

IMMEDIATE RESPONSE VERSUS DELAYED RESPONSE
FOR RETEACHING MULTIPLICATION TABLES
USING A MICROCOMPUTER

by

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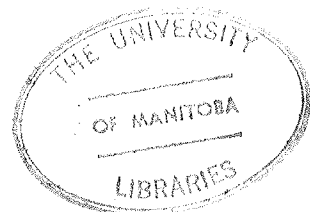
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A B S T R A C T

This study investigated the effects of immediate response and feedback versus delayed response and feedback upon the learning and retention of multiplication facts using a microcomputer.

A population of twenty five grade six students were randomly divided into three treatment groups. All the possible sixty-six pairs of multiplication facts from two through twelve were displayed on a microcomputer screen. The students were required to type in a response under one of three time conditions. One group had 2.5 seconds to input an answer. The second group was given up to six seconds to input an answer and the third group was allowed to take as long as they wished. A pretest, ten treatment sessions, a posttest, and a retention test approximately thirty days later completed the study. A three by three two factor ANOVA of the groups' scores showed a significant difference in favour of the immediate response treatment group (2.5 seconds). The open time response group rated second. The research indicates that students should learn multiplication facts as a conditioned response with immediate (2.5 seconds) responses and feedback.

(iii)

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CHAPTER ONE

INTRODUCTION

In a report to the U.S. Department of Health, Education, and Welfare, (Office of Education, Bureau of Research), Marilyn Suydam and Alan Riedesel (1970) summarized research into elementary mathematics from 1900 to 1968. They found "Computational errors with basic facts are the greatest source of pupil difficulty, with lack of understanding second." Further, that "Drill and practice are necessary for computational accuracy".

A major educational concern is to help students overcome their difficulties with computation. This will certainly remain true in the future, even if ultimately illustrated by computers and calculators.

RATIONALE FOR THE STUDY

Mathematical computations and operations seem to be inhibited frequently by two conditions: first, when no mechanical aids are available and computations are long and complicated; second, when the concept of multiplication is understood but the facts cannot be instantly recalled. To overcome this lack of instant recall students often use

compensating strategies or cognitive bypasses. Consider an instance where the stimulus (S) is 6 times 7 and an immediate conditioned response (R) should be 42. If the student has no immediate response then he or she may use a cognitive bypass which is a laborious strategy similar to that in the following example. Six times five equals thirty, six times two is twelve. Therefore 30 plus 12 finally gives the necessary 42. A chain of such side algorithms can be seen to make an extended algorithm unmanageable. Conventional forms of drill and practice may actually reinforce the learning of such side algorithms. There is an obvious benefit to the student when an S can elicit an immediate and appropriate R.

DEFINITION OF TERMS

The following are definitions for terms used in this study:

C.A.L. is the use of the computer to assist in the acquisition of learning.

Feedback is knowledge of results of an action or reaction.

Immediate Response is operationally defined for this paper as a response within three seconds.

Microcomputer or microprocessor is a small portable self-contained unit sometimes called the personal or home or hobby computer. It has a keyboard, central processing unit, memory, and a visual output device.

Short term memory is memory which lasts up to about six seconds. It could be considered similar to a circular recording tape which takes about six seconds to make a circuit past an erasing point. So it is always recording and erasing.

Long Term Memory is a more permanent memory which causes a permanent change of behaviour or learning.

Rote learning for this study is defined as learning
* for simple recall.

CHAPTER 2

REVIEW OF COMPUTER LITERATURE

"The computer is incredibly fast, accurate and stupid. Man is unbelievably slow, inaccurate, and brilliant. The marriage of the two is a force beyond calculation."

This quote by Leo Cherne (1976) is found in "The Best of Creative Computing." Given that this statement is a fairly accurate assessment, it would be a terrible waste if we could not interface man with this incredible machine. It can be particularly helpful as an educational tool.

Ideally, teachers first teach the concepts of multiplication. They then provide for adequate practice and drill with such aids as flashcards, and a variety of short tests. The feedback from these aids is slow. No matter how quickly given, it cannot match the instant feedback of the computer. Delayed feedback is frustrating for students who are unsure of their competence and may reinforce side algorithms which in fact may compound the problem. Therefore it is pedagogically advantageous to provide the S, accept immediate response R, initiate immediate feedback and keep track of errors for further practice. The computer is capable of being programmed to do all of these things.

The computer in the early forties was affordable only to governments and in the fifties to giant corporations and universities. However, as technology progressed, computers became available at remarkably lower prices. The biggest impact came when the small personal or microcomputer became universally available. There are many types of computers from large main frame computers (with remote hook-ups) connected by telephone lines or direct lines to networks to mini computers capable of supporting many terminals from teletypes to cathode ray tubes (CRT) - also called the VDT (video display terminal.)

Large costly terminals and networks are the basis of many large funded projects. Here is a selection as reported by Braun in 1977:

1. PLATO, which developed impressive hardware and software and an extensive body of courseware.
2. TICCIT, which developed an interesting hardware delivery system, and a powerful courseware development system.
3. Projects Solo and Soloworks, which have developed some novel ways of exposing high-school students to computers, as well as substantial amounts of mathematics courseware.
4. The Huntington Computer Project, which identified a variety of ways of using computer in high-school science, mathematics, and social-science classes, including a

substantial set of simulations in biology, physics, and the social sciences.

5. The Physics Computer Development Project, which has demonstrated the effectiveness of interactive computation and graphic displays in undergraduate physics courses.

6. MATHLAB in which the computer assists the student with such common procedures as differentiation, polynomial factorization, and Laplace transforms.

7. LOGO, with its "turtle", which an elementary-school child can use to develop very complex algorithms for controlling the motion of the turtle.

8. CRICISAM, a calculus course in which the computer supports the student in learning difficult concepts, and in developing an algorithmic approach to problem solving.

9. The CASE system and the Lister Hill Network, in which medical students diagnose and "treat" the computer (simulating a patient) which presents a wide variety of symptom-disease complexes.

10. IMPRESS, which permits students to access a large social-data base, and to extract a wide variety of statistical reports from the machine without the usual difficulties of data bases.

11. ERIC, an educational data base where many of the references used in this study were found.

In the last thirteen years a technological innovation

has emerged which may rapidly and forcefully change the educational environment of teachers and students. We are in the age of the microcomputer. Not since the invention of the printing press (making books, newspapers, and magazines universally available for education) has anything so stirred educators. The technology is diversifying by the month as new microcomputers replace older ones.

The microcomputer was chosen in this study for the following reasons:

1. The microcomputer, unlike big main frame computers, is a self contained system, eliminating the need for phone lines and the sources of other external problems.

2. The microcomputer is cost effective. A micro costs about the same as a terminal for larger expensive computers. New generations of micros are becoming increasingly available to classroom teachers and in contrast to the increasing price of textbooks, the computer is dramatically decreasing in price.

3. It is portable and may be moved from room to room like most other audio-visual equipment in a school.

4. They are quiet. This allows microcomputers to be used in the classroom with a minimum of disturbance to students.

5. Its versatility allows it to be used for drill, tutorials, or simulations in all subject areas.

6. It can contribute to computer literacy. As we enter the age of the computer, computer literacy becomes increasingly important for both teachers and students.

7. Motivation is another large factor. As a classroom teacher, this writer has had a computer in the classroom for over three years and finds that students literally fight to work on the machine. They do not consider time on the computer as work. Many students regard the computer as a person who has the ability to interact with them in a friendly, helpful, and personal way. This is especially so when they see their names appearing on the screen. This love for computers has increased with the recent flood of computerized games both in commercial arcades and the home.

Many students have personal computers available in their own homes or at the homes of friends. In terms of motivation and feedback, the computer is consistent and patient. It does not have good days or bad days, it is always consistent.

Crandall (1976) suggests that the computer may be particularly effective with minority groups. He quotes from the Coleman report of 1966 that poor people consider success a matter of fate or luck. These people are often not capable of planning changes in their environments. When something good happens, they attribute it to fate, not to anything they can control. But if they do

something, and receive instant feedback, the cause and effect becomes apparent and with it the concept of control over the environment. Without instant feedback superstition can explain failure. Crandall believes the computer and computer assisted instruction can motivate minority groups to feel that they can take control for the following reasons:

- 1) the computer gives the student total control;
- 2) it operates in a cause-and-effect mode;
- 3) it is direct;
- 4) it provides immediate feedback;
- 5) it, if programmed to, gives explicit, specific directions.

Bakken (1979) found that average and low achieving students made the greatest gains over time in arithmetic using CAL.

Ryba (1980) evaluated the use of microcomputers to assist in teaching word recognition to mentally retarded adults and found that "computer related learning environments give the adult learner considerably more control of the teaching situation,..."

Most of the published research, studies, and experiments have shown CAI to be effective (see appendix E. Fiorentino's summary table of 20 studies in mathematics with positive results).

The object of this study is to test which response and feedback most significantly improves learning and retention of multiplication facts.

The experiment is computer based because the computer provides precise control of feedback; it has a high intrinsic motivation for students and; it has the ability to keep accurate records without the teacher having to do the recording. In addition, students become more familiar with operating the computer and this leads to computer literacy.

COMPUTER LITERACY

Literacy may be defined as the ability to converse, read, and write. Computer Literacy, to this writer, is understanding enough about computers to: 1) be familiar with their manner of operation; 2) be able to write and understand simple programs; and 3) be able to converse comfortably with other computer literate people.

Computer Literacy has been defined by Horn and Poirot (1981) as a general understanding of electronic computing which is an area of knowledge that includes 1) an understanding of the technology used when processing information, 2) an understanding of the effects that computers have and will have in and on society, and 3) an understanding of how computers are problem solving tools. In fact Robert S. Mclean (1981) on the cover of an article

"Education Toward Computers as Intellectual Amplifiers" shows a tool box with the following nine tools as a partial list of computer applications the students of today need for survival to cope with the information revolution:

1) Information Editing, where the student uses small amounts of information in the computer and writes without having to write and rub out, rewrite and erase again - the mess of pencils and erasers. The examples Mclean quotes are changes from 90% copying, erasing, and recopying compositions and only 10% for thoughts. With a word processor it becomes 80% for thoughts about the composition and only 20% for technical details.

2) Computer Models or simulations of real world situations and models give the students a chance to attempt to try different options and see their effects.

3) Machine Exploration gives students a chance to investigate different solutions to various conditions by inputting solutions to problems and games.

4) Information Storage and Retrieval searching data bases such as ERIC or using Telidon for researching information.

5) Information Presentation in which students could make presentations using the graphic modes and experimental routines to communicate.

6) Human/Machine Interaction, that is getting a feel

for what the computer can do and how we can make better use of it.

7) Instrumentation on how machines can sense the environment and give data regarding those samplings or be linked to experiments to record information.

