overline{)\ 45.}$.

DIVIDE (Cont'd.)

INSTRUCTIONAL CONSIDERATIONS:

- For students at the elementary level (Grades 3-6).
- Students should know how to divide numbers within the specified range, i.e. if he is dividing a 1-digit number into a 3-digit number, then he should know about "long division".
- If working with decimals, the student should know about the concept of decimal alignment. (see Objectives #4)
- Approximate run time: 20-25 minutes for 10 problems.

```
 77/02/28. 21.07.14.
PROGRAM   DIVIDE

THIS IS A DRILL IN DIVISION FOR REMEDIATION.

HI. THERE. WHAT IS YOUR FIRST NAME? FRANK

WHAT IS YOUR LAST NAME, FRANK ? FIORENTINO

IS THIS YOUR CORRECT NAME ?    FRANK  FIORENTINO  ? YES

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? 3


HOW MANY DIGITS (FROM 1 TO  3 ) DO YOU WANT IN THE
NUMBER THAT YOU DIVIDE BY ? 1



       9       )  891
               -------
= ? 99

TREMENDOUS, FRANK. THAT IS RIGHT. THE ANSWER IS  99 .

               -------
       2       )  268
= ? 134

SUPERB, FRANK.  134  IS THE CORRECT ANSWER.

               -------
       9       )  972
= ? 109

THAT IS NOT CORRECT. THE ANSWER IS  108 .


THE DRILL IS OVER, FRANK.

NUMBER OF PROBLEMS ATTEMPTED:  3

NUMBER OF PROBLEMS CORRECT:  2

PERCENTAGE:  66.6667
```

```
WOULD YOU LIKE TO DO SOME MORE PROBLEMS ? YES
HOW MANY PROBLEMS (FROM 1 TO 15) WOULD YOU LIKE TO DO ? 2

DO YOU WANT TO WORK WITH DECIMALS ? YES

HOW MANY DECIMAL PLACES (FROM 0 TO 5) WILL YOU
HAVE IN YOUR ANSWER ? 2

HOW MANY DIGITS (FROM 1 TO 9) DO YOU WANT IN DIVIDEND ? 4
HOW MANY DECIMAL PLACES (FROM 0 TO  4 ) IN DIVIDEND ? 2

HOW MANY DIGITS (FROM 1 TO  4 ) IN THE DIVISOR? 1
HOW MANY DECIMAL PLACES (FROM 0 TO  1 ) IN DIVISOR? 1


                -------
      .6        ) 14.91

= ? 24.85

SUPERB, FRANK.  24.85  IS THE CORRECT ANSWER.


                -------
      .1        ) 32.1

= ? 320
THAT IS NOT CORRECT. THE ANSWER IS  321 .

THE DRILL IS OVER, FRANK.
NUMBER OF PROBLEMS ATTEMPTED:  2
NUMBER OF PROBLEMS CORRECT:  1
PERCENTAGE:  50

WOULD YOU LIKE TO DO SOME MORE PROBLEMS ? NO

GOOD-BYE, FRANK. HAVE A NICE DAY.
```

SPEL 128

DESCRIPTION:

SPEL 128 is a spelling drill. The student may do from 1 to 20 randomly-selected questions. In each question, the student is given a group of four related words, one of which is misspelled. The student must choose the number (position) of the misspelled word, and then spell the word correctly. He is marked both on his ability to choose the right misspelled word and his ability to spell the word correctly. If the student fails to give the correct spelling, an error message is printed, followed by the correct spelling. He is then asked to re-type the word correctly. At the end of the drill, the student's score is listed by the total percentage correct.

OBJECTIVES:

1. To give the student practice in recognizing the misspelled word in a group of four words.
2. To give the student practice in correctly spelling the misspelled word.

INSTRUCTIONAL CONSIDERATIONS:

- For students at the elementary level (Grades 2-6)
- Student should be familiar with all of the words presented in the groups.
- Student should have had previous experience in identifying misspelled words.
- Approximate run time: 25 minutes for 20 questions.

REFERENCE:

Most of the spelling words were selected from the DOLCH Spelling Word List, obtained from Mrs. Wedel, Central North School.

SPEL128

```
 SPELLING DRILL NUMBER 1

 WHAT IS YØUR FIRST NAME? CHERYL
 WHAT IS YØUR LAST NAME ? FIØRENTINØ
 HELLØ CHERYL HØW ARE YØU TØDAY?

 DØ YØU WANT TØ SEE THE INSTRUCTIØNS? TYPE YES ØR NØ
? NØ

 ØK LET'S BEGIN...


 ANIMALS        LARGE          SAYES          SEA

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? 3

 VERY GØØD CHERYL

 WHAT IS THE CØRRECT SPELLING?
? SAFS

 NØT EXACTLY CHERYL THE WØRD IS SPELLED:   SAYS

 CLUBS          STAMPES        LEAST          PASSES

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? 2

 VERY GØØD CHERYL

 WHAT IS THE CØRRECT SPELLING?
? STAMPS

 RIGHT ØN CHERYL YØU ARE DØING GREAT

 BØTTØM         LØØKS          DREAM          LATIR

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? 4

 VERY GØØD CHERYL

 WHAT IS THE CØRRECT SPELLING?
? LATER

 RIGHT ØN CHERYL YØU ARE DØING GREAT
```

```
 EVERY          LUCKILIY        LEAF            SMALLEST

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? 2

 VERY GØØD CHERYL

 WHAT IS THE CØRRECT SPELLING?
? LUCKILY

 RIGHT ØN CHERYL YØU ARE DØING GREAT

 INJØY          KEPT            LAUGH           BREAD

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? 1

 VERY GØØD CHERYL

 WHAT IS THE CØRRECT SPELLING?
? ENJØY

 RIGHT ØN CHERYL YØU ARE DØING GREAT

 MUSIC          HØSPITAL        WØRLD           LEAVES

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? 0

 VERY GØØD CHERYL

 RUBBING        BRØWN           VALENTINE       FRIUT

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? 4

 VERY GØØD CHERYL

 WHAT IS THE CØRRECT SPELLING?
? FRUIT

 RIGHT ØN CHERYL YØU ARE DØING GREAT

 YELLØW         BYCICLE         WHALE           LADIES

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? 2

 VERY GØØD CHERYL

 WHAT IS THE CØRRECT SPELLING?
? BICYCLE

 RIGHT ØN CHERYL YØU ARE DØING GREAT
```

```
 SWEET          HAVING          WAGØN          AMUØNT

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? 4

 VERY GØØD CHERYL

 WHAT IS THE CØRRECT SPELLING?
? AMØUNT

 RIGHT ØN CHERYL YØU ARE DØING GREAT

 ALLWAYS        HØUSES          DECIDE          CLAPPED

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? ALWAYS

 NØ CHERYL ALWAYS IS NØT CØRRECT. TRY AGAIN.

 WHAT WØRD IS MISSPELLED? TYPE IN 1,2,3,4,ØR 0
? 1

 VERY GØØD CHERYL

 WHAT IS THE CØRRECT SPELLING?
? ALWAYS

 RIGHT ØN CHERYL YØU ARE DØING GREAT

 THAT'S ALL FØR TØDAY CHERYL YØU HAD  9    CØRRECT
 AND  1    WRØNG WHICH IS  90.    PERCENT CØRRECT

 GØØDBYE CHERYL HAVE A GØØD DAY

CP        0.355 SECS.

RUN CØMPLETE.
```

SPELB1

DESCRIPTION:

SPELB1 is a spelling drill. The student is offered ten drills to choose from: tricky words, opposites, questions, homonyms, plurals, months, weekdays, numbers, contractions, and provinces. (See DATA for examples.) Each drill has five questions. In one sitting, the studentmmay do as many of the drills as he chooses. At the end of the drill, a "Kronas Komputer Kollege Spelling Report" is issued. This lists the student's score: number of words attempted, number of words correct, and percentage, along with a short message to the parents. This is then followed by a list of the spelling words with which the student showed difficulty.

OBJECTIVES:

1. To give the student practice in spelling commonly-misspelled words.
2. In some of the drills, the student is given practice in abbreviations of words, e.g. Tues.——Tuesday.
3. To give the student practice in: forming plurals of words (drill 5), forming contractions (drill 9), choosing the correct spelling of a word (drill 1), knowing the opposite (antonym) of a word (drill 2), knowing homonyms (drill 4), etcetera.

SPELB1 (Cont'd.)

INSTRUCTIONAL CONSIDERATIONS

- For students at the elementary level (Grades 3-6).
- Student should be familiar with the words in the particular drill he is doing, e.g. if he has chosen drill #4, then he should be familiar with the definition of a homonym, and he should have had some previous experience in working with them.
- Depending on the drill chosen, the student may have to be familiar with: the spelling of tricky words, opposites, general knowledge of questions, homonyms, forming plural words, spelling the months of the year, spelling the days of the week, spelling numbers, forming contractions, and spelling the provinces of Canada and knowing some major cities found in each province.
- Approximate run time: 5-10 minutes for each drill (of 5 questions each).

```
PROGRAM    SPELBI

HI, MY NAME IS KRONOS, WHAT IS YOUR FIRST NAME? TONY
WHAT IS YOUR LAST NAME TONY ? FIORENTINO

IS THIS YOUR CORRECT NAME ?    TONY  FIORENTINO ? YES
ARE YOU A BOY OR A GIRL? PRINT WHICH? BOY I THINK
ARE YOU A BOY OR A GIRL? PRINT WHICH? OK BOY
ARE YOU A BOY OR A GIRL? PRINT WHICH? BOY

HELLO TONY I AM GLAD TO MEET YOU.

I CAN OFFER DRILLS IN THE FOLLOWING TOPICS

     1 ):      TRICKY WORDS
     2 ):      OPPOSITES
     3 ):      QUESTIONS
     4 ):      HOMONYMS
     5 ):      PLURALS
     6 ):      MONTHS
     7 ):      WEEKDAYS
     8 ):      NUMBERS
     9 ):      CONTRACTIONS
     10 ):     PROVINCES

TYPE IN THE NUMBER OF THE DRILL YOU WANT TO TRY ? 22
I CAN OFFER ONLY TEN TOPICS TONY
YOUR NUMBER  22  IS TOO LARGE
PLEASE TRY AGAIN TONY
TYPE IN THE NUMBER OF THE DRILL YOU WANT TO TRY ? 1

 HERE WE GO
  **  **  **  **  **  **  TRICKY WORDS  **  **  **  **  **  **

HERE ARE TWO WORDS, ONE OF WHICH IS MISSPELLED.

WHICH ----      RIBBON     OR     RIBON

CHOOSE WHICH ONE IS CORRECTLY SPELLED

NOW, TYPE IT OUT CORRECTLY? RIBBON

O.K., TONY
```

WHICH ---- RECIEVE OR RECEIVE

CHOOSE WHICH ONE IS CORRECTLY SPELLED

NOW, TYPE IT OUT CORRECTLY? RICIEVF

YOU GOOFED, TONY.THE CORRECT WORD IS RECEIVE

LET'S LEARN THAT WORD. LOOK AT IT AGAIN.