8) Process Control where the computer is coupled with instruments and has the ability to turn electrically controlled apparatus on or off.

9) Networking or exchanging information with other computers or humans.

McClean says that these skills are more relevant for secondary students but things at the high school level usually seem to get pushed lower and lower into the elementary schools. This researcher has had students at the grade six level using a word processor for more than two years now and the results have impressed parents and teachers alike. Students with a record of tardiness have started coming to school earlier than the teachers so they will have time to type their stories into the computer.

Moshell (1982) in an article about the computer as an intelligence amplifier, stated "It has been quite inconvenient to bring much of the world into our schools. Many schools teach years of science without a single experiment. Almost no schools use real experiments in which the result is not foreordained and rigged. The

central promise that computers hold for education, all of education, is the provision of a domain in which kids don't have to take someone's word as to what happens." Thus the student can, by using the computer, take his or her ideas and try them out. They can, by simulation of the real world, try to find what does work and what does not work in their own classroom.

Papert (1980) also tries to amplify students' ideas with LOGO, a computer language he invented for children. There are several ways of using LOGO. In one mode, students teach themselves to use a mechanical turtle by programming a computer. In another mode, the students can draw figures in color, and then rotate, duplicate, review, and repeat procedures to see what they can do with the computer.

Vierling (1973) says that since computers are designed to accurately manipulate information at great speed, they should be used to generate practice problem-sets. They should generate different types of worksheets for drill and practice or for practice of parallel skills. This is in fact happening and is reported as being well received according to questionnaires answered by teachers.

There are many popular articles extolling the virtues or lack of virtues of computers, how to select a computer, or what to do with a computer. Here is a sampling. Stewart (1981) wrote an article in Popular Computing "How

should schools use Computers" where he says the computer is a new teaching tool. Stewart quotes Arthur Luehrmann, founder of Computer Literacy Inc. as dividing computer uses into three categories: learning from, learning with, and learning about. Stewart has some criticisms of C.A.I. (Computer Assisted Instruction) mainly concerning the multitude of Drill and Practice programs and some pedagogically poor programs written by specialists from areas other than education.

Gawronski (1981) talks about Computer Literacy and School Mathematics and quotes a paper given to the National Council of Supervisors of Mathematics (NCSM) in 1978 which claims that students should be aware of the many uses of computers in society such as teaching/learning, recording financial transactions and storing and retrieving information. The National Council of Teachers of Mathematics (NCTM) in its Agenda for Action: Recommendations for School Mathematics of the 1980s states, "mathematics programs (must) take full advantage of the power of calculators and computers at all grade levels." The National Science Foundation (NSF) and the National Institute of Education (NIE) support research and development efforts in the area of computer literacy. There are many definitions as to what computer literacy is. Certain concepts are inherent in all definitions; they

are: what the computer can and cannot do, what a program can and cannot do, and how to program a computer.

Eisele (1980) argues in an article entitled "A Case For Universal Computer Literacy." "People have the right to and benefit from oportunities to learn about computers in educational institutions." He lists the following learning opportunities for justifying putting computer literacy into the curriculum:

- 1) Developing skills to use computer applications which bear on persistent life situations.

- 2) Developing computing proficiency as a skill for everyday home skills.

- 3) Developing ethical practices in providing computer services to others.

- 4) Developing ethical practices of consumption of computer services.

- 5) Developing positive attitudes toward the pervasive role of computers in contemporary society.

Halapin (1982) defines computer literacy as "the knowledge and attitudes that will permit students to use computers in meaningful and productive ways throughout the course of their education and life." He believes the teacher should be taught to use the computers first. Without the enthusiasium of the teacher students will see the computer as non-humanistic or as a toy for games.

Driscoll (1983) in an article entitled "Sam and the Microcomputer" says "computers can be fun and be used for games, but they need to nurture thoughtful learning as well."

Bell (1981) sites a course evaluation of student teachers opinions of a "Computers in Education Course" and found; 1) student teachers have a fairly high regard for the usefulness of computer literacy for teachers, 2) that there was no sexual bias for the appropriateness of either sex learning about computers, 3) college students preparing to be teachers are fairly confident about their own abilities to use computers and have positive attitudes towards computers after a single computer literacy course in college, 4) college students value the importance of computer literacy but are not as confident about their own abilities to use computers as they are about the importance of computers to society, and 5) it is possible to acquire a fairly good understanding of computer uses in society, to learn a significant and useful number of programming skills, and to be able to produce professional quality computer-enhanced curriculum materials through a single three-credit college course.

Linda Gojak (1983) in an article entitled "Taking the first step with a computer" gives methods (for teachers with no background in computers) of how to deal with them.

She also found that teachers and parents who work with computers are viewed as more valuable resource people.

Goles (1982/83) in a two part article "Games as Teaching Tools: Effective uses of the Child in All of Us" says that what we learn by playing games may not always be very evident but it can have "deep roots." What better way to learn then by enjoying ourselves. Educators and programmers should take advantage of this important way of learning.

One way of learning through games is by simulation of the real world and the computer can do this effectively. Hunter (1983) discusses the implications of computer simulation and model building for grades K to 8. He is presently in the process of writing a textbook for junior-senior high schools on understanding computer models for programming and understanding social and natural phenomena.

Trade journals such as Creative Computing advertise educational programs from different companies and have educational articles such as "Computers in Education: 4 How-to tutorials". Lubar (April 1982) discusses the merits of and evaluation of four educational games: Crossword Magic (word puzzle), Master Type (typing instruction), The Vocabulary Baseball Game (contains 1000 words), Meet The President (recognition of past American Presidents).

Following these articles David Ahl reviews six management games including "Lemonade Stand" where the student has to make decisions about how much fruit and sugar to buy considering the weather conditions, and how much to charge in order to make a profit or break even. The other five are on the same vein in markets, investments, running a cartel, and managing money. In the same magazine there is a review of a series of programs "Introduction to Organic Chemistry" where David Lubar talks about the teaching modes (tutorial mainly), the graphics, the demonstrations, and gives the level of instruction. In this case he suggests High School or College. In the same magazine, Dan Isaacson reviews "Arith-Magic", and this is about problem solving for older kids.

The computer craze is found not only in trade journals. For example, the April 1983 issue of Better Homes and Gardens has an article by Dan Kaercher on how "Computers are Changing the Classroom". He says computers are in all levels from preschool to high school and are being used for "computer literacy - giving students the fundamental skills to cope with life in the computer age." He makes nine suggestions for the parents, ranging from helping after school with computer clubs, to organizing, and to raising funds for computers in the schools.

Time (January 3, 1983) instead of making man "The man

of the Year" has taken the unprecedented step of making the computer "Machine of the Year". An indication perhaps that a machine has done more for man than man has for man?

COMPUTER ASSISTED INSTRUCTION

Barker (1982) in an article "Some Experiments in Man-Machine Interaction Relevant to Computer Assisted Instruction" makes three basic observations:

1) Conventional methods of lectures as means of teaching and disseminating technical information to large groups of mixed ability learners is inadequate.

2) Content teachers - specialists - for example teachers of the physically handicapped find using the computer alone without other devices such as special keyboards, audio facilities, high quality graphics, is not enough. Therefore hardware (computers and devices) and software (course materials or computer programs) has to be integrated to other curricula.

3) Teachers do not have enough time to develop programs while conducting their normal classroom duties.

Barker concludes that teachers need powerful authoring languages to develop programs for individual teacher needs and the support of multimedia instructional resources.

Seidman (1981) reports on the significant gains of grade five students logical reasoning after being taught a computer programming language called LOGO, a programming

language developed for young children.

Steir (1983) says that reading is a skill needed to survive in a media centered society and computer literacy is also a skill needed to survive in the present escalation of technology. Steir believes that efficient reading skills and computer literacy can be effective when combined. She taught BASIC programing for three weeks and found a definite correlation between reading improvement and progress on computer literacy. Evaluation also brought the following conclusions:

- 1) Students were interested to the point of excitement concerning learning.

- 2) Students helped each other to overcome the difficult skill of computer programming.

- 3) Students recognized that their math book held many clues to computer programming.

- 4) The projects were excellent and students went beyond investigating simple magazine articles to interviewing professional people.

Barber (1982), Bradley (1982), Henney (1982) all found computer literacy and computers significantly improved reading skills.

Robertson (1978), Hasselbring (1982), Hasselbring and Crossland (1982) all found computer assisted spelling advantageous to learning.

Mandell (1983) describes a computer program to help young children learn about the alphabet.

Reeves (1978) found "severely and profoundly deaf students were able to work independently at a computer terminal and CAL can be a practical means of reinforcing the academic skills of deaf students."

Maslasm (1983), Costa (1981), Costa (1982), Costa and Costa (1982) all discuss and describe how a microcomputer is being used by children in school libraries.

Upitis (1982) talks about the microcomputer being used to teach music composition.

Prentice (1981) uses, as this writer does, the computer to make and print a classroom newspaper. The motivation of students using the computer as a word processing unit increases to the point where rewrites are looked upon as a chance to take a turn on the computer. Many of these students, who are adverse to coming to school on time, will try to make an appointment an hour earlier than school starts to make sure that they have time on the computer.

Watkins and Webb (1981) investigated the effectiveness of computer assisted instruction found that mathematics skills were increased for learning disabled students in an elementary school.

Groucho (1982) used the microcomputer to teach energy

conservation in a game format. Rakow and Glenn (1982) also used a microcomputer to teach about acid rain in a game mode.

As previously mentioned, the computer has many other uses in the classroom other than mathematics drill and practice and the spin-off benefits are only limited by the teacher's imagination.

The arguments for use of the computer in the classroom could fill several books. One purpose of this study is to demonstrate that by using the computer to take immediate response and give immediate feedback students can improve their ability to recall multiplication facts. However other benefits are computer literacy for both teacher and student which as the review of the literature points out is becoming more and more important in this age of technology.

CHAPTER 3

REVIEW OF LEARNING THEORY

INTRODUCTION

This review of the literature is directed towards the following areas:

- 1) Memory and learning,
- 2) short term memory transfer to long term memory,
- 3) conditioning,
- 4) rote learning,
- 5) factors identified in solving computational problems,
- 6) a review of some teaching methods,
- 7) the importance of feedback (especially immediate feedback),
- 8) a look into concentration, anxiety, stress, and learning,
- 9) the use of electronic feedback, and finally
- 10) the use of the computer as a learning tool.

MEMORY and LEARNING have been crucial topics for teachers as far back as Plato and Aristotle.

Ebbinghaus (1879 to 1880) is credited with the first quantitative methods and laboratory procedures for studying memory and learning. He made up 2300 nonsense syllables and counted the numbers of repetitions necessary to memorize lists up to a criterion. The other variable

measured was the time in seconds taken to reach the criteria. The Ebbinghaus approach was the premier model for memory studies for about seventy years.

F.C. Bartlett (1932) tested recall over time intervals from single treatments (a story, passage, etc.). His model of memory was a schematic process of a contextual nature, where context clues were used to facilitate memory of a passage.

Ausubel (1968) said learning must be meaningful and must be done in a meaningful fashion, that is, the difficulty of learning nonsense syllables is increased by the fact that the syllables do not have meaning. The learning of the multiplication tables for grade six students has importance and meaning for them every day in mathematics lessons. Ausubel says that there is abundance of research showing that prior learning is not transferable to new learning without the necessity of being overlearned. That being the case then teachers should not go on teaching mathematics until fact tables are overlearned.

SHORT TERM and LONG TERM MEMORY transfer are paramount in this study. William James (1890) first spoke about long term and short memory but he called them primary and secondary memory. Broadbent (1958) used the terms short term memory (STM) and long term memory (LTM) and found that, with repetition, STM incidents are transferred to

LTM.

During the late 1950's, Brown (1958), Peterson and Peterson (1959), and Sperling (1960) were among a number of people working with short term and long term memory transfer. There was much discussion as to which model should be employed. Whether it is a chain, a pathway, or incremented segments is not within the scope of this study. The point they made was that there is a transfer from short term to long term memory.

CONDITIONED REFLEXES: reflexes are elicited by a stimulus. Simple reflexes are the blink of an eye from the stimulus of an object approaching. A stimulating object (candy) elicits a simple reflex (salivating). However, we have learned the word candy (a stimulating object) stimulates us to salivate (a conditioned reflex). Thus we have learned to salivate (a simple reflex). By the act of learning, a simple reflex becomes a conditioned reflex. In this study, the purpose of these immediate response and feedback treatments are to have the products of multiplication tables act like a conditioned reflex.

CLASSICAL CONDITIONING may be considered the results of transfer from short term to long term memory. Pavlov's (1927) experiment with the bell and the salivating dog was considered the premier case of classical conditioning and of great importance to this study was his belief that a

conditioned response is the smallest unit of learning.

CONNECTIONISM THEORY as presented by Thorndike (1913) was based on two constructs, "The law of effect" and "The law of exercise". The law of effect was a changeable connection between a situation and a response where the connection's strength was increased when followed by a satisfying situation. His law of exercise featured the critical importance of knowledge of results for the connection to be learned.

THE STATIC LAWS OF THE REFLEX as presented by Skinner (1938) concern the underlying thesis of this study.

1) The Law of Threshold states that there is a minimum intensity of stimulus required to elicit a response. This minimum critical value is termed the stimulus threshold. The students of this study were, or were not, under the constraints of time therefore the stimulus was quite intense.

2) The Law of Latency is an interval of time (called the latency) elapsing between the beginning of the stimulus and the beginning of the response. Skinner says that one important property of latency is that it is usually a function of the intensity of the stimulus. Therefore, intensity of the stimulus is increased as the time for response is decreased. This will be discussed in chapter six in conjunction with the results of this study.

3) The Law of Magnitude of the Response states that the magnitude is a function of the intensity of the stimulus. Skinner uses the example that a mild electrical shock on the foot may bring only a simple lifting of the foot whereas if the intensity of the shock is greater the subject may respond more intensely over a longer period of time (hopping about on one foot).

4) The Law of After Discharge means the response may persist for some time after the cessation of the stimulus. For example the hopping about on one foot may continue for some time.

5) The Law of Temporal Summation is a prolongation of a stimulus or repetitive presentation within certain limiting rates has the same effect as increasing the intensity. This study is concerned with the question of whether there are enough repetitions in the treatment to change an incorrect response to a multiplication stimulus. All of these laws are descriptive for breaking down the stimulus / response ratio in order to allow the S/R to be empirically measured.

OPERANT CONDITIONING as presented by Skinner (1954), says that the correct response to a situation must be reinforced or rewarded for training and the more immediate the positive reward, the stronger the connection. Therefore, it may be considered that a connection will be strengthened by the positive reward of a correct response and the

connection weakened by the dissatisfaction of an incorrect response or answer. Thus the faster the feedback the stronger the correct connection and the sooner an incorrect connection is broken.

Lysakowski and Walberg (1981) in a study of reinforcement and learning used meta-analysis, a process which converts the results of a large number of experiments to an "effective size" to look for the effectiveness of a particular treatment. The effective size is defined as the mean of the experimental groups' results minus the mean of the control groups' results over the standard deviation of the control group. Their results showed reinforcement has a large consistent effect on learning in a wide range of classroom circumstances. They reported "the differences in reinforcement highest between control groups in special schools and, possibly of girls." There was no significant difference to some types of reinforcers being more effective than others.

LEARNING THEORY

In a speech delivered to the First General Session, DAVI Conference, Houston, March 1968, Gagne talks about the four learning theorists whom he believes have had the greatest impact on learning theory in this century. The first he names is Neal E. Miller (1957) who suggested four principles which may be described in the words: motivation,

cue, response, reward. Interpolation from these four principles into the treatments described in chapter 4 would be: 1) motivation, students want to succeed and work on the computer, 2) cues, the painting in of a box on the video display screen "cues" the subject that another number fact is coming, 3) response is important, to change the student from passive learning (spectating) to active learning by active participation. When a student types in a response as fast as possible that student is very active. 4) Reward is supplied when the student sees their response and the correct answer together. These general principles Gagne feels have "limitations in practical usefulness" because of their obviousness and feels that skilled teachers apply or "incorporate these four principles to some degree" naturally. He next describes B.F. Skinner's views on instruction as similar to Miller's, 1) motivation is necessary, 2) subject must make a response and this response needs to be reinforced. Reinforcement need not be a reward (for example electrical shocks). Gagne feels that Skinner focusses around "stimulus control" to make more elaborate learning, shaping, chaining, and discrimination. Next Gagne talks about his own theories in "The Conditions of Learning" (1965) where the first principle emphasized is that of "distinctive conditions for different kinds of learning". The eight conditions for learning or his

learning types are: 1) signal learning (classical conditioning); 2) stimulus / response learning (which is the proposition of this study); 3) chaining (connections of S's to an R); 4) verbal association or verbal chaining similar to number 3 but uses language not motor skills; 5) discrimination learning where a person learns to make more than one response to a stimuli; 6) concept learning and 7) rule learning are what most instruction in school concerns; 8) problem solving is part of a process that takes place within the learner. These conditions are in a hierarchy and some conditions are prerequisite for other higher learning. For instance, the learning defined in this study is concerned with type 1 and 2 which are required for types 6, 7, and 8. Along with these types of learning Gagne has eight phases which constitute a single act of learning. They are: 1) motivation, 2) apprehending, 3) acquisition, 4) retention, 5) recall, 6) generalization, 7) performance, and 8) feedback. Gagne also talks about Ausubel's theory that learning must be meaningful to the learner and says that Ausubel insists that all school learning is meaningful and that this process is different from rote learning.

ROTE LEARNING or commitment to memory does not signify understanding. In the past the memorization of sections of the Bible or long obtrusive poems was considered good mental discipline. There were memory exercises to expand

and develop "mental muscles". Most modern educators do not place the same value on rote learning. But without the rote learning of simple multiplications facts (there seems to be no other method to retain learning of these academically vital facts) students go through many distracting and time consuming ways of doing computations. Therefore it would seem that "rote learning" still has some important role to fill. However, if we do not like the term 'rote learning' then we should rename the exercise 'Drill and Practice.'

Seagoe (1970) says "Logical learning consists of organizing or reorganizing material. If the learner can fit a new item into an existing overall concept, it is no longer confusing. Logical learning transfers to rote learning more than rote learning does to logical learning. Therefore, memorizing should come after understanding, not before. ... Drill and overlearning are important in rote learning, unimportant in logical learning."

Suppes (1966) demonstrated that memory was the most important factor in a study that attempted to identify the factors contributing to the difficulties of solving problems.

Ashlock (1972) stated that if a child is to use arithmetic to solve problems it is important that he or she master the basic facts, (in other words memory work). He

suggests that teachers make learning varied by using the following aids and strategies:

- 1) Flash cards
- 2) A toy store
- 3) Games
- 4) Open number sentence activities
- 5) Worksheets such as puzzles.

Tietz (1968) has shown that different TEACHING METHODS for the concepts of multiplication are not necessarily a factor in student performance following learning. He tested two different methods of teaching multiplication, repeated addition versus a co-ordinate system and ordered pairs. The results showed no significant difference. If the methods of teaching multiplication do not make a difference then this researcher proposes the following MODEL: each multiplication fact is a coded response to a particular stimulus (? times ?) and the answer (??) is the immediate response.

FEEDBACK or K R is defined as the knowledge of results of an action or reaction to a stimulus. There have been many studies of K R and immediate feedback under many different names. Saltzman (1951) investigated the effect of delaying knowledge of results on the rate of learning four-place numerals in a verbal maze. He found immediate K R showed higher learning than delayed K R.

Sax (1960) found that increased delay of K R required a greater number of trials necessary to learn a given criteria of Chinese symbols. He used Chinese symbols with people who were unfamiliar with them so that there would be no interference from prior learning.

Bourne (1957) reported that performance of students in an introductory psychology class were inversely related to delay of feedback within a time-frame of 0 to 8 seconds.

Reese and Lipsitt (1970) surveyed 14 studies of delayed feedback between 1960 and 1970. They found delay of K R showed significantly less learning for 8 of the studies and in five there was no significant difference. The last study showed lower learning from delayed K R when the task was more difficult. Reese and Lipsitt state they have found no studies where increased learning resulted from delayed reinforcement.

Hannafin (1980) showed significantly that feedback proved to be both practical and effective when he had one class taught math skills with no feedback and one class received what he called "systematic feedback". The study confirmed the effectiveness and practicality of feedback-based systems.

Krumboltz and Weisman (1962) reported that more frequent feedback yields better learner performance. Rosenstack, Moor and Smith (1965) also found that more

frequent K R yields better learner performance.

Gay (1970), in a study that tested the effect of timed reviews, showed that one review was better than no review. A better treatment consisted of an early review after twenty-four hours, then again six or seven days later. This proved to be optimal for long retention. Whereas Tait, Hartly and Anderson (1973) reported on three groups with: 1) no feedback, 2) passive feedback where students watched answers being done, and 3) active feedback where students had to punch in corrections. They found a significant difference between group 1 when compared to groups 2 and 3. However, they found no significant difference between groups 2 and 3.