----RECEIVE

SAY IT TO YOURSELF.SPELL IT OUT AS I TYPE IT

RECEIVE RECEIVE

NOW,TYPE IT OUT CORRECTLY,SAYING EACH LETTER AS YOU TYPE? RECEIVE

YOU LEARN VERY QUICKLY TONY

WHICH ---- CHIMNEY OR CHIMPEY

CHOOSE WHICH ONE IS CORRECTLY SPELLED

NOW, TYPE IT OUT CORRECTLY? CHIMNEY

RIGHT ON, TONY

WHICH ---- WRITTEN OR WRITEN

CHOOSE WHICH ONE IS CORRECTLY SPELLED

NOW, TYPE IT OUT CORRECTLY? WRITTEN

RIGHT ON, TONY

WHICH ---- CHEIF OR CHIEF

CHOOSE WHICH ONE IS CORRECTLY SPELLED

NOW, TYPE IT OUT CORRECTLY? CHIEF

CORRECT, TONY

LET'S GO ON TO YOUR NEXT GROUP, TONY

THAT'S THE END OF THE DRILL. NOW A REPORT YOU CAN TAKE HOME

FIRST, TEAR OFF THIS SHEET ON THE LINE BELOW

```
**********************************************************

                KRONAS KOMPUTER KOLLEGE
                   SPELLING REPORT

PUPIL: TONY FIORENTINO

NUMBER OF WORDS ATTEMPTED=  5

NUMBER OF WORDS CORRECT=  4

PERCENTAGE=  80

COMMENTS:
        DEAR PARENTS:-
                        TONY NEEDS MUCH MORE SPELLING DRILL.
HE SHOULD DO MY DRILL UNTIL HE CAN SCORE 95.
                                    YOURS TRULY,
                                       KRONAS



**********************************************************

----------------------------------------------------------
TEAR OFF REPORT CARD ON THE LINE ABOVE
GOOD-BYE, TONY. LET'S TALK AGAIN REAL SOON.


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


CP        1.275 SECS.

RUN COMPLETE.




OLD,SPEL128
 SPEL128 NOT FOUND.

BYE

76HANDI.   LOG OFF.  21.26.53.
76HANDI.   CP        3.865 SEC.

@
```

APPENDIX C

ARITHMETIC AND SPELLING HIERARCHIES

Name _____

Room # _____

Computer Time Periods _____

1	Add: one digit + one digit (over 10) ex: 7+6 Addsan	DATE							
2	Add: two digits + one digit ex: 35+6 Addsan	SCORE							
3	Subt: two digits-one digit ex: 14-8 Subtsan								
4	Add: two digits + two digits ex: 36+42 Addsan								
5	Subt: two digits-two digits ex: 42-27 Subtsan								
6	Mult: one digit x 1 ex: 9 x 1 Multsan								
7	Mult: one digit x 2 ex: 7 x 2 Multsan								
8	Mult: one digit x 3 ex: 8 x 3 Multsan								
9	Mult: one digit x 4 ex: 7 x 4 Multsan								
10	Mult: one digit x 5 ex: 7 x 5 Multsan								
11	Add: 3 digits + 3 digits ex: 426+337 Addsan								
12	Subt: 3 digits-3 digits ex: 436-242 Subtsan								
13	Mult: two digits x 1 ex: 25 x 1 Multsan								
14	Mult: two digits x 2 ex: 25 x 2 Multsan								
15	Mult: two digits x 3 ex: 36 x 3 Multsan								
16	Mult: two digits x 4 ex: 37 x 4 Multsan								
17	Mult: two digits x 5 ex: 85 x 5 Multsan								

APPENDIX C

Name _____

Room #_____

Computer Time Periods _____

18	Divide: one digit ÷ one digit (no decimal) 2 8 Divide	DATE SCORE						
19	Divide: two digits ÷ one digit (no decimal) 2 24 Divide							
20	Mult: one digit x 6 ex: 7 x 6 Multsan							
21	Mult: one digit x 7 ex: 8 x 7 Multsan							
22	Mult: one digit x 8 ex: 8 x 8 Multsan							
23	Mult: one digit x 9 ex: 7 x 9 Multsan							
24	Divide: one digit ÷ one digit (decimal) 2 7 Divide							
25	Divide: two digits ÷ one digit (decimal) 2 35 Divide							
26	Mult: two digits x 6 ex: 27 x 6 Multsan							
27	Mult: two digits x 7 ex: 29 x 7 Multsan							
28	Mult: two digits x 8 ex: 37 x 8 Multsan							
29	Mult: two digits x 9 ex: 94 x 9 Multsan							
30	General Review (higher level mathematics) Specify (may be 3 digit multiplication) (2 digit divisor etc.)							

APPENDIX C

SPELLING DRILLS

Part I SPELB1												
1. Tricky Words	Date Score											
2. Opposites												
3. Questions												
4. Homonyms												
5. Plurals												
6. Months												
7. Weekdays												
8. Numbers												
9. Contractions												
10. Provinces												
Part II SPEL 128												

APPENDIX D

DATA TREATMENT DESIGN

Data Treatment Design

	Subjects	Pretest (1) b1	Pretest (2) b2	Post-test b3	Retention Test b4
Treatment Group 1 CAI-Math	1	X_{111}	X_{112}	X_{113}	X_{114}
	2	X_{211}	X_{212}	X_{213}	X_{214}
	3	X_{311}	X_{312}	X_{313}	X_{314}
	⋮	⋮	⋮	⋮	⋮
	n	X_{n11}	X_{n12}	X_{n13}	X_{n14}
Treatment Group 2 CAI-Spelling	1	X_{121}	X_{122}	X_{123}	X_{124}
	2	X_{221}	X_{222}	X_{223}	X_{224}
	3	X_{321}	X_{322}	X_{323}	X_{324}
	⋮	⋮	⋮	⋮	⋮
	n	X_{n21}	X_{n22}	X_{n23}	X_{n24}
Treatment Group 3 No-CAI (control)	1	X_{131}	X_{132}	X_{133}	X_{134}
	2	X_{231}	X_{232}	X_{233}	X_{234}
	3	X_{331}	X_{332}	X_{333}	X_{334}
	⋮	⋮	⋮	⋮	⋮
	n	X_{n31}	X_{n32}	X_{n33}	X_{n34}

APPENDIX E

INTERCORRELATIONS BETWEEN ARITHMETIC AND SPELLING SCORES FOR THE THREE TREATMENT GROUPS

APPENDIX E

Discussion of the Intercorrelations Between Arithmetic and Spelling

The data showing the intercorrelations between arithmetic and spelling can be found in Table Fourteen. By inspection it can be seen that the intercorrelations between the arithmetic and spelling scores for the treatment group 2 (C.A.L. Spelling) are, descriptively, much lower than for the other two groups, (C.A.L. Arithmetic and Non-C.A.L. groups). Even though the correlations are significant at the .05 level, T-tests were performed to check if there were any significant differences in the way each treatment group related to the dependent variables of arithmetic and spelling achievement.

The T-tests were used to examine the greatest differences, which occurred between pretest 2 for all three groups. The results obtained from these T-tests revealed no significant differences between any two of the three groups. Therefore since these tests were for the greatest descriptive differences, no further statistical tests were needed.

APPENDIX E

TABLE FOURTEEN —
Intercorrelations Between Arithmetic and Spelling Scores for the Three Treatment Groups

C.A.L. Math Group (Treatment 1)

	Math pre 2	Math post	Math ret
Spelling:			
pre 2	0.73		
post		0.71	
ret			0.70

C.A.L. Spelling Group (Treatment 2)

	Math pre 2	Math post	Math ret
Spelling:			
pre 2	0.46		
post		0.46	
ret			0.49

Non-C.A.L. Group (Control)

	Math pre 2	Math post	Math ret
Spelling:			
pre 2	0.69		
post		0.54	
ret			0.60

$r < .388$ (.05)

$r < .496$ (.01)

APPENDIX F

RAW SCORE SUMMARY TABLES

(MEANS AND STANDARD DEVIATIONS)

APPENDIX F

TABLE FIFTEEN: (Raw Score Summary Tables - Means and Standard Deviations)

Group 1 (C.A.L. Arithmetic) Arithmetic Scores

	Pre 1	Pre 2	Post	Ret
1.	4.6	4.3	4.8	4.8
2.	5.3	5.6	5.7	5.2
3.	5.6	6.3	6.8	6.8
4.	3.3	3.0	4.1	4.5
5.	3.5	3.9	3.9	4.0
6.	4.2	4.3	4.7	4.9
7.	4.9	5.1	5.3	5.2
8.	6.0	5.3	6.0	6.4
9.	4.6	3.8	5.6	5.6
10.	4.6	4.5	6.2	5.9
11.	6.2	5.2	7.1	7.9
12.	5.4	6.0	6.6	6.7
13.	2.1	2.1	3.0	2.8
14.	5.7	4.6	6.0	5.3
15.	5.7	5.9	6.4	7.2
16.	5.8	5.6	6.2	6.1
17.	5.3	6.4	6.4	6.4
18.	6.6	7.7	7.7	6.6
19.	5.8	5.9	6.2	6.0
20.	1.8	1.8	1.8	1.8
21.	6.0	4.9	5.8	5.2
22.	6.3	6.6	6.5	6.3
23.	5.6	5.3	5.7	5.0
24.	4.8	4.7	4.9	5.0
Totals	119.70	118.80	133.40	131.60
Means	4.988	4.950	5.558	5.483
S.D.	1.250	1.380	1.335	1.350
$(S.D.)^2$	1.56	1.90	1.78	1.82

TABLE FIFTEEN (Cont'd.) (Raw Score Summary Tables - Means and Standard Deviations)

Group 2 (C.A.L. Spelling) Arithmetic Scores

	Pre 1	Pre 2	Post	Ret
1.	8.2	8.0	8.4	8.2
2.	5.6	4.2	5.2	5.3
3.	4.4	3.9	4.4	4.2
4.	4.5	3.5	3.3	4.7
5.	5.4	5.7	5.6	5.4
6.	5.8	5.9	5.7	5.3
7.	7.4	7.7	8.4	8.2
8.	4.6	5.1	3.7	3.7
9.	5.3	4.9	4.9	5.3
10.	3.5	3.1	3.2	3.6
11.	3.7	3.8	3.8	3.9
12.	2.5	2.9	3.3	3.6
13.	4.3	3.8	4.4	4.4
14.	3.6	3.0	3.7	3.2
15.	4.1	4.8	4.8	3.9
16.	7.7	6.1	7.1	7.3
17.	5.6	5.3	4.6	4.1
18.	5.0	5.2	4.8	4.6
19.	5.4	5.8	6.6	6.5
20.	4.4	4.4	3.7	5.4
21.	3.5	3.8	3.8	3.1
22.	5.0	4.9	4.6	5.7
23.	5.8	5.3	5.8	5.8
24.	3.7	3.9	3.9	4.5
Totals	119.00	115.00	117.70	119.9
Means	4.958	4.792	4.904	4.996
S.D.	1.386	1.330	1.485	1.428
$(S.D.)^2$	1.920	1.768	2.205	2.039