Seagoe (1970) in her book "The Learning Process and School Practice" states that for certain types of learning, simple short feedback is important. She gives the example of the teacher telling a student that he/she has made a spelling error. But, does not tell what the error is then the student thinks they should avoid that word. However, if the teacher immediately gives the correct spelling the student knows she/he has an alternative (right or wrong) response. Thus for this type of learning short and simple immediate feedback is important. Seagoe also suggests studies show the following: 1) practice without knowledge of results brings little or no improvement, 2) knowledge of

results brings marked improvement in performance, 3) the more detailed and specific the knowledge of results the greater the progress, 4) the more positive the knowledge of results, the greater the progress, 5) immediate knowledge of results is superior to delayed knowledge, and 6) classes and individuals differ in the ways in which they respond to knowledge of results. Seagoe sums up by saying, "The implications of these facts for teaching are clear. For most effective learning, knowledge of results should be introduced as quickly as possible and as specific as possible."

ELECTRONIC FEEDBACK is reported by Hohlfield (1973) in his study "Effectiveness of an Immediate Feedback Device for Learning Basic Multiplication Facts". He used a Monroe 1665, which he described as a "machine" capable of being programmed to present a number pair for multiplication and wait for the student's response. If the response was correct, the machine printed the response. If it was incorrect, it printed "error" and then repeated the numbered pair. The study compared the effectiveness for learning 100 basic multiplication combinations. He also compared the above method with what he called "regular classroom procedures". The subjects were 84 fifth grade students who scored low enough on a basic multiplication pretest to need to leave the classroom for special help.

After 25 math class days of treatment, there was a posttest and two retention tests - one month and three and one-half months later. Significant differences favoured the electronic device group on both acquisition and the short term retention but not on the long term retention.

CONCENTRATION, ANXIETY, STRESS, LEARNING, and HABITUATION (attention) are all inter-related as the following studies suggest: Cattell (1966) suggested that anxiety is a function of unresolved doubt about expected outcomes. Therefore it follows that providing feedback will reduce anxiety. But is reducing anxiety a helpful thing? Drive theory, as explained by Spence and Spence (1966), predicts that high-anxiety subjects perform better than low-anxiety subjects on simple tasks in which a single habit tendency is involved. High anxiety and performance are related to the ability to attend to a task. No one particularly children, can stay "tuned in" to the whole world and all the people around them without being totally disoriented and confused. People have ways of "tuning out" (habituation). We also have ways of directing our full attention. These fully attentive sessions, or tuned-in sessions, are generally brought about by stress. Stress, as Hans Selye (1974) said in his book "Stress Without Distress", is a very useful and necessary part of our life.

Maslow (1968) in his chapter on "Health as Transcendence

of Environment" says that being focussed on a task produces organization for efficiency, both within the organism and in the environment. What is irrelevant, is pushed aside and not noticed. One needs only to look at the focused concentration during the playing of arcade games to appreciate the implications for learning on the computer.

Computer assisted learning has been very well documented by numerous studies and the majority of results are significantly positive for this type of learning. Fiorentino (1977) in his master's thesis cites over 47 studies supporting CAL in the areas of language arts and mathematics. See Appendix E for a summary table of twenty studies that involved CAL and mathematics.

In SUMMARY, this review of the literature has shown that memory and learning can be quantified and there is a transfer from short term to long term memory. Pavlov believed that a conditioned response was the smallest unit of learning. A central idea of this thesis is that multiplication facts may be considered as small units of learning. Skinner suggests that reinforcement should be immediate and follow each correct response in small units of learning. By using immediate feedback the correct response is immediately corrected and helps to erase erroneous learning and increases retention of facts. Several researchers have shown that memory or recall

contributes to the solving of problems and that, active response and feedback improves retention for recall of these small units of learning.

CHAPTER 4

METHOD

THE PROBLEM

Many children having difficulty with mathematical computations could be helped if multiplication facts were learned so thoroughly, that, on demand they would be instantly recalled. There would be no delays or engaging in distracting unproductive strategies during computations because the student would know multiplication facts as a conditioned response. The stimulus would be "X times Y" and the conditioned response would be "A". For example let $X = 6$, $Y = 7$, and $A = 42$ therefore 6×7 (S=6 X 7 - R=42).

The review of the literature supports the view that transferring facts from short term memory to long term memory can be facilitated by instant feedback and that some anxiety may help master this type of learning.

RESEARCH HYPOTHESIS

There will be a significant difference between three randomly selected groups of grade six students from the same classroom being retaught multiplication facts for factor "A" response time and factor "B" retention of learning. The first group (GROUP a1) is allowed only 2.5 seconds to make a response and receive immediate feedback.

A second group (GROUP a2) is allowed up to 6.0 seconds to make a response and receive immediate feedback, while a third group (GROUP a3) has all the time they wish to take to make their response and receive immediate feedback.

There will be a pretest (b1) and a posttest (b2) immediately after treatment and a retention test (b3) approximately thirty days later.

Specifically the null hypotheses tests for instant response and feedback for the retention of multiplication facts are:

Null Hypothesis (1)

There will be no difference between treatment effects (test scores) of the levels of factor A (2.5 seconds, 6.0 seconds, and open-ended).

Null Hypothesis (2)

There will be no difference between treatment effects (test scores) of the level of factor B (pretest, posttest, and retention test).

THE SAMPLE

The subjects were twenty-five grade six students from the same classroom at an elementary School in the city of Winnipeg's Assiniboine South School Division Number Three. The total school population was approximately 167 kindergarten to grade six students in closed classrooms. The subjects under study ranged from 11 to 13 years of age with a mean age of 11.5 years. All students live in the

local area surrounding the school.

The sample of twenty-five students was divided into three groups. A draw was held to randomly assign each student in one of the three groups. Then a coin was tossed to see which treatment group became either the 2,5 second group (a1), the 6 second group (a2) or the open ended group (a3).

LIMITATIONS OF THE SAMPLE

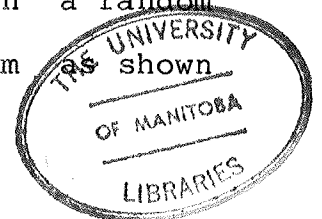
The purpose of this study was to evaluate the effects of instant response and feedback for relearning of multiplication facts using a microcomputer.

A factor taken into consideration was the small size of the sample. However it was concluded that with such a small sample the independant and dependant variables could be more tightly controlled.

Another factor considered was student familiarity with the keyboard of the single microcomputer available for this study. To this end students had been allowed to use the computer after school for games, drill and practice in other subject areas. The students had also used the microcomputer as a word processor so they were familar with the keyboard and the number pad beside the keyboard.

INSTRUMENTATION

A pretest, posttest and retention test consisting of sixty-six pairs of multiplication facts (put in a random sequence) was programmed into a computer program



in Appendix A. Sixty-six pairs (from two through twelve) were chosen excluding the one times table. It was considered in consultation with other teachers in the school that the one times table is unnecessary at the grade six level. Table 1 shows the sixty-six multiplication fact pairs and their products.

TABLE 1

66 Pairs of Multiplication Facts Being Learned

[illegible]

TREATMENT

Group one was the immediate response/feedback group and received drill and practice on the computer which was programmed to allow only 2.5 seconds before the answer was displayed on the computer. After a six second delay (as a box is painted in on the video display screen) a new question appears. The student's score as with the other two groups was reported at the end of the session as a percentage of correct responses.

Group two was allowed 6.0 seconds to make a response before the correct answer was displayed on the video screen. As in group 1 a six second display of the correct answer was on the screen while a box was painted in prior to the next question.

The third group (the open-ended group) was allowed as much time as needed to type in an answer. As soon as the answer was entered they received immediate feedback.

INSTRUCTIONAL PROGRAMS

The computer software was programmed by this researcher in a high level computer language called Beginner's All Purpose Instructional Code (BASIC). A listing and sample runs of the program is shown in appendix A. The student selected the appropriate drill for that day and took his or her turn on the computer to work through the program. When the student completed his/her session on the computer they took the print-out showing

their report to the teacher for recording. The student's results are graphed and tabled in appendix C.

The drill and practice programs required active participation by the students. There were two forms of the three treatments called:

DRILL 1 and DRILL 1A (only 2.5 seconds allowed for a response.)

DRILL 2 and DRILL 2A (6 seconds allowed for a response.)

DRILL 3 and DRILL 3A (no time limit for the response.)

Only the order of the presentation of the multiplication facts varied between the "A" form and the original form not the facts themselves.

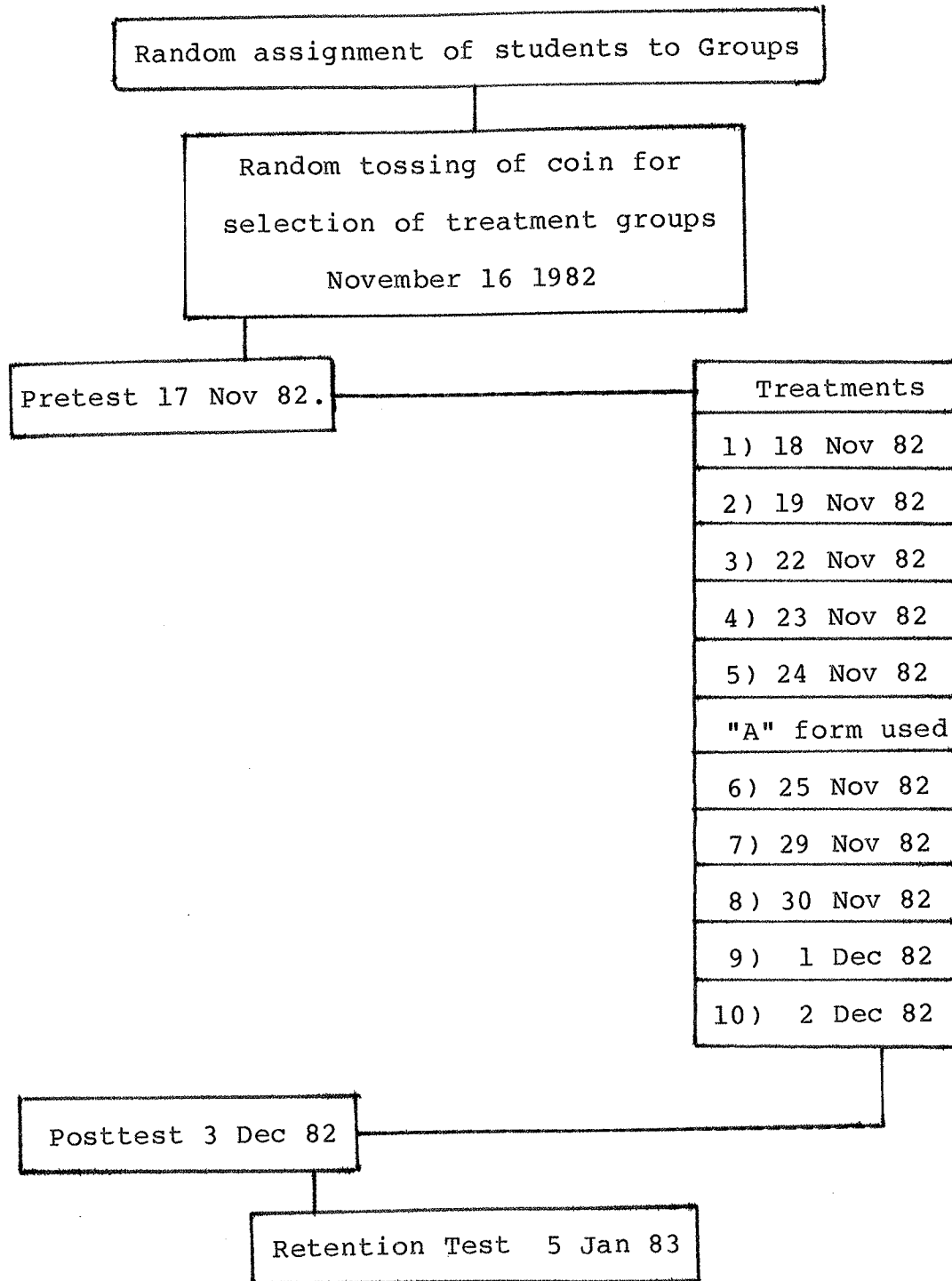
In a trial run of the program with several elementary teachers it was decided there should be a time delay in between questions to allow the student to mentally prepare for the coming question and also have the correct response displayed as a type of reinforcer. So a delay is programmed in while a box is painted-in on the video display terminal. This painting-in of the box acts as sort of a count-down before the next question and focuses the students attention. The box is also painted in on the pretest, posttest, and retention test.

ADMINISTRATION

The treatment took place in the classroom with one student working on the computer while the rest of the class

did their normal work. The students would finish their treatment and quietly go to their seat and the next student then went to the computer and started working with little or no interruption to the rest of the class.

Figure One
Flowchart of Procedure



APPARATUS

The Computer was a TRS 80 Model III 48K with dual disks and a line printer I. The programs were written in a high level language called BASIC by this author onto 5 1/4 inch floppy disks. Program listings are shown as appendix A. Two hardcopies of each student's results and errors were printed out - one for the student and one for record keeping purposes.

STATISTICAL PROCEDURE

Statistical analyses were done on the data obtained from twenty-four of the twenty-five subjects in the sample. One subject was randomly dropped from the first treatment group with nine subjects in it to make three groups of eight in order to make equal cells for the statistical analysis.

A three by three analysis of variance tested the instructional programs (treatments) for significant differences over the repeated measures of the pretest B_1 , posttest B_2 , and retention test B_3 . A test for main effects using the Newman-Keuls method as explained in Chapter 4 of Winer (1971) was also done.

STATISTICAL HYPOTHESES

The following are the statistical hypotheses of the Analysis of Variance for Repeated Measures

1. Null Hypothesis $H_0: A_1 - A_2 - A_3 = 0$

If three groups of grade six students in an elementary school are administered a test of multiplication facts as shown

in Appendix A and are administered the same test at the completion of the study there will be no significant difference between the treatment effects (means) of the levels of factor A (i.e. treatment 2.5 seconds, 6.0 seconds, open time, group means).

Alternative Hypothesis $H_1 \neq H_0$

If three groups of grade six students in an elementary school are administered a test of multiplication facts as shown in Appendix A, and are administered the same tests at the completion of the study, there will be a significant difference between the treatment effects (means) of the levels of factor A (i.e. treatment 2.5 seconds, 6.0 seconds, open time, group means).

2. Null Hypothesis $H_0: B_1 - B_2 - B_3 = 0$

If three groups of grade six students in an elementary school are administered a test of multiplication facts as shown in Appendix A of the study there will be no significant difference between the treatment effects (means) of the levels of factor B (over a pretest, a posttest, and a retention test.)

Alternative Hypothesis $H_1 \neq H_0$

If three groups of grade six students in an elementary school are administered a test of multiplication facts as shown in appendix A of the study, there will be a significant difference between the treatment effects (means) of the levels of factor B (over a pretest, a posttest, and a retention test.)

Using the Neuman-Keuls method the following treatment means were tested over time:

$$\begin{array}{ll} H_0 & H_1 \\ \bar{X}_1 = \bar{X}_2 \text{ (2.5 second grp = 6.0 second grp)} & \text{or } \bar{X}_1 \neq \bar{X}_2 \\ \bar{X}_1 = \bar{X}_3 \text{ (2.5 second grp = open-ended grp)} & \text{or } \bar{X}_1 \neq \bar{X}_3 \\ \bar{X}_2 = \bar{X}_3 \text{ (6.0 second grp = open-ended grp)} & \text{or } \bar{X}_1 \neq \bar{X}_3 \end{array}$$

Comparison was made at .05 and .01 levels of significance.

$$\begin{array}{ll} H_0 & H_1 \\ \bar{X}_4 = \bar{X}_5 \text{ (pretest = posttest)} & \text{or } \bar{X}_4 \neq \bar{X}_5 \\ \bar{X}_4 = \bar{X}_6 \text{ (pretest = retention test)} & \text{or } \bar{X}_4 \neq \bar{X}_6 \\ \bar{X}_5 = \bar{X}_6 \text{ (posttest = retention test)} & \text{or } \bar{X}_5 \neq \bar{X}_6 \end{array}$$

Comparison was made at .05 and .01 levels of significance.

A correlation matrice was done for the;

- 1) 2.5 second group,
- 2) 6.0 second group,
- 3) open-ended group,
- 4) all groups between the following variables:
pretest scores with posttest scores.
pretest scores with retention test scores.
posttest scrores with retention test scores.

CONTROLS for INTERNAL VALIDITY were considered for nine points as discussed by Campbell and Stanley (1966). They are, history, maturation, testing, instrumentation, regression, selection biases, mortality, interaction

between selection, experimental conditions.

1. History was similar for both groups because they were in the same school classroom.

2. Maturation was not a problem in the eight weeks the experiment ran.

3. The act of testing did not appear to affect one group differently from the other group because they took the same the tests at the same time.

4. Instrumentation was controlled by the subject responses to the same computer tests by all groups.

5. Regression, if there is a problem, was similar for all treatment groups.

6. Selection bias was controlled by random selection. The teacher and the students went down the nominal roll and the students drew lots out of the three groups for placement. The teacher and the students then flipped a coin to see which group received what treatment.

7. Mortality was not a problem due to the shortness of the observation period and no transfers in or out during treatment period.

8. Interaction between the groups in terms of selection, treatment, and testing for what might be called the Hawthorne Effect (where one group is favoured with the teacher's attentions and thus overextend themselves) was controlled by all groups working on the computer. An agreement was made by students and teacher to reverse the

treatment to the groups in about six months for review - if the class or the teacher felt further drill and practice was required.

9. By using a self-contained classroom experimental conditions can be controlled so that there is no bias for any group. The teacher was able to monitor the situation so that there was no John Henry effect (where one group tries to out do the other groups in a competitive situation and thus over-achieves).

The results of this study are reported in Chapter five and discussed in Chapter 6.

CHAPTER 5

RESULTS

This chapter will present the results of the study. A detailed discussion of the results in relation to the hypotheses will follow in chapter 6 along with some conclusions and considerations for further studies.

The intercorrelations were calculated for the three groups and for total group scores (2.5 seconds, 6.0 seconds and open-ended). Results are presented in Table Two. The results show that the pretest to posttest and retention test are highly correlated and very stable for the 2.5 second group and the open-ended group at the .05 and .01 levels of significance. However the 6.0 second group showed very little correlation between the pretest, posttest, and retention test but did show a significant correlation at the .05 level for the posttest and the retention test. A graph of the subject test scores for each group can be found in appendix G for descriptive purposes.

TABLE TWO CORRELATION MATRICES

+++++
CORRELATION MATRIX FOR 2.5 second response GROUP

	PRETEST	POSTTEST	RETENTION TEST
PRETEST	1.00	.764 *	.834 **
POSTTEST		1.00	.921 **
RETENTION TEST			1.00

* P < .05 r critical = .666 df(7)

** P < .01 r critical = .798 df(7)

+++++
CORRELATION MATRIX FOR 6.0 second response GROUP

	PRETEST	POSTTEST	RETENTION TEST
PRETEST	1.00	.442	.12
POSTTEST		1.00	.717 *
RETENTION TEST			1.00

* P < .05 r critical = .707 df(6)

** P < .01 r critical = .834 df(6)

+++++
CORRELATION MATRIX FOR open time response GROUP

	PRETEST	POSTTEST	RETENTION TEST
PRETEST	1.00	.918 **	.918 **
POSTTEST		1.00	.946 **
RETENTION TEST			1.00

* P < .05 r critical = .707 df(6)

** P < .01 r critical = .834 df(6)

+++++
CORRELATION MATRIX FOR ALL GROUP SCORES

	PRETEST	POSTTEST	RETENTION TEST
PRETEST	1.00	.687 **	.707 **
POSTTEST		1.00	.881 **
RETENTION TEST			1.00

* P < .05 r critical = .396 df(23)

** P < .01 r critical = .505 df(23)

Analysis of Variance

The summary table for the analysis of variance appears in table three. The test scores and the scores of daily lessons (treatments) are in percentages as shown in appendix D. The means, standard deviations, and correlation predictions also appear in appendix D. From chapter 4 the Null Hypotheses are:

1) There will be no difference between the treatment effects of factor A (2.5 seconds, 6.0 seconds, or open-ended time for response and immediate feedback).

2) There will be no difference between the treatment effects of the levels of factor B (period of time between the pretest, posttest, and the retention test.)

For Hypothesis 1 the F ratio obtained was 8.04 at the .0011 level of significance. Therefore the Null Hypothesis was rejected since there was a significant difference between the treatments, and the alternative hypothesis was accepted.

For Hypothesis 2 the obtained F ratio was 86.4 which was significant at the 0.0001 level. The Null Hypothesis was rejected and the Alternative Hypothesis accepted. To determine the difference(s) an Aposteriori probing technique was used.