TABLE FIFTEEN (Cont'd.) (Raw Score Summary Tables - Means and Standard Deviations)

Group 3 (NON-C.A.L.)Arithmetic Scores

	Pre 1	Pre 2	Post	Ret
1.	8.6	7.1	7.6	7.7
2.	8.2	7.4	7.7	7.8
3.	3.5	3.5	3.1	3.5
4.	5.9	7.1	6.0	6.1
5.	6.0	5.6	5.9	5.9
6.	3.9	4.2	5.0	5.1
7.	6.2	5.4	5.9	5.3
8.	6.0	6.4	6.1	6.1
9.	3.4	3.9	4.0	3.5
10.	3.5	3.1	2.7	2.9
11.	1.8	1.8	1.8	1.8
12.	3.2	2.9	3.2	3.0
13.	3.1	2.9	2.9	2.7
14.	4.1	3.0	3.7	3.5
15.	4.4	5.0	5.2	5.0
16.	3.2	2.9	3.3	3.3
17.	2.9	3.6	3.7	3.6
18.	4.9	4.6	4.1	4.3
19.	6.1	6.4	5.8	5.6
20.	5.0	5.6	6.0	5.9
21.	8.4	7.4	8.5	8.0
22.	7.1	6.4	5.9	5.9
23.	5.0	5.8	6.0	6.0
24.	5.8	5.3	6.0	5.9
Totals	120.20	117.30	120.10	118.40
Means	5.008	4.888	5.004	4.933
S.D.	1.907	1.719	1.776	1.755
$(S.D.)^2$	3.636	2.954	3.154	3.080

APPENDIX F

TABLE FIFTEEN (Cont'd.) (Raw Score Summary Tables - Means and Standard Deviations)

Group 1 (C.A.L. Arithmetic) Spelling Scores

	Pre 1	Pre 2	Post	Ret
1.	4.9	5.0	6.1	6.0
2.	4.4	5.0	5.1	5.4
3.	5.3	5.5	4.9	6.0
4.	4.4	4.0	3.4	4.8
5.	3.6	3.6	3.8	3.6
6.	2.1	2.2	3.6	3.5
7.	5.5	6.0	5.8	6.0
8.	3.9	4.0	5.4	5.4
9.	5.1	4.8	4.4	5.1
10.	6.3	5.9	6.1	6.0
11.	5.2	5.8	6.3	5.5
12.	5.5	5.5	4.7	4.2
13.	3.8	3.4	4.4	3.5
14.	4.8	5.0	5.4	5.3
15.	7.5	7.1	7.5	7.0
16.	7.0	6.6	7.5	7.2
17.	7.0	7.1	7.3	7.0
18.	6.3	5.6	6.3	5.9
19.	5.4	5.8	6.1	5.4
20.	1.8	1.8	1.8	1.8
21.	7.0	6.7	6.6	6.6
22.	7.5	7.0	8.5	8.0
23.	5.6	5.7	4.3	3.9
24.	4.5	4.3	4.2	4.5
Totals	124.40	123.40	129.50	127.60
Means	5.183	5.142	5.396	5.317
S.D.	1.511	1.435	1.546	1.421
$(S.D.)^2$	2.283	2.059	2.390	2.019

APPENDIX F

TABLE FIFTEEN (Cont'd.) (Raw Score Summary Tables - Means and Standard Deviations)

Group 2 (C.A.L. Spelling) Spelling Scores

	Pre 1	Pre 2	Post	Ret
1.	8.1	7.0	8.3	8.1
2.	5.5	5.8	6.8	6.3
3.	5.4	5.4	5.9	5.7
4.	5.5	5.5	6.0	5.6
5.	5.9	6.1	5.8	5.6
6.	4.8	5.0	5.4	5.2
7.	3.8	3.4	4.5	4.4
8.	4.6	4.0	5.2	5.1
9.	4.4	3.9	4.8	4.6
10.	4.1	3.6	3.8	3.8
11.	4.4	4.8	4.7	4.3
12.	3.5	3.0	4.9	4.7
13.	3.2	2.7	3.0	3.4
14.	4.6	4.0	4.5	4.3
15.	5.5	5.7	5.4	5.7
16.	5.5	5.6	5.6	6.1
17.	7.0	6.3	7.3	6.6
18.	5.0	4.7	6.0	5.4
19.	6.1	6.1	6.6	6.6
20.	4.2	3.9	5.1	5.1
21.	3.6	4.3	4.6	4.6
22.	5.4	5.3	5.6	5.5
23.	6.8	7.0	8.0	7.6
24.	2.8	2.8	3.4	3.2
Totals	119.70	115.90	131.20	127.50
Means	4.988	4.829	5.467	5.313
S.D.	1.259	1.270	1.304	1.202
$(S.D.)^2$	1.585	1.612	1.700	1.444

APPENDIX F

TABLE FIFTEEN (Cont'd.) (Raw Score Summary Tables - Means and Standard Deviations)

Group 3 (Non-C.A.L.) Spelling Scores

	Pre 1	Pre 2	Post	Ret
1.	6.6	5.7	7.0	6.8
2.	4.4	5.5	5.6	6.1
3.	4.8	4.8	6.4	5.3
4.	7.3	6.8	6.8	6.8
5.	8.1	7.8	8.1	7.3
6.	4.2	4.4	5.4	4.7
7.	4.8	4.7	4.7	4.4
8.	5.9	7.0	7.0	7.3
9.	4.7	5.2	5.9	5.2
10.	6.3	6.0	5.3	6.6
11.	2.0	1.8	2.0	2.0
12.	3.2	2.4	3.0	2.4
13.	3.9	3.0	3.7	3.4
14.	2.8	2.4	3.0	2.7
15.	3.6	3.6	2.0	2.1
16.	3.4	3.2	2.4	2.0
17.	2.7	2.5	2.1	2.1
18.	5.4	5.3	5.7	5.7
19.	5.7	5.5	6.8	6.1
20.	8.5	7.6	7.6	7.3
21.	6.1	6.6	6.5	6.4
22.	5.4	5.0	4.3	5.1
23.	5.6	5.1	5.1	5.5
24.	7.0	6.4	8.1	7.3
Totals	122.40	118.30	124.50	120.60
Means	5.100	4.929	5.188	5.025
S.D.	1.731	1.711	1.995	1.951
$(S.D.)^2$	2.996	2.927	3.980	3.806

APPENDIX G

LEARNING CURVES FOR EACH SUBJECT

ANALYSIS OF GROUP DATA

APPENDIX G

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 four, five, six, seven, eight, and nine for arithmetic achievement and in figures ten, eleven, twelve, thirteen, fourteen, and fifteen for spelling achievement.

ARITHMETIC ACHIEVEMENT - C.A.L. Arithmetic Group (Group 1)

As shown in figures four and five, 18 pupils showed gains from pretest 2 to the retention test. Out of all the pupils in this group, 11 showed a decline from pretest 1 to pretest 2, while 11 showed an increase and 2 remained constant. During the treatment period, 19 pupils increased, while 4 remained constant and 1 decreased slightly. During the retention period, 8 pupils increased slightly, while 5 remained constant, and 11 decreased slightly. The greatest gain was 2.7 years, the smallest was 0.1 year and the mean gain was 0.81 years.

C.A.L. Spelling Group (Group 2)

As shown in figures six and seven, 17 pupils showed gains from pretest 2 to the retention. Out of all the pupils in this group, 12 showed a decline from pretest 1 to pretest 2, while 11 showed an increase and 1 remained constant. During the treatment period, 11 pupils increased, while 6 remained constant, and 7 decreased. During the retention period, 10 pupils increased, while 3 remained constant and 11 decreased slightly. The greatest gain was 1.2 years, the smallest gain was 0.1 year, and the mean gain was 0.68 years.

Non-C.A.L. Group (Group 3)

Fewer pupils showed gains in this group than did pupils from the two C.A.L. groups. As shown in figures eight and nine, only 11 pupils showed gains compared to 13 that made no gains. Out of all the pupils in this group, 13 pupils declined from pretest 1 to pretest 2, while 9 increased and 2 remained constant. During the treatment period, 15 showed gains, 7 showed losses and 2 remained the same. During the retention period, 7 pupils increased, while 6 remained constant and 11 decreased. The greatest gain was 0.9 years, the smallest was 0.1, and the mean gain was 0.45 years.

SUMMARY FOR ARITHMETIC DATA

Out of all 72 subjects, 41 showed no gains compared to 31 that showed gains from pretest 1 to pretest 2. This mixed result may be explained partly by the observation that most of the pupils seemed to be more anxious during pretest 1—thus making pretest 2 more reliable.

The day of pretest 2 was an unusually warm day. Some of the pupils were observed to be uncomfortable due to heat in the testing room. This may have adversely affected the scores of some of the pupils on pretest 2.

As shown in the graphs, the gains in arithmetic achievement made by the C.A.L.-arithmetic pupils are larger than those of the other pupils. For example, the mean gain in the C.A.L. arithmetic group was 0.81 years, compared to 0.68 years for the C.A.L. spelling group and 0.45 for the non C.A.L. group. Overall, from pretest 2 to retention test, 17 pupils

from the C.A.L. arithmetic group made gains compared to 17 from the C.A.L. spelling group and 11 from the non-C.A.L. group.

During the retention period, 11 pupils from each group showed losses, compared to 13 from each group that gained or stayed constant. Regardless, the gains or losses were small compared to the overall gains. Therefore, retention of learning remained fairly constant.