TABLE Three
Analysis of Variances Summary Table
for Repeated Measures Design

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
A (treatment)	747.86	2	373.93	8.04*
Subjects within Groups	10193.125	21	485.39	10.44*
B (over period of time)	8031.8611	2	4015.93	86.4*
AB	287.8889	2	143.94	1.55
B times Subjects within groups	1952.25	42	46.48	
Totals	21212.984	69		

* $p < .001$

TABLE Four

Newman-Keuls Test for Differences Over Factor A

Treatment, Using Group Means

		A2	A3	A1
Ordered				
Means		53.542	59.33	61.083
Differences		A2	A3	A1
of	A2	-	5.788 *	7.541 *
Means	A3		-	1.753
		A2	A3	A1
		6.0 sec grp	open-ended grp	2.5 sec grp
A2 6.0 sec grp			*	*
A3 open-ended grp				

* $p < .05$

TABLE Five

Newman-Keuls Test for Differences Over Factor B

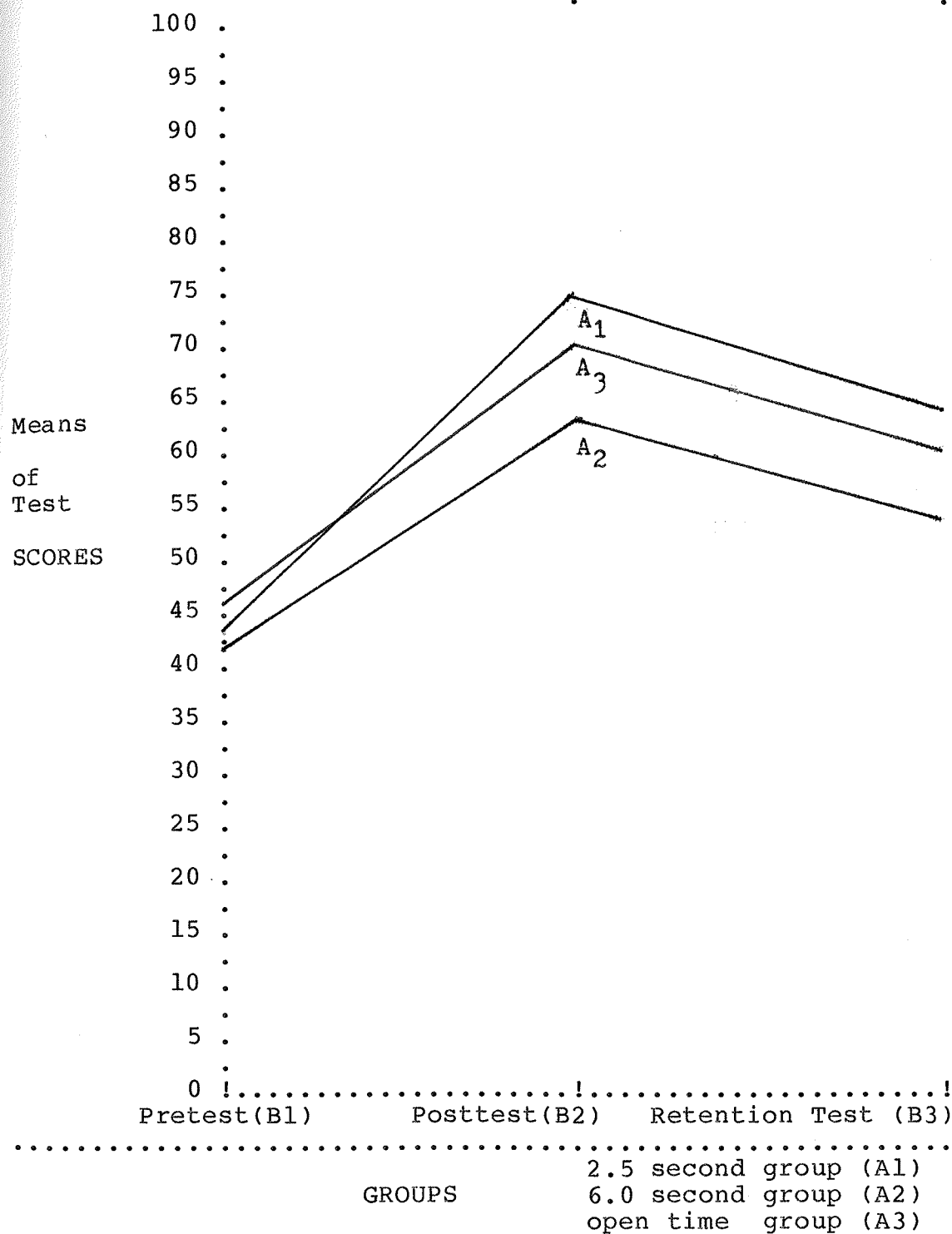
Time, Using Test Means

		B1	B3	B2
Ordered				
Means		44.083	60.208	69.667
Differences		B1	B3	B2
of	B1	-	16.125 *	25.584 *
Means	B3		-	9.459 *
		B1	B3	B2
		Pretest	Retention test	Posttest
B1 Pretest			*	*
B3 Retention Test				*

* $p < .05$

FIGURE Two

Means of Factor A (treatment) over Factor B (time)



CHAPTER 6

DISCUSSION and CONCLUSIONS

This study helps to support the assumption that CAI is a very viable, simple, and welcome addition to the classroom. Although limited to mathematics in this study, other curricula, such as spelling may benefit just as well.

ANALYSIS OF VARIANCE

The null hypothesis (1) for factor A was rejected. The alternative hypothesis that there was a difference in learning was accepted at the .0011 level of significance for the treatment. The thesis was that the best learning treatment would be the 2.5 second response.

The null hypothesis (2) was rejected for factor B and the alternative hypothesis accepted at the .0001 level of significance. This indicates that there was a difference of learning over a period of time. The differences expected were: there would be an increased score for multiplication facts for all groups immediately following treatment and that there would be a falling-off of scores over a period of time. See table three.

The Newman-Keuls probing technique was used to find where the significant differences occurred. The results of factor A, regarding the treatment for the different response times, showed significant differences in scores between the 6.0 second group and the other two groups. Indicating the learning was similar for the 2.5 second group and the open-ended group. See Table Four.

The Newman-Keuls results (Table Five) for factor B, over time, indicate significant differences at the .05 level for all three tests (pretest, posttest, and retention test). This indicates learning and retention of learning took place. As could be expected the best learning was indicated right after the treatment. Retention between the posttest and the retention test was significant to a lesser degree due to some expected loss over time.

Results of the correlation were very high and stable except for the 6.0 second group. The lack of correlation for the 6.0 second group between the pretest and the retention test can be explained by looking at the learning curves (Figure 5) and considering the small size of the sample, individual score changes cause a greater affect on the results of correlation. Other results reveal that gains in learning and retention were significant for the 2.5 second group, the open-ended group, and total group scores. They were significant at the .01 level with the exception

of the pretest to posttest for the 2.5 second group where learning was best and the correlation was at the .05 level of significance.

GENERAL COMMENTS

The results of this study show:

1) All groups learned significantly and retained significantly their multiplication facts by using the computer.

2) Learning is greater when the learner gives an immediate response and receives immediate feedback. The best treatment group was the instant response group, where only 2.5 seconds was allowed for the input of an answer. The open-ended response group was next best indicating possibly that with no pressure, and repetition of the treatment, learning takes place. The least significant learning took place with the group which was allowed 6.0 seconds to respond. Possibly the combination of a time constraint and, the use of various multiplication strategies instead of learning as a conditioned response were the reasons for being the least effective method.

3) After a one month period, learning was retained more significantly for the immediate response group. The next best group was the open-ended time group and the 6 second group showing the least significance for retention of learning.

4) The results of this study indicate drill and practice should be short sessions (as the treatments were), with student concentration focused entirely on the learning task.

5) The study supports the idea that the learning of small bits is better with increased tension. The inference being that 2.5 seconds to type in an answer put the student under increased tension.

The study indicates immediate response best, and the second best was the open ended group, which is open to interpretation that this type of learning is either best under high pressure or no pressure at all.

Results show the least effective method to learn is to have sufficient time to respond but the time constraint, while not extreme, causes learning interference. One interpretation of this phenomenon could be that the students are under constraints and attempt to answer using compensating strategies.

TABLE SIX

TABLE OF GROUP AND TEST MEANS

	B1	B2	B3	
	Pretest	Posttest	Retention Test	GROUP MEANS
A1				
2.5 second group	43.50	75.00	64.75	= 61.08
A2				
6.0 second group	42.75	63.25	54.63	= 53.54
A3				
open-ended group	46.00	70.75	61.25	= 59.33
TEST				
MEANS	44.08	69.67	60.21	

SOME IMPLICATIONS FOR CONSIDERATION:

1) The computer, as a learning tool, used after the student has been taught the concepts is an excellent "Drill and Practice" machine.

2) These students first learned their multiplication fact drills with pencil and paper. Therefore it follows that computer drills are significantly better than pencil and paper drill and practice, probably due to the high motivation students have working with the microcomputer and more importantly the feedback is immediate. The results differ from Hohlfield's (1973) study, who found no difference for long term retention between a paper and pencil group and a group using an electronic feedback device.

3) The microcomputer is a worthwhile addition to the classroom and helps maintain class control by setting a business-like attitude for the students.

4) The implications for teachers are to get parents and students involved to purchase micros for your classroom and school.

5) Research has shown that drill and practice sessions should be short and concentrated on the task at hand.

6) Reinforcement for simple tasks need only be the students response shown with the correct response.

7) Students like elaborate reinforcement at first.

But, when they really get motivated to learn, elaborate reinforcement is time consuming and seems to make the student exasperated because the learning is not coming fast enough. Therefore the simple reinforcement of getting the correct answer is sufficient.

8) Not all students learn the same way. Some students appear to get a total block when faced with what to them may seem to be extreme time constraints. These students may need the open ended treatments at first, to raise their self-confidence before attempting to refine their skills by doing the immediate response learning.

9) Have the students help you write the program by typing it into the computer, debugging, and saving it. Also have them make suggestions for modification of the programs in Appendix A.

10) Appendix F shows the means of the three groups daily treatments. It is interesting to note that the open time group has a high nearly flat learning line which starts at 94% and stays around 96%. The 6.0 second group has a line which starts 82% and climbs to a high of 93%, whereas the 2.5 second group starts with a mean of 48% and climbs to a high of 82%. Of the 2.5 second group it is noteworthy that on the posttest all subjects but one scored less than the previous day with treatment number ten (see appendix D). Also of interest on day 6 a different

presentation order (drills 1A, 2A, and 3A) of multiplication facts was used in treatment sessions. This researcher believes that the students were unconsciously picking up cues from the order of presentation even though each session started at a randomly different place in the order of the 66 multiplication facts. This will be discussed again as point 3 in the implications for further study.

LIMITATIONS OF THE STUDY

The references to stress are only by inference. There should have been a measurement of stress for the three groups during treatment. It is purely an assumption that 2.5 seconds to input an answer is more stressful than 6.0 seconds.

The computer could have been programmed to record how quickly the open-ended group were inputting their responses which might give further insight as to why they scored better on the tests than the 6.0 second group.

The small size of the sample caused large changes in statistics by individual scores.