APPENDIX G

TABLE SIXTEEN -

Summary of Arithmetic Group Data

	Gains	Losses	Constant
Group 1			
1) from pretest 1 to pretest 2	11	11	2
2) treatment period	19	1	4
3) retention period	8	11	5
4) overall from pretest 2 to retention test	18	4	2
Group 2			
1) from pretest 1 to pretest 2	11	12	1
2) treatment period	11	7	6
3) retention period	10	11	3
4) overall from pretest 2 to retention test	17	7	0
Group 3			
1) from pretest 1 to pretest 2	9	13	2
2) treatment period	15	7	2
3) retention period	7	11	6
4) overall from pretest 2 to retention test	11	12	1

FIGURE FOUR - Learning Curves of the Subjects from the C.A.L. Arithmetic Group Showing Gains in Arithmetic Achievement

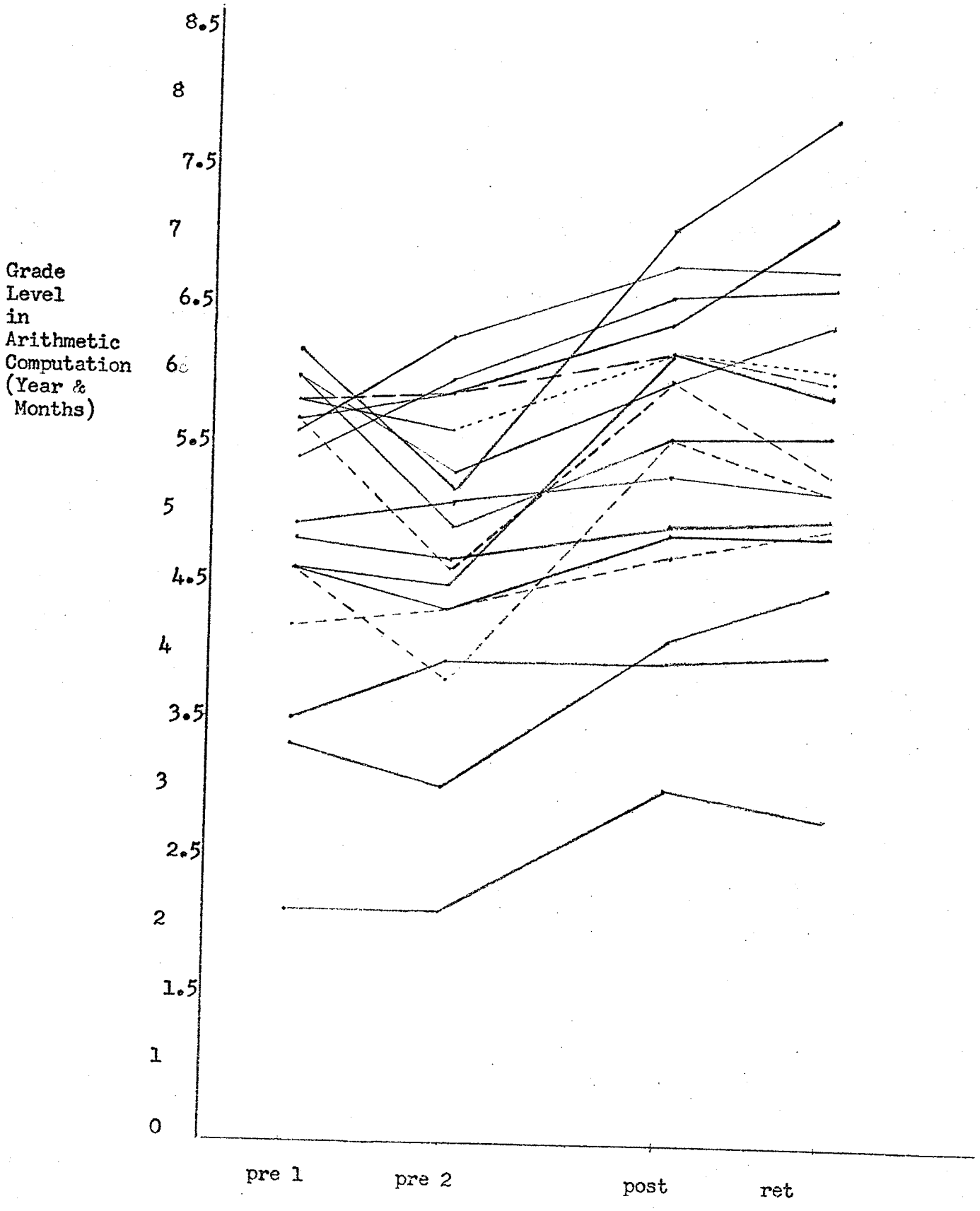


FIGURE FIVE – Learning Curves of the Subjects from the C.A.L. Arithmetic Group Showing No Gains in Arithmetic Achievement

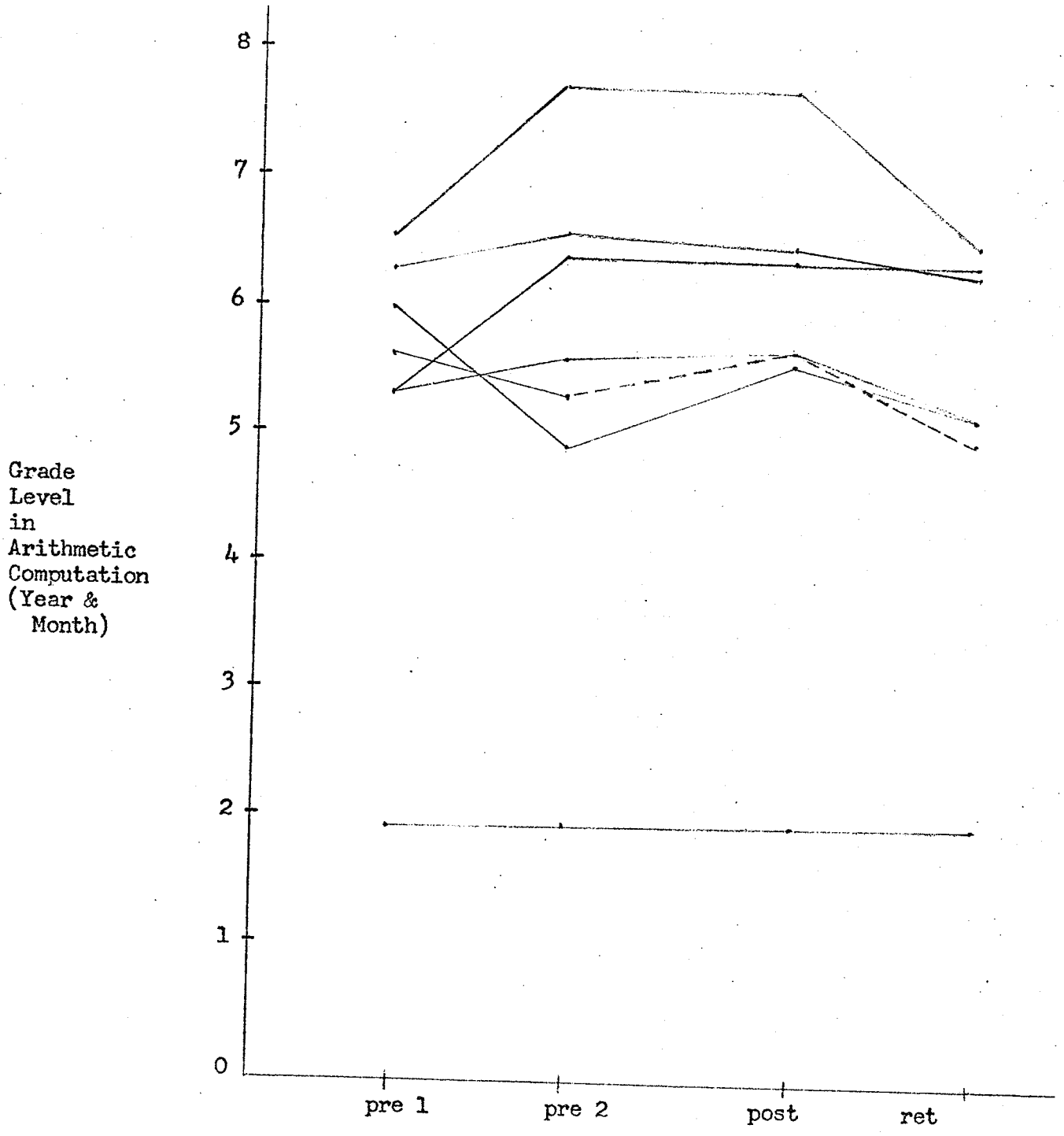


FIGURE SIX - Learning Curves of Subjects from the C.A.L. Spelling Group Showing Gains in Arithmetic Achievement

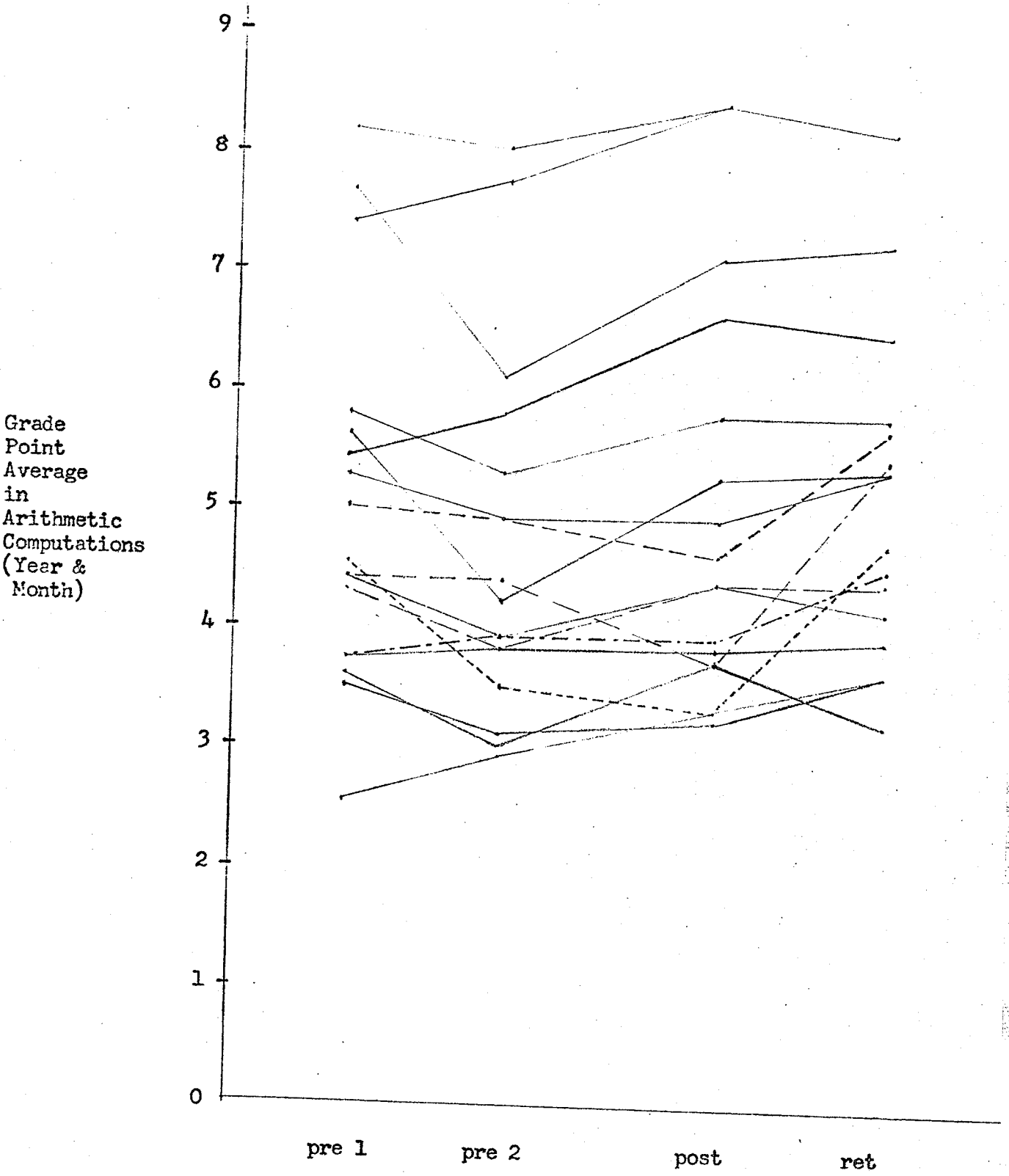


FIGURE SEVEN - Learning Curves of Subjects from the C.A.L. Spelling Group Showing No Gains in Arithmetic Achievement

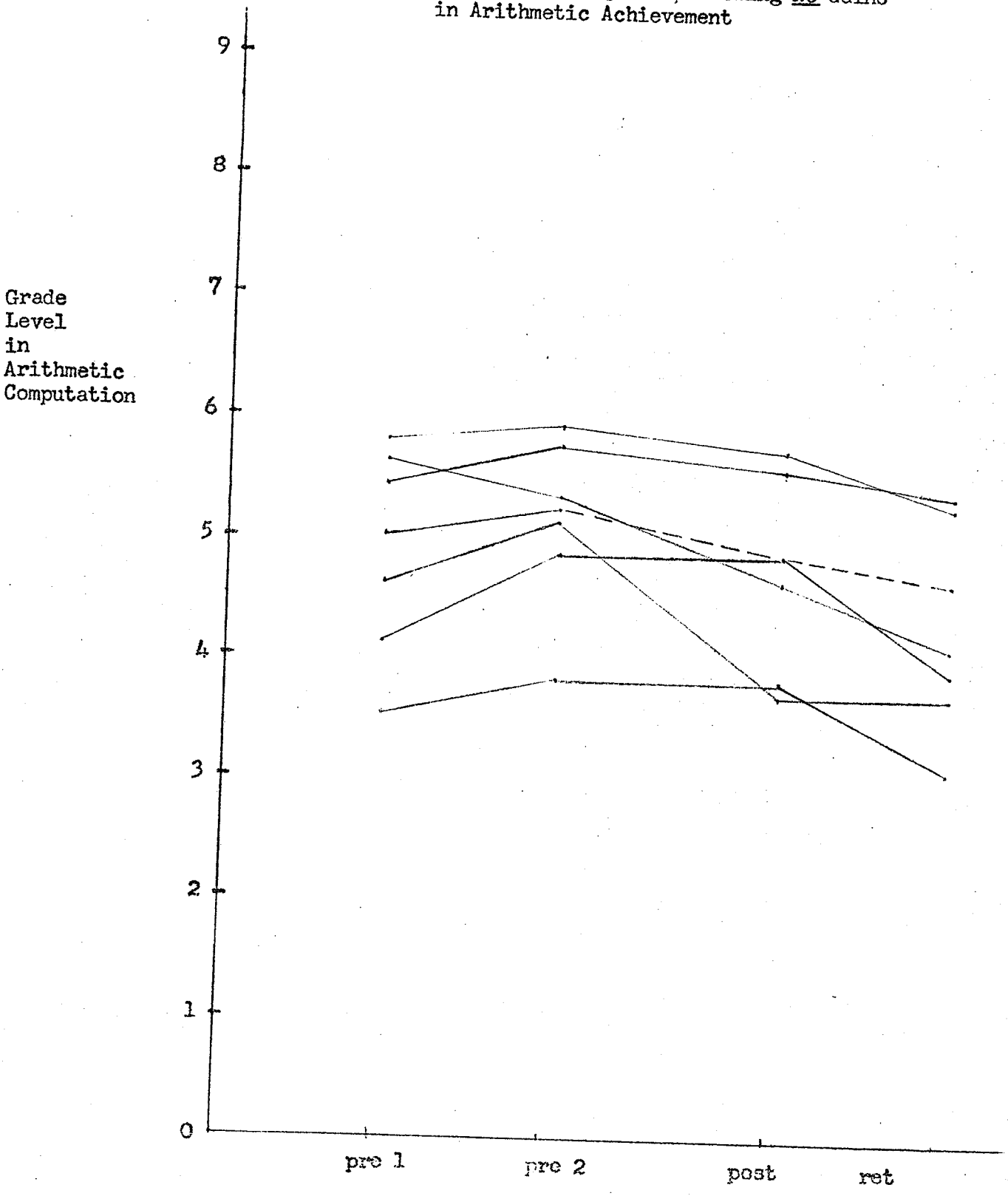


FIGURE EIGHT – Learning Curves of Subjects from the Non-C.A.L. Group Showing Gains in Arithmetic Achievement

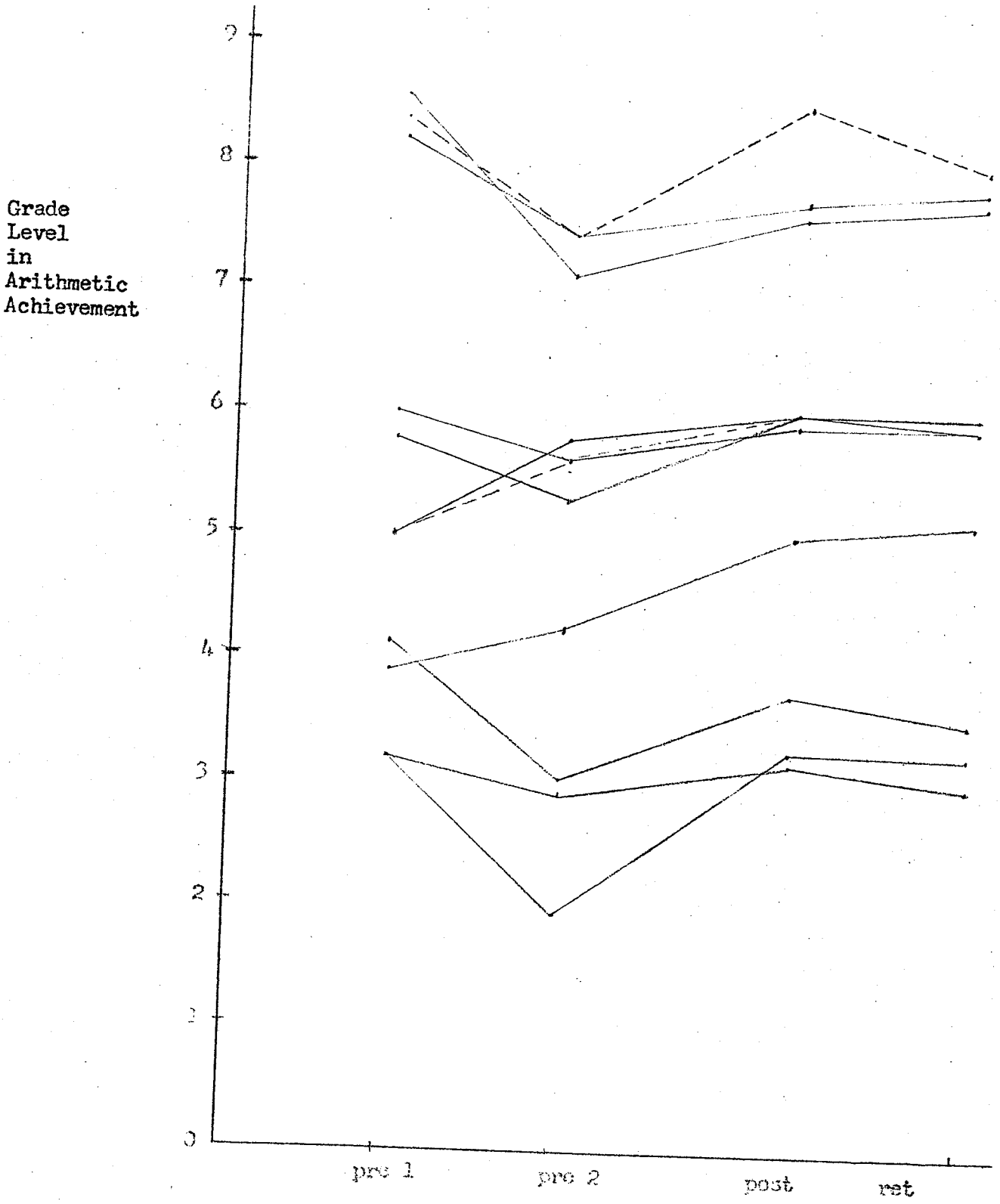
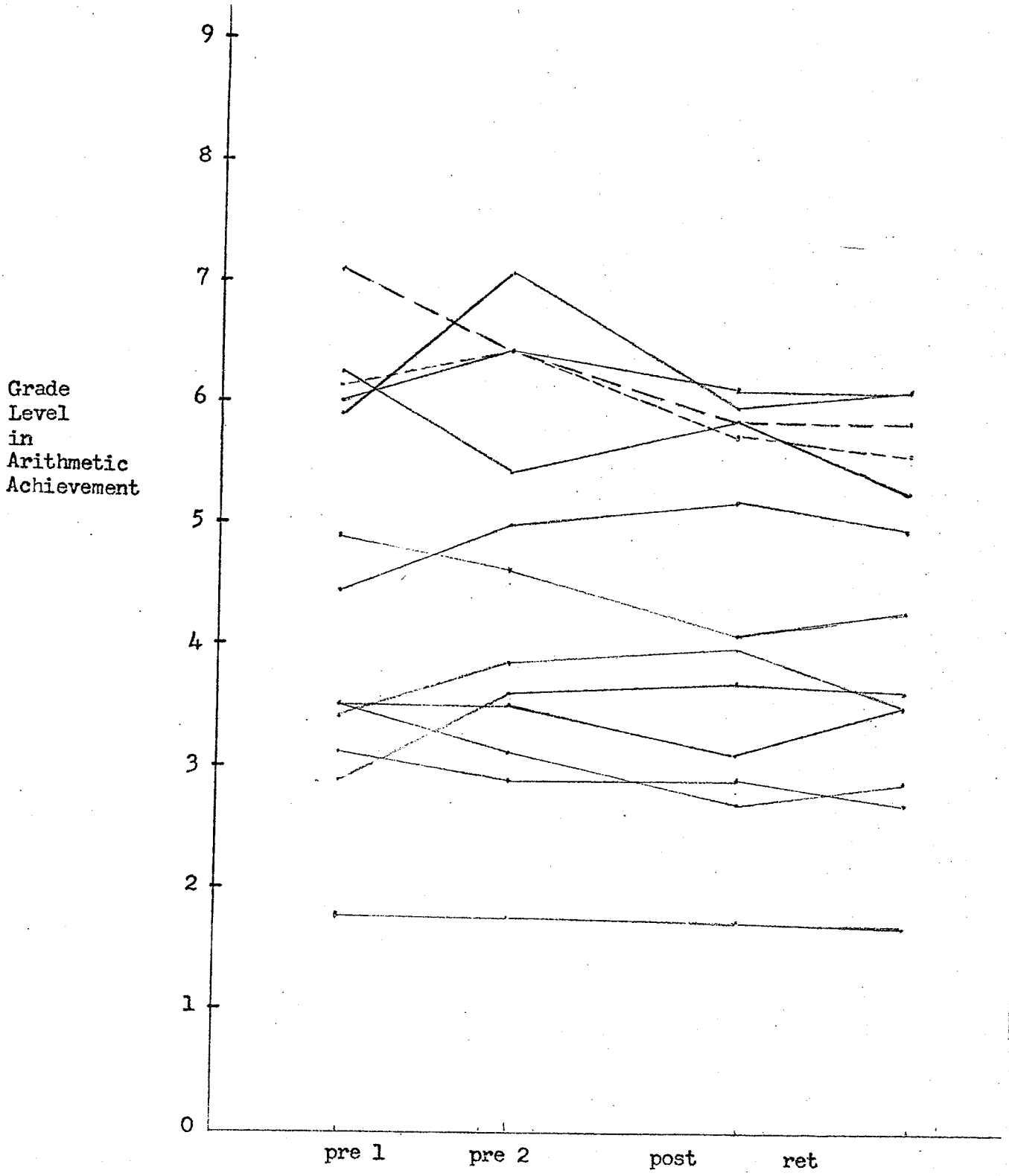


FIGURE NINE - Learning Curves of Subjects from the Non-C.A.L. Group Showing No Gains in Arithmetic Achievement



APPENDIX G (Cont'd.)