IMPLICATIONS FOR FURTHER STUDY

1) The greatest implication from this study is to present drill and practice curricula like the multiplication tables either in an intense setting or, in an extremely relaxed situation. How quick must the

response time be? Here it was best at 2.5 seconds. Would 3.5 seconds or 4.5 seconds make a difference? Where does learning response time drop off? Here the 6.0 seconds time constraint was chosen because that seems to be (according to the literature) as long as short term memory is retained.

2) Further studies could involve finding out more about cognitive bypasses of multiplication strategies. The study could record the students strategies, do ten treatments, then resurvey and compare changes in the multiplication strategies.

3) In light of Skinner's law of temporal summation and the drop in the learning curve as shown in appendix F, the question arises which learning would be more effective? 1) The treatment of 66 multiplication facts repeated in order, versus, 2) a treatment of the 66 multiplication facts being produced in random order.

SUMMATION

The theories of Learning Theory, and Teaching, sometimes are quite removed from the teaching environment and have little practical use in the classroom. This researcher, a classroom teacher, hopes that this experiment, which was;

- 1) so simple to program into the computer,
- 2) carry-out in the classroom,

3) and also rewarding for his students,
will be utilized possibly in other areas such as spelling,
vocabulary, phonics, and science facts by other teachers.

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APPENDIX A

Listing of Computer Software Programs

```
1 CLEAR
2 'POWER DRILL 1 MULTIPLICATION DRILL BY BILL CAMIER
3 CLEAR 1000:DEFINT A-Z:DIMA(78),B(78)
4 CLS:PRINTCHR$(23)
5 PRINT"          DRILL 1"
6 PRINT"          *****":PRINT
7 PRINT "This is a MULTIPLICATION  DRILL and you should
      try and put the answers in as fast as possible.":PRINT
8 FOR I=1 TO 66: READ A(I),B(I): NEXT
9 PRINT "Enter your name here please "
10 INPUT N$
11 R= RND(66) : CLS : PRINTCHR$(23);
12 GOSUB 32
13 FOR I = R TO 66:GOSUB 16 :NEXT
14 FOR I = 1 TO R-1:GOSUB 16 :NEXT
15 GOTO 22
16 CLS:PRINTCHR$(23);
17 A1$=INKEY$
18 PRINT A(I)" X "B(I)" = ";
19 GOSUB 27 'SUB 27 IS FOR THE ANSWER
20 IF D=A(I)*B(I) THEN C=C+1 : GOSUB 32 : RETURN
21 IF D<>A(I)*B(I) THEN W=W+1:GOSUB32 :RETURN
22 CLS:PRINT:PRINTCHR$(23);"Drill 1 report for ";N$
23 PRINT:PRINT"You did ";C+W;" questions."
24 PRINT:PRINT"          and"
25 PRINT:PRINT"YOUR SCORE IS ";INT((C*100)/(C+W)+.5);" % "
26 END
27 A1$="":B1$="":C1$=""
28 A1$=INKEY$:Z=Z+1:IFA1$=""AND Z<80THEN28 ELSE PRINTA1$;:
  D=VAL(A1$):IFA(I)*B(I)<10GOTO31
29 B1$=INKEY$:Z=Z+1:IFB1$=""ANDZ<120THEN29 ELSE PRINTB1$;:
  D=VAL(B1$)+10*VAL(A1$):IFA(I)*B(I)<100GOTO31
30 C1$=INKEY$:Z=Z+1:IFC1$=""AND Z<140THEN30 ELSE PRINTC1$;:
  D=VAL(C1$)+10*VAL(B1$)+100*VAL(A1$)
31 Z=0:PRINT:PRINTA(I);" X ";B(I);" = ";A(I)*B(I): RETURN
32 XL=10:XR=55:YT=25:YB=38'SETTING XR SETS LENGTH OF TIME
33 FORX=XLTOXR:FORY=YBTOYB:SET(X,Y):NEXTY,X:RETURN
34 DATA 9,12,5,10,9,11,7,7,8,9,4,6,2,3,5,6,2,6,3,10,4,7
35 DATA 5,12,6,12,2,12,4,4,2,10,7,8,5,9,8,12,9,9,2,8,3,5
36 DATA 4,9,6,6,5,11,3,9,6,10,3,4,4,11,2,5,10,11,6,7,7,9
37 DATA 3,6,4,10,8,10,4,8,3,11,6,11,5,8,3,7,5,7,6,8,7,11,7
38 DATA 10,2,9,2,4,4,12,8,8,11,12,5,5,12,12,4,5,2,2,11,11
39 DATA 8,11,3,3,10,10,2,7,3,12,2,11,10,12,3,8,9,10,6,9
40 DATA 7,12
```

```
1 CLEAR
2 'POWER DRILL 1A MULTIPLICATION DRILL BY BILL CAMIER
3 CLEAR 1000:DEFINT A-Z:DIMA(78),B(78)
4 CLS:PRINTCHR$(23)
5 PRINT"          DRILL 1A"
6 PRINT"          *****":PRINT
7 PRINT "This is a MULTIPLICATION  DRILL and you should
      try and put the answers in as fast as possible.":PRINT
8 FOR I=1 TO 66: READ A(I),B(I): NEXT
9 PRINT "Enter your name here please "
10 INPUT N$
11 R= RND(66) : CLS : PRINTCHR$(23);
12 GOSUB 32
13 FOR I = R TO 66:GOSUB 16 :NEXT
14 FOR I = 1 TO R-1:GOSUB 16 :NEXT
15 GOTO 22
16 CLS:PRINTCHR$(23);
17 A1$=INKEY$
18 PRINT A(I)" X "B(I)" = ";
19 GOSUB 27 'SUB 27 IS FOR THE ANSWER
20 IF D=A(I)*B(I) THEN C=C+1 : GOSUB 32 : RETURN
21 IF D<>A(I)*B(I) THEN W=W+1:GOSUB 32:RETURN
22 CLS:PRINT:PRINTCHR$(23);"Drill 1A report for ";N$
23 PRINT:PRINT"You did ";C+W;" questions."
24 PRINT:PRINT"          and"
25 PRINT:PRINT"YOUR SCORE IS ";INT((C*100)/(C+W)+.5);" % "
26 END
27 A1$="":B1$="":C1$=""
28 A1$=INKEY$:Z=Z+1:IFA1$=""AND Z<80THEN28 ELSE PRINTA1$;:
  D=VAL(A1$):IFA(I)*B(I)<10GOTO31
29 B1$=INKEY$:Z=Z+1:IFB1$=""ANDZ<120THEN29 ELSE PRINTB1$;:
  D=VAL(B1$)+10*VAL(A1$):IFA(I)*B(I)<100GOTO31
30 C1$=INKEY$:Z=Z+1:IFC1$=""AND Z<140THEN30 ELSE PRINTC1$;:
  D=VAL(C1$)+10*VAL(B1$)+100*VAL(A1$)
31 Z=0:PRINT:PRINTA(I);" X ";B(I);" = ";A(I)*B(I): RETURN
32 XL=10:XR=55:YT=25:YB=38'SETTING XR SETS LENGTH OF TIME
33 FORX=XLTOXR:FORY=YTTOYB:SET(X,Y):NEXTY,X:RETURN
34 DATA 6,10,8,4,11,8,6,5,11,2,4,5,3,2,5,5,9,4,7,5,2,2,7,2
35 DATA 9,10,5,8,6,6,12,8,7,7,3,7,12,7,2,4,3,9,9,7,4,4,9,9
36 DATA 3,6,10,7,3,3,11,4,6,4,5,2,9,6,11,7,12,3,9,5,3,10,9
37 DATA 8,8,10,10,10,7,8,12,6,11,5,6,2,8,8,2,10,11,6,12,4
38 DATA 11,9,5,10,7,6,12,2,4,10,4,7,4,3,12,12,9,2,12,9,2,8
39 DATA 8,6,12,10,11,11,12,5,10,11,3,8,5,3,12,11,11,3,5,12
```

```
1 CLEAR
2 'POWER DRILL 2 MULTIPLICATION DRILL BY BILL CAMIER
3 CLEAR 1000:DEFINT A-Z:DIMA(78),B(78)
4 CLS:PRINTCHR$(23)
5 PRINT"          DRILL 2"
6 PRINT"          *****":PRINT
7 PRINT "This is a MULTIPLICATION  DRILL and you should
      try and put the answers in as fast as possible.":PRINT
8 FOR I=1 TO 66: READ A(I),B(I): NEXT
9 PRINT "Enter your name here please "
10 INPUT N$
11 R= RND(66) : CLS : PRINTCHR$(23);
12 GOSUB 32
13 FOR I = R TO 66:GOSUB 16 :NEXT
14 FOR I = 1 TO R-1:GOSUB 16 :NEXT
15 GOTO 22
16 CLS:PRINTCHR$(23);
17 A1$=INKEY$
18 PRINT A(I)" X "B(I)" = ";
19 GOSUB 27 'SUB 27 IS FOR THE ANSWER
20 IF D=A(I)*B(I) THEN C=C+1 : GOSUB 32 : RETURN
21 IF D<>A(I)*B(I) THEN W=W+1:GOSUB32 :RETURN
22 CLS:PRINT:PRINTCHR$(23);"Drill 1 report for ";N$
23 PRINT:PRINT"You did ";C+W;" questions."
24 PRINT:PRINT"          and"
25 PRINT:PRINT"YOUR SCORE IS ";INT((C*100)/(C+W)+.5);" % "
26 END
27 A1$="":B1$="":C1$=""
28 A1$=INKEY$:Z=Z+1:IFA1$=""AND Z<280THEN28 ELSE PRINTA1$;;
  D=VAL(A1$):IFA(I)*B(I)<10GOTO31
29 B1$=INKEY$:Z=Z+1:IFB1$=""ANDZ<420THEN29 ELSE PRINTB1$;;
  D=VAL(B1$)+10*VAL(A1$):IFA(I)*B(I)<100GOTO31