SPELLING ACHIEVEMENT - C.A.L. Arithmetic Group (Group 1)

As shown in figures ten and eleven, 14 pupils showed gains from pretest 2 to the retention test, while 10 pupils showed no gains. Out of all the pupils in this group, 11 pupils increased from pretest 1 to pretest 2, while 10 declined and 3 remained constant. Most pupils generally increased during the treatment period (15 out of 24), while most declined slightly or stayed constant during the retention period (18 out of 24). The greatest gain was 1.4 years, the smallest gain was 0.1 years and the mean gain was 0.59 years.

C.A.L. Spelling Group (Group 2)

As shown in figures twelve and thirteen, 21 pupils gained from pretest 2 to the retention test, while 3 pupils showed no gains. Out of all the pupils in this group, 10 pupils increased from pretest 1 to pretest 2, while 12 declined and 2 remained constant. Most pupils generally increased during the treatment period (20 out of 24), while most declined slightly during the retention period (17 out of 24). The greatest gain was 1.7 years, the smallest gain was 0.1 years and the mean gain was 0.61 years.

Non-C.A.L. Group (Group 3)

As can be seen in figures fourteen and fifteen, 14 pupils showed gains from pretest 2 to the retention test, while 10 pupils showed no gains. Out of all the pupils in this group, 5 pupils increased from

pretest 1 to pretest 2, while 17 declined and 2 remained constant. Just over half of the pupils increased slightly (13) during the treatment period, while 5 declined and 6 remained constant. During the retention period, just over half (14) declined, while 6 gained and 4 remained constant. The greatest overall gain was 1.1 years, the smallest gain was 0.1 years, and the mean gain was 0.48 years.

SUMMARY FOR SPELLING DATA

Out of all 72 subjects, 46 showed no gains compared to 26 that showed gains from pretest 1 to pretest 2. This result is similar to that attained for arithmetic, and consistent with the explanation offered for the arithmetic data.

As was the case in arithmetic, the graphs show that the gains in spelling achievement attained by the C.A.L. spelling pupils, were larger than those of the other pupils. For examole, the mean gain for the C.A.L. spelling group was 0.61 years compared to a 0.59 years for the C.A.L. arithmetic group and 0.48 years for the non-C.A.L. Overall from pretest 2 to the retention test, 21 pupils from the C.A.L. spelling group gained, compared to 14 from the C.A.L. arithmetic group and 14 from the non-C.A.L. group.

During the retention period, a majority of pupils (49) declined or remained constant, compared to 23 who showed small gains. This indicates that retention for spelling was not as good as it was for arithmetic. This may be explained by the fact that the spelling drills were not as suitable to the needs of the pupils as were the arithmetic drills.

APPENDIX G

TABLE SEVENTEEN

Summary of Spelling Group Data

	Gains	Losses	Constant
Group 1			
1) from pretest 1 to pretest 2	11	10	3
2) treatment period	15	8	1
3) retention period	6	15	3
4) overall from pretest 2 to retention test	14	9	1
Group 2			
1) from pretest 1 to pretest 2	10	12	2
2) treatment period	20	3	1
3) retention period	3	17	4
4) overall from pretest 2 to retention test	21	2	1
Group 3			
1) from pretest 1 to pretest 2	5	17	2
2) treatment period	13	5	6
3) retention period	14	6	4
4) overall from pretest 2 to retention test	14	8	2

FIGURE TEN - Learning Curves of Subjects from the C.A.L. Arithmetic Group Showing Gains in Spelling Achievement

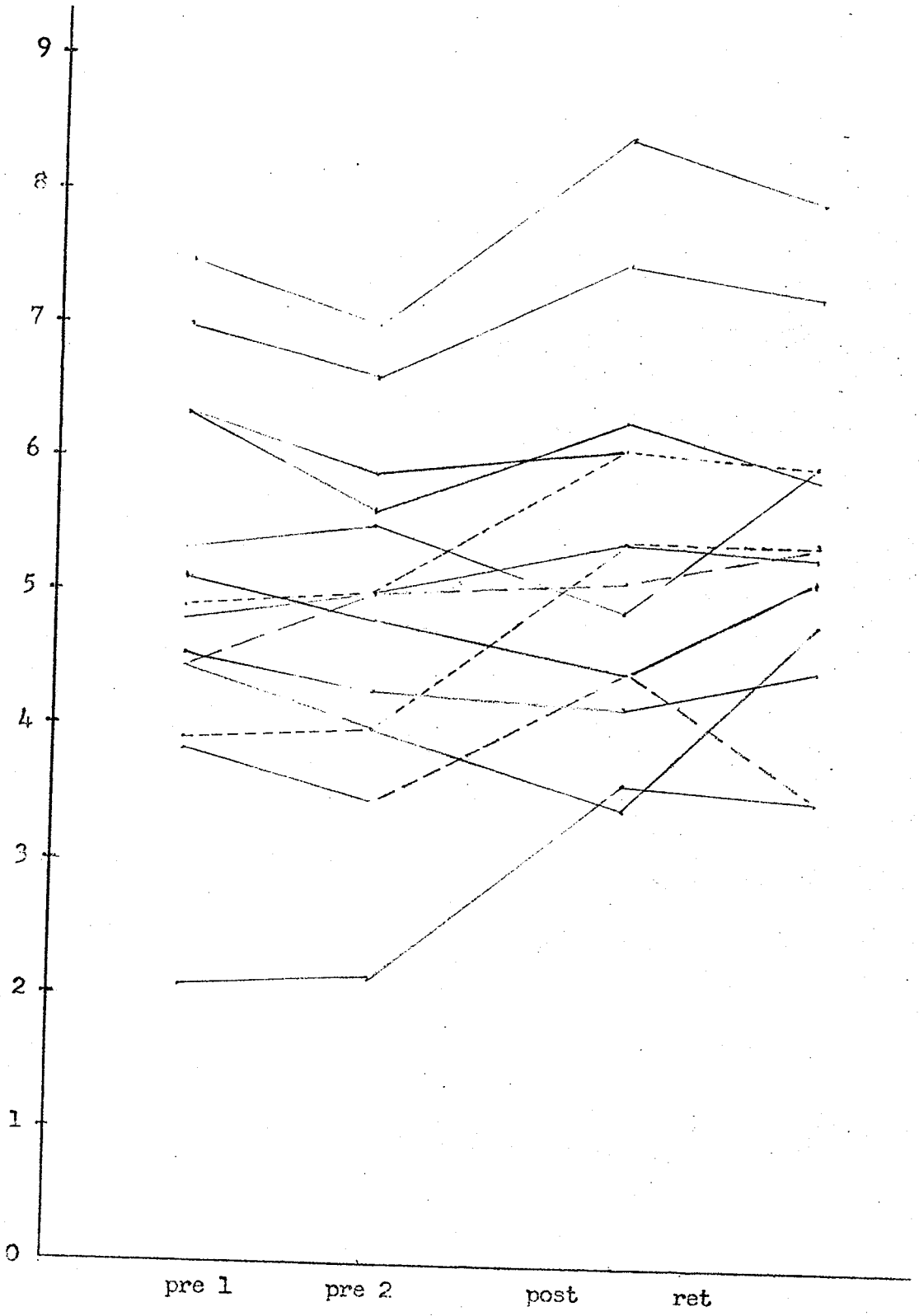


FIGURE ELEVEN - Learning Curves of Subjects from the C.A.L. Arithmetic Group Showing No Gains in Spelling Achievement

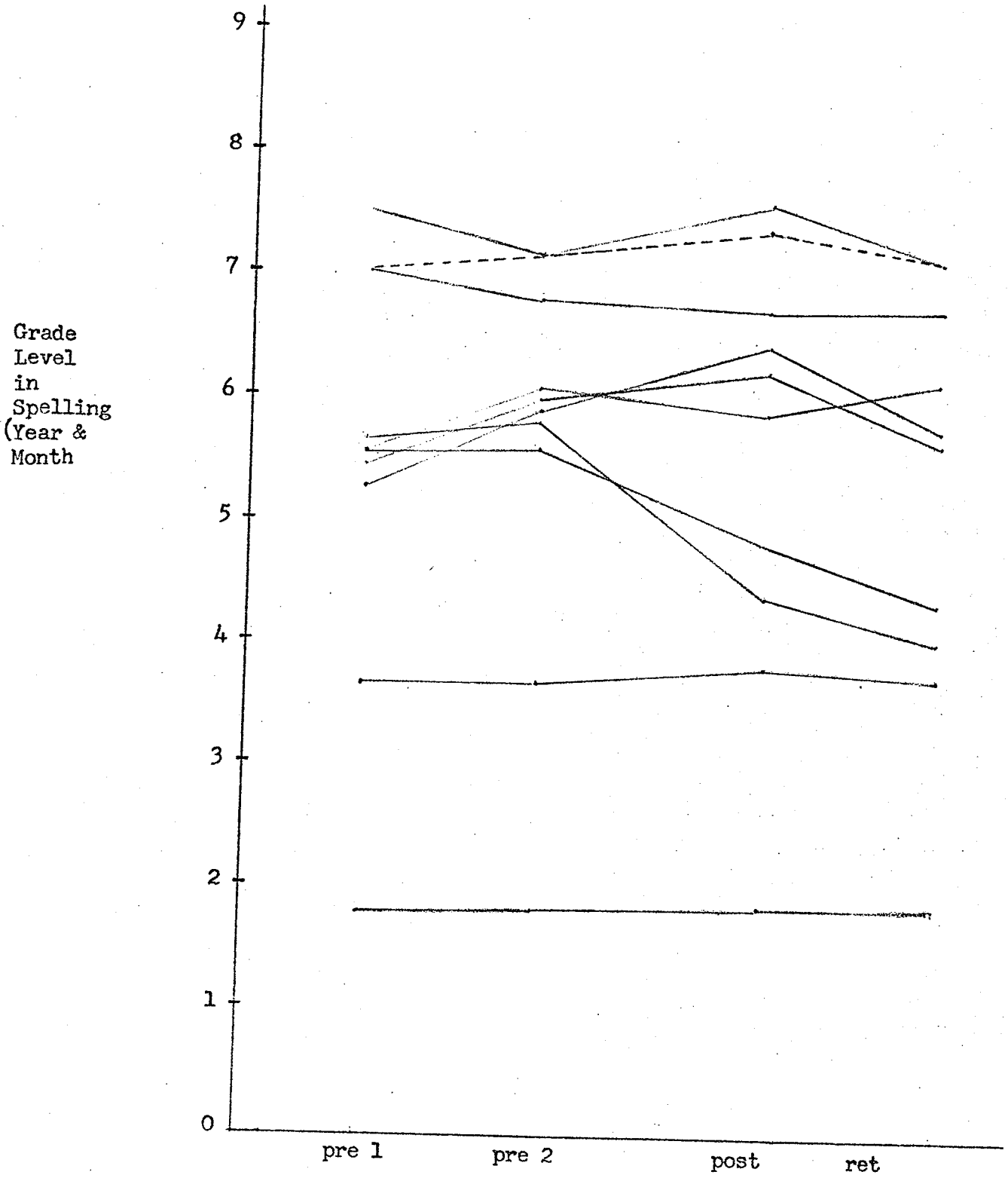


FIGURE TWELVE - Learning Curves of Subjects from the C.A.L. Spelling Group Showing Gains in Spelling Achievement

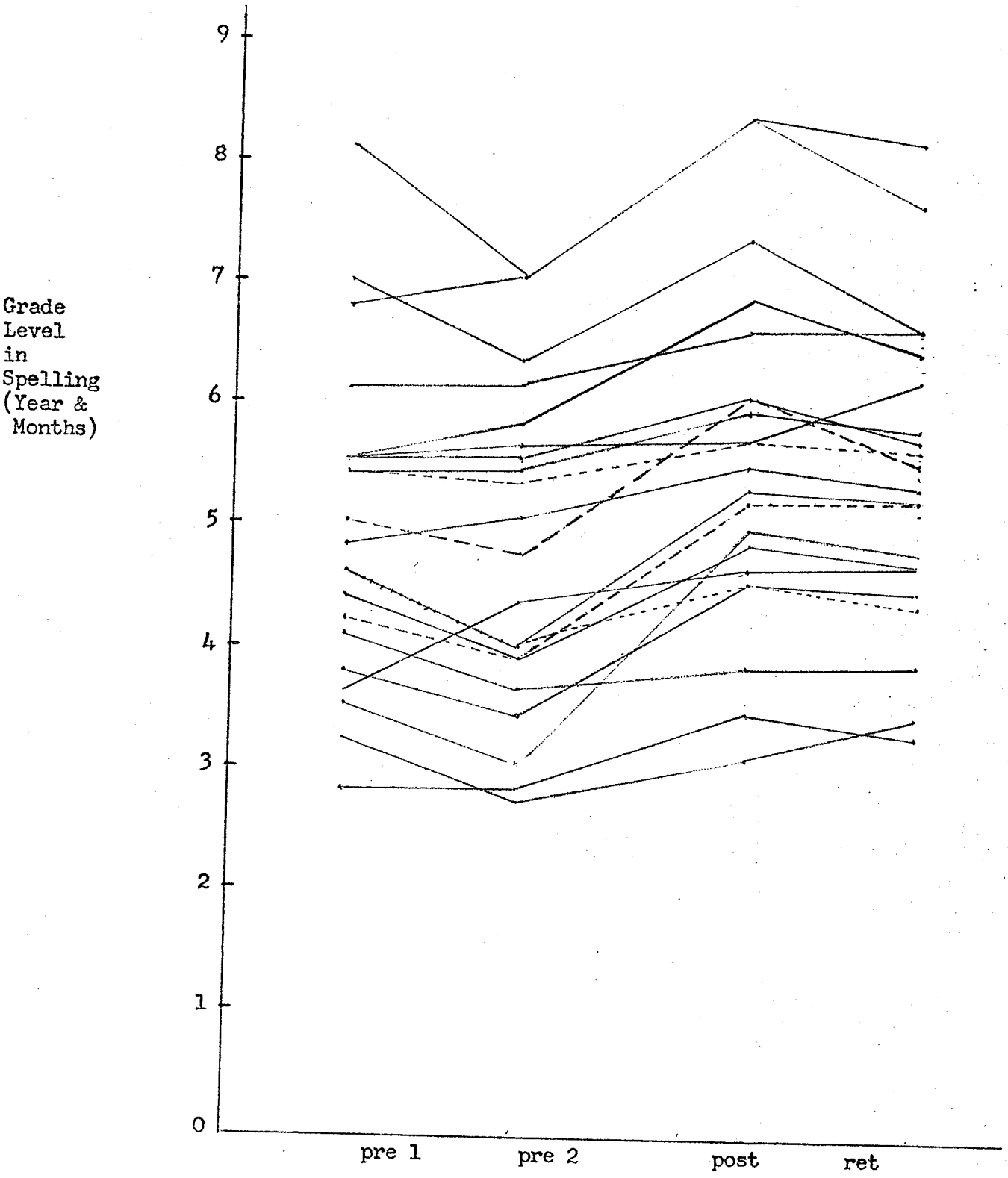


FIGURE THIRTEEN - Learning Curves of Subjects from C.A.L. Spelling Group Showing No Gains in Spelling Achievement

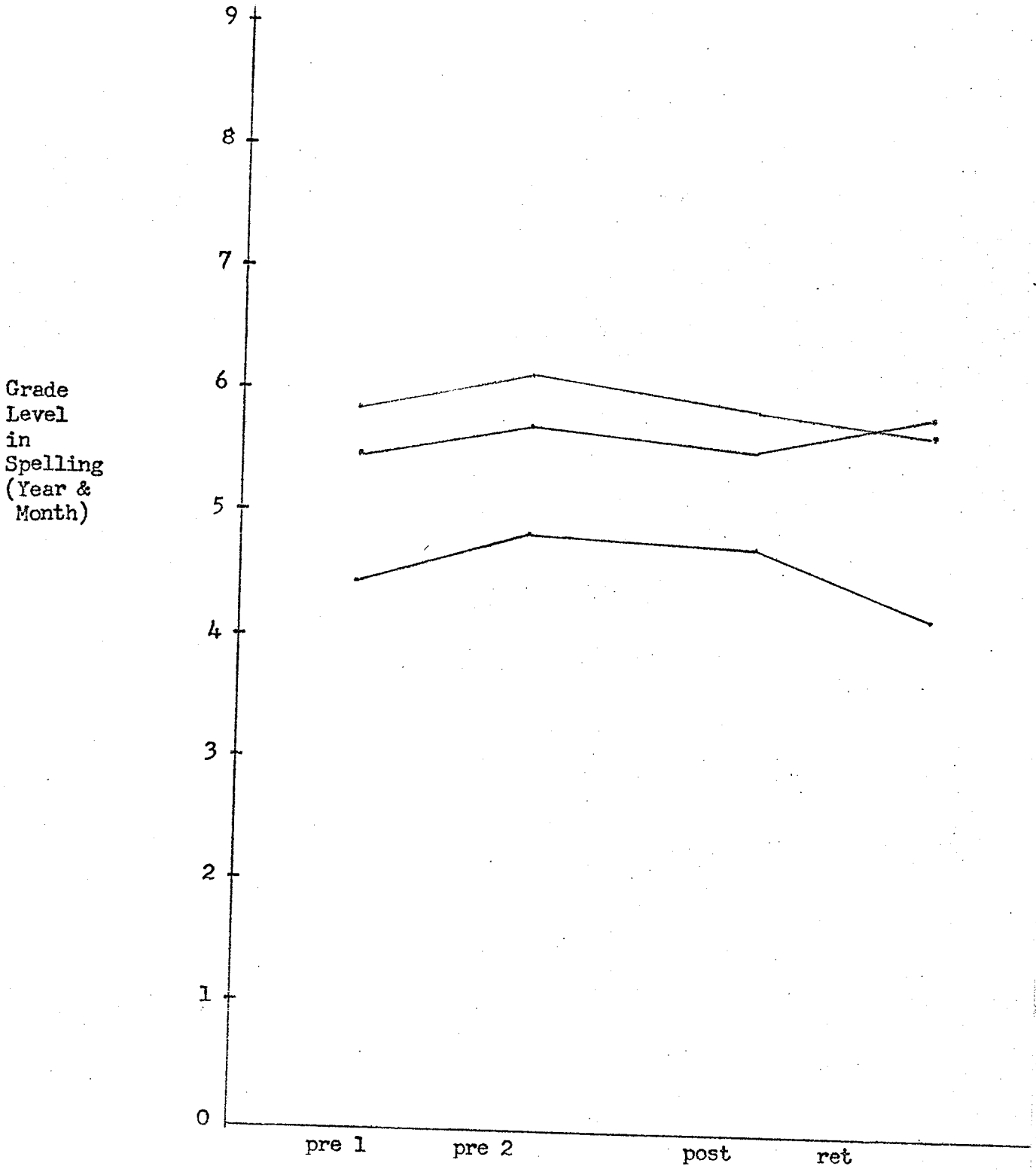


FIGURE FOURTEEN - Learning Curves of Subject from the Non-C.A.L. Group Showing Gains In Spelling Achievement

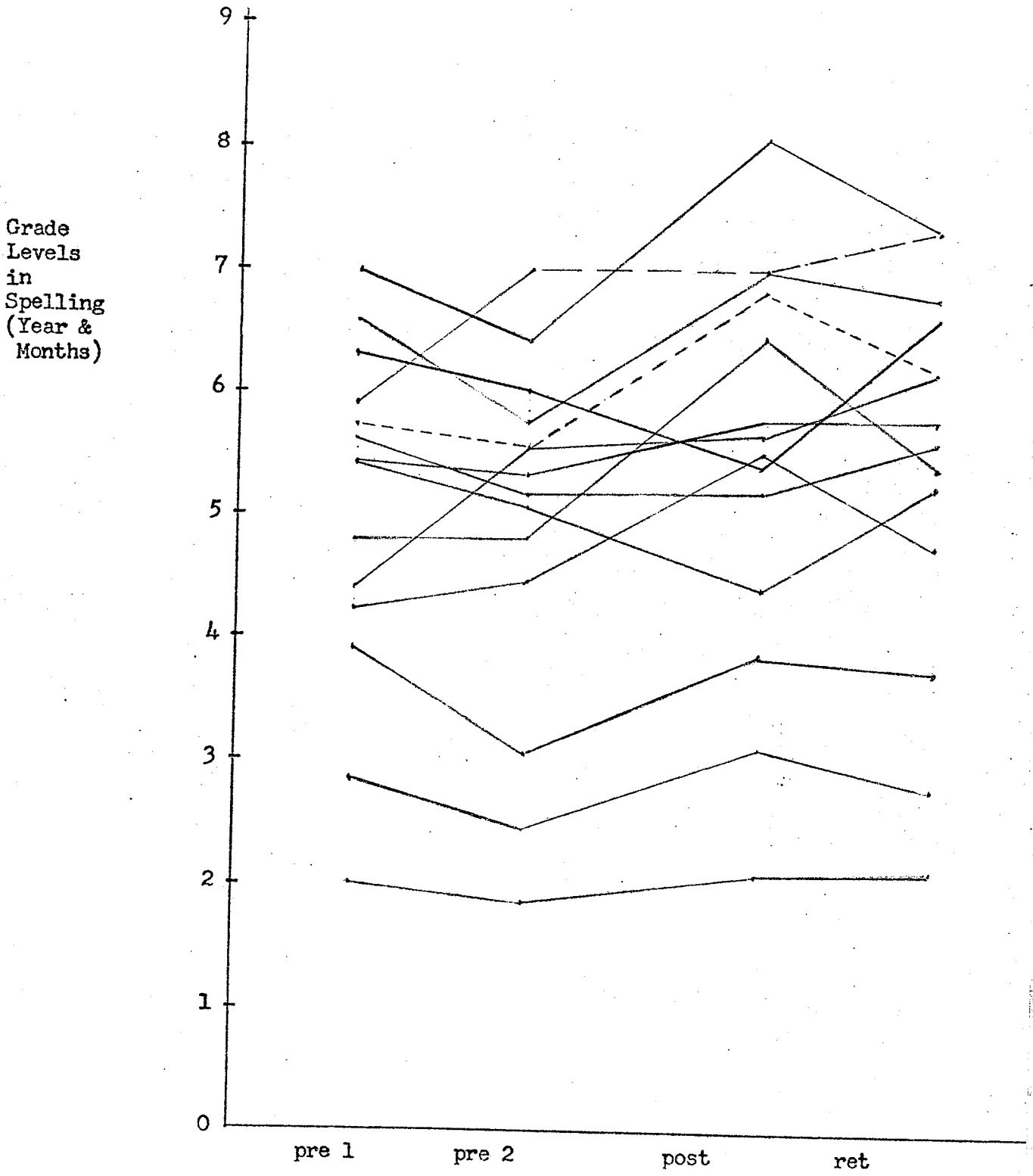
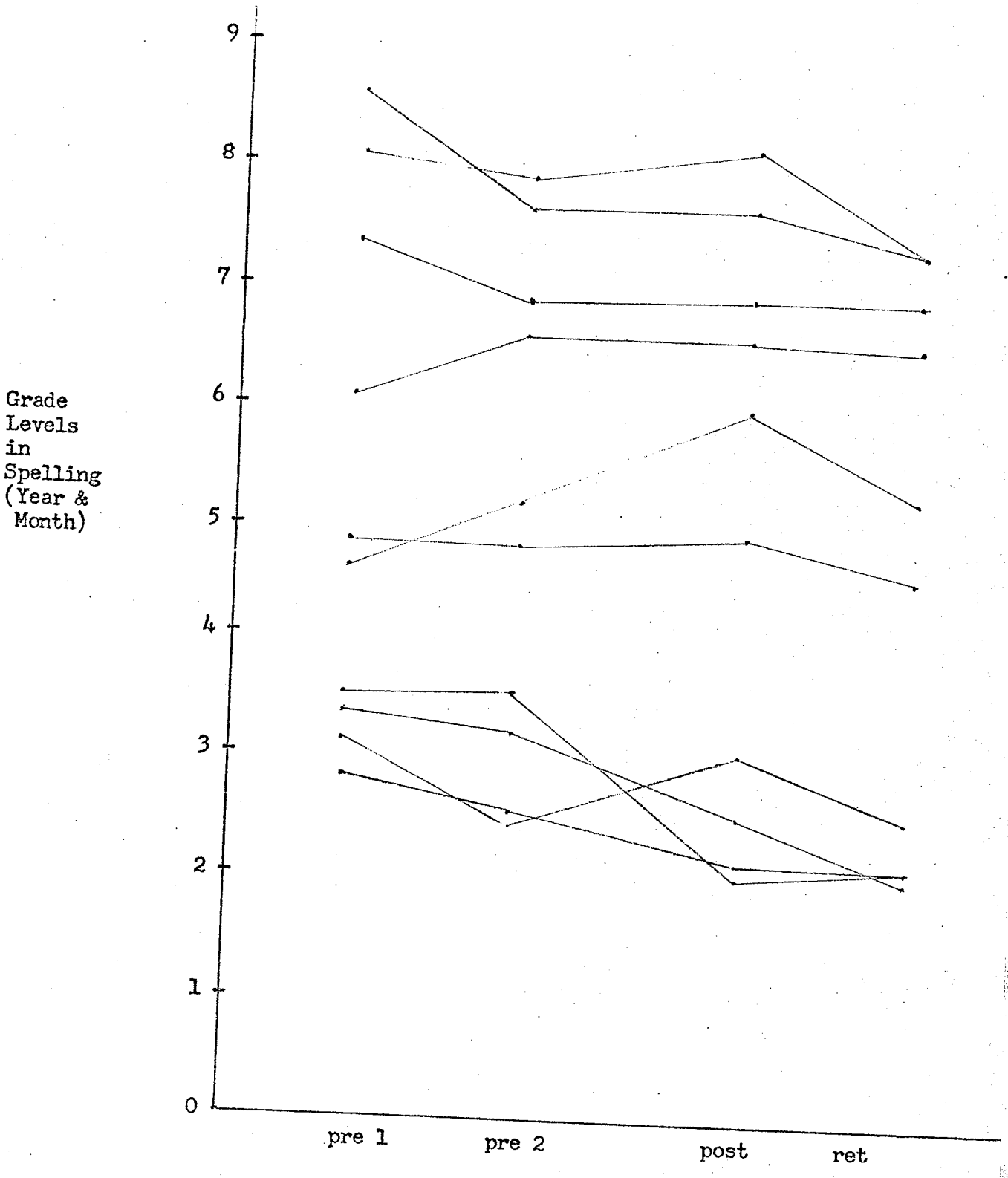


FIGURE FIFTEEN - Learning Curves of Subjects from the Non-C.A.L. Group Showing No Gains in Spelling Achievement



APPENDIX H

PROGRAMS PRESENTLY AVAILABLE ON THE SYSTEM — C.A.L.M. MANUALS

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

MATHEMATICS DRILLS

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 $ 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.
- 1 TO 20 RANDOMLY GENERATED PROBLEMS.
- ADDITION OF 2 TO 6 NUMBERS.
- 1 TO 6 DIGITS IN EACH NUMBER.
- CHOICE OF NUMBER OF DECIMAL PLACES IN
THE NUMBERS.
- ALL BY SELECTION.

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- (OLD) DRILL IN CORRECT USE OF IRREGULAR 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- (OLD) DRILL IN CORRECT USE OF IRREGULAR 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- (OLD) DRILL IN THE CORRECT USE OF IRREGULAR 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.

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- (OLD) 10 DIFFERENT SPELLING TOPICS OF 5 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 OR 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.

B35. CONTRN- EXPANSIONS TO CONTRACTIONS
CONTRACTIONS TO EXPANSIONS
- NEGATIVES, 'BE VERBS', AND 'HAVE VERBS'
- COMBINATION AVAILABLE

B36. SYLACT- DIVIDING WORDS INTO SYLLABLES AND PLACING ACCENTS.
- COMPOUND WORDS, DOUBLE CONSONANTS, PREFIXES, SUFFIXES, ETC.
- COMBINATION AVAILABLE

B37. RHYME- DRILL IN RHYMING WORDS AT TWO LEVELS.
- LEVEL #1 WORDS HAVE THE SAME ENDINGS
- LEVEL #2 WORDS HAVE DIFFERENT ENDINGS
- EACH LEVEL IS DIVIDED INTO 3,4,5,6 : LETTER WORDS.

B38. DICTN1- DRILL IN 'ALPHABETICAL ORDER'
- HELPFUL FOR BEGINNING DICTIONARY WORK.
- WORDS WITH DIFFERENT FIRST LETTERS
- WORDS WITH SAME FIRST LETTERS
- NUMBER OF WORDS TO BE ORDERED (2 TO 5) BY SELECTION
- DATA BANK OF 240 RANDOMLY SELECTED WORDS

B39. ANALOGY- PRACTICE IN SOLVING ANALOGIES
- JUNIOR-HIGH LEVEL AND UP
- ANALOGIES INVOLVING OPPOSITES
- ANALOGIES INVOLVING CAUSE AND EFFECT
- TWO LEVELS OF REASONING: DIRECT AND INDIRECT.
- COMBINATION AVAILABLE

FRENCH DRILLS

C1. FRANC1 - DRILL IN USING THE CORRECT ARTICLES.
- THREE DIFFERENT DRILLS OF 10 QUESTIONS EACH. - BY SELECTION.

C2. FRANC2 - DRILL IN CONVERTING SINGULAR NOUNS TO PLURAL NOUNS, AND IN CONVERTING MASCULINE NOUNS TO FEMININE NOUNS.
- SIX DIFFERENT DRILLS OF 10 QUESTIONS EACH. - BY SELECTION.

C3. FRANC3 - TEN DIFFERENT DRILLS IN VARIOUS TOPICS. ALL DRILLS ARE IN THE SENTENCE FORM. - BY SELECTION.

C4. FRANC4 - DRILL IN USE OF IRREGULAR VERBS OF PRESENT TENSE.
- QUESTIONS BY SELECTION

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.

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.

APPENDIX I

SUMMARY OF COSTS

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SUMMARY OF COSTS

Initially, there were three schools involved in this project—the Ellen Douglass School for the Physically Handicapped, the Manitoba School for the Deaf, and Central North Upgrading in Transcona. The total annual cost for the entire project was $15,000. The Department of Education contributed 60% of the total cost, while each school division was responsible for their share of the remaining 40%, or $2,000 per annum per school division.

A breakdown of monthly costs for the terminal at Central North is as follows:

1)	computer terminal	$ 62.65
2)	monthly telephone line costs	7.65
3)	computer connect time	100.00
4)	processing time	25.00
5)	paper costs	15.00
	Total	$210.30

In addition, extra costs were incurred for student service fellowships, program development, consulting fees and discounted disc-storage space.

Relating these costs to the number of pupils—assume that each pupil is scheduled on the computer terminal for a 15-minute session. Based on a $5\frac{1}{2}$ hour day, there will be 22 sessions per day per pupil. Assuming a 20-day month, the total number of sessions would be approximately 440. As shown above the total approximate cost per month was $210. Therefore, the cost per pupil session is $210 ÷ 440 which is approximately $0.48 per session.

The cost effectiveness can be shown as follows:

During the three months of treatment, 17 pupils using C.A.L. arithmetic made a total gain of 149 months. Therefore, the cost per pupil per month gain was approximately $8.39.

Similarly, in C.A.L. spelling, 21 pupils made a total gain of 127 months. Therefore, the cost per pupil per month gain was approximately $9.84.