30 C1$=INKEY$:Z=Z+1:IFC1$=""AND Z<640THEN30 ELSE PRINTC1$;;
  D=VAL(C1$)+10*VAL(B1$)+100*VAL(A1$)
31 Z=0:PRINT:PRINTA(I);" X ";B(I);" = ";A(I)*B(I): RETURN
32 XL=10:XR=55:YT=25:YB=38'SETTING XR SETS LENGTH OF TIME
33 FORX=XLTOXR:FORY=YBTOYB:SET(X,Y):NEXTY,X:RETURN
34 DATA 9,12,5,10,9,11,7,7,8,9,4,6,2,3,5,6,2,6,3,10,4,7
35 DATA 5,12,6,12,2,12,4,4,2,10,7,8,5,9,8,12,9,9,2,8,3,5
36 DATA 4,9,6,6,5,11,3,9,6,10,3,4,4,11,2,5,10,11,6,7,7,9
37 DATA 3,6,4,10,8,10,4,8,3,11,6,11,5,8,3,7,5,7,6,8,7,11,7
38 DATA 10,2,9,2,4,4,12,8,8,11,12,5,5,12,12,4,5,2,2,11,11
39 DATA 8,11,3,3,10,10,2,7,3,12,2,11,10,12,3,8,9,10,6,9
40 DATA 7,12
```



```
1 CLEAR
2 'POWER DRILL 2A MULTIPLICATION DRILL BY BILL CAMIER
3 CLEAR 1000:DEFINT A-Z:DIMA(78),B(78)
4 CLS:PRINTCHR$(23)
5 PRINT"          DRILL 2A"
6 PRINT"          *****":PRINT
7 PRINT "This is a MULTIPLICATION  DRILL and you should
      try and put the answers in as fast as possible.":PRINT
8 FOR I=1 TO 66: READ A(I),B(I): NEXT
9 PRINT "Enter your name here please "
10 INPUT N$
11 R= RND(66) : CLS : PRINTCHR$(23);
12 GOSUB 32
13 FOR I = R TO 66:GOSUB 16 :NEXT
14 FOR I = 1 TO R-1:GOSUB 16 :NEXT
15 GOTO 22
16 CLS:PRINTCHR$(23);
17 A1$=INKEY$
18 PRINT A(I)" X "B(I)" = ";
19 GOSUB 27 'SUB 27 IS FOR THE ANSWER
20 IF D=A(I)*B(I) THEN C=C+1 : GOSUB 32 : RETURN
21 IF D<>A(I)*B(I) THEN W=W+1:GOSUB32 :RETURN
22 CLS:PRINT:PRINTCHR$(23);"Drill 2B report for ";N$
23 PRINT:PRINT"You did ";C+W;" questions."
24 PRINT:PRINT"          and"
25 PRINT:PRINT"YOUR SCORE IS ";INT((C*100)/(C+W)+.5);" % "
26 END
27 A1$="":B1$="":C1$=""
28 A1$=INKEY$:Z=Z+1:IFA1$=""AND Z<280THEN28 ELSE PRINTA1$;:
  D=VAL(A1$):IFA(I)*B(I)<10GOTO31
29 B1$=INKEY$:Z=Z+1:IFB1$=""ANDZ<420THEN29 ELSE PRINTB1$;:
  D=VAL(B1$)+10*VAL(A1$):IFA(I)*B(I)<100GOTO31
30 C1$=INKEY$:Z=Z+1:IFC1$=""AND Z<640THEN30 ELSE PRINTC1$;:
  D=VAL(C1$)+10*VAL(B1$)+100*VAL(A1$)
31 Z=0:PRINT:PRINTA(I);" X ";B(I);" = ";A(I)*B(I): RETURN
32 XL=10:XR=55:YT=25:YB=38'SETTING XR SETS LENGTH OF TIME
33 FORX=XLTOXR:FORY=YTTOYB:SET(X,Y):NEXTY,X:RETURN
34 DATA 6,10,8,4,11,8,6,5,11,2,4,5,3,2,5,5,9,4,7,5,2,2,7,2
35 DATA 9,10,5,8,6,6,12,8,7,7,3,7,12,7,2,4,3,9,9,7,4,4,9,9
36 DATA 3,6,10,7,3,3,11,4,6,4,5,2,9,6,11,7,12,3,9,5,3,10,9
37 DATA 8,8,10,10,10,7,8,12,6,11,5,6,2,8,8,2,10,11,6,12,4
38 DATA 11,9,5,10,7,6,12,2,4,10,4,7,4,3,12,12,9,2,12,9,2,8
39 DATA 8,6,12,10,11,11,12,5,10,11,3,8,5,3,12,11,11,3,5,12
```

```
1 CLEAR
2 ' DRILL 3 MULTIPLICATION DRILL BY BILL CAMIER
3 CLEAR 1000:DEFINT A-Z:DIMA(78),B(78)
4 CLS:PRINTCHR$(23)
5 PRINT"          DRILL 3"
6 PRINT"          *****":PRINT
7 PRINT "This is a MULTIPLICATION  DRILL and you should
  try and put the answers in as fast as possible.":PRINT
8 FOR I=1 TO 66: READ A(I),B(I): NEXT
9 PRINT "Enter your name here please "
10 INPUT N$
11 R= RND(66) : CLS : PRINTCHR$(23);
12 FOR I = R TO 66:GOSUB 15 :NEXT
13 FOR I = 1 TO R-1:GOSUB 15 :NEXT
14 GOTO 20
15 CLS:PRINTCHR$(23);'PRINT QUESTION
16 PRINTA(I)" X "B(I)" = ";;INPUTD
17 PRINTA(I);" X ";B(I);" = ";A(I)*B(I):FOR J=1TO600:NEXTJ
18 IF D=A(I)*B(I) THEN C=C+1: RETURN
19 IF D<>A(I)*B(I) THEN W=W+1:RETURN
20 CLS:PRINT:PRINTCHR$(23);"Drill 3 report for ";N$
21 PRINT:PRINT"You did ";C+W;" questions."
22 PRINT:PRINT"          and"
23 PRINT:PRINT"YOUR SCORE IS ";INT((C*100)/(C+W)+.5);" % "
24 END
34 DATA 9,12,5,10,9,11,7,7,8,9,4,6,2,3,5,6,2,6,3,10,4,7
35 DATA 5,12,6,12,2,12,4,4,2,10,7,8,5,9,8,12,9,9,2,8,3,5
36 DATA 4,9,6,6,5,11,3,9,6,10,3,4,4,11,2,5,10,11,6,7,7,9
37 DATA 3,6,4,10,8,10,4,8,3,11,6,11,5,8,3,7,5,7,6,8,7,11,7
38 DATA 10,2,9,2,4,4,12,8,8,11,12,5,5,12,12,4,5,2,2,11,11
39 DATA 8,11,3,3,10,10,2,7,3,12,2,11,10,12,3,8,9,10,6,9
40 DATA 7,12
```

```
1 CLEAR
2 ' DRILL 3A MULTIPLICATION DRILL BY BILL CAMIER
3 CLEAR 1000:DEFINT A-Z:DIMA(78),B(78)
4 CLS:PRINTCHR$(23)
5 PRINT"          DRILL 3A"
6 PRINT"          *****":PRINT
7 PRINT "This is a MULTIPLICATION DRILL and you should
try and put the answers in as fast as possible.":PRINT
8 FOR I=1 TO 66: READ A(I),B(I): NEXT
9 PRINT "Enter your name here please "
10 INPUT N$
11 R= RND(66) : CLS : PRINTCHR$(23);
12 FOR I = R TO 66:GOSUB 15 :NEXT
13 FOR I = 1 TO R-1:GOSUB 15 :NEXT
14 GOTO 20
15 CLS:PRINTCHR$(23);'PRINT QUESTION
16 PRINTA(I)" X "B(I)" = ";;INPUTD
17 PRINTA(I);" X ";B(I);" = ";A(I)*B(I):FOR J=1TO600:NEXTJ
18 IF D=A(I)*B(I) THEN C=C+1: RETURN
19 IF D<>A(I)*B(I) THEN W=W+1:RETURN
20 CLS:PRINT:PRINTCHR$(23);"Drill 3A report for ";N$
21 PRINT:PRINT"You did ";C+W;" questions."
22 PRINT:PRINT"          and"
23 PRINT:PRINT"YOUR SCORE IS ";INT((C*100)/(C+W)+.5);" % "
24 END
25 DATA 6,10,8,4,11,8,6,5,11,2,4,5,3,2,5,5,9,4,7,5,2,2,7,2
26 DATA 9,10,5,8,6,6,12,8,7,7,3,7,12,7,2,4,3,9,9,7,4,4,9,9
27 DATA 3,6,10,7,3,3,11,4,6,4,5,2,9,6,11,7,12,3,9,5,3,10,9
28 DATA 8,8,10,10,10,7,8,12,6,11,5,6,2,8,8,2,10,11,6,12,4
29 DATA 11,9,5,10,7,6,12,2,4,10,4,7,4,3,12,12,9,2,12,9,2,8
30 DATA 8,6,12,10,11,11,12,5,10,11,3,8,5,3,12,11,11,3,5,12
```

```
1 CLEAR
2 'POSTTEST FOR POWER MULTIPLICATION DRILL BY BILL CAMIER
3 CLEAR 1000:DEFINT A-Z:DIMA(78),B(78)
4 CLS:PRINTCHR$(23)
5 PRINT"          POSTTEST"
6 PRINT"          *****":PRINT
7 PRINT "This is a MULTIPLICATION  DRILL and you should
      try and put the answers in as fast as possible.":PRINT
8 FOR I=1 TO 66: READ A(I),B(I): NEXT
9 PRINT "Enter your name here please "
10 INPUT N$
11 R= RND(66) : CLS : PRINTCHR$(23)
12 GOSUB 32
13 FOR I = R TO 66:GOSUB 16      :NEXT
14 FOR I = 1 TO R-1:GOSUB 16      :NEXT
15 GOTO 22
16 CLS:PRINTCHR$(23)
17 A1$=INKEY$
18 PRINT A(I)" X "B(I)" = ";
19 GOSUB 27      'SUB 290 IS FOR THE ANSWER
20 IF D=A(I)*B(I) THEN C=C+1 : GOSUB 32      : RETURN
21 IF D<>A(I)*B(I) THEN W=W+1:GOSUB32      :RETURN
22 CLS:PRINT:PRINTCHR$(23);"Report for ";N$
23 PRINT:PRINT"You did ";C+W;" questions."
24 PRINT:PRINT"          and"
25 PRINT:PRINT"YOUR SCORE IS ";INT((C*100)/(C+W)+.5);" % "
26 END
27 A1$="":B1$="":C1$=""
28 A1$=INKEY$:Z=Z+1:IFA1$=""AND Z<80THEN28 ELSE PRINTA1$;:
D=VAL(A1$):IFA(I)*B(I)<10GOTO31
29 B1$=INKEY$:Z=Z+1:IFB1$=""ANDZ<120THEN29 ELSE PRINTB1$;:
D=VAL(B1$)+10*VAL(A1$):IFA(I)*B(I)<100GOTO31
30 C1$=INKEY$:Z=Z+1:IFC1$=""AND Z<140THEN30 ELSE PRINTC1$;:
D=VAL(C1$)+10*VAL(B1$)+100*VAL(A1$)
31 Z=0:CLS:PRINTCHR$(23);:RETURN
32 XL=10:XR=55:YT=25:YB=38'SETTING XR SETS LENGTH OF TIME
33 FORX=XLTOXR:FORY=YBTOYB:SET(X,Y):NEXTY,X:RETURN
34 DATA 9,12,5,10,9,11,7,7,8,9,4,6,2,3,5,6,2,6,3,10,4,7
35 DATA 5,12,6,12,2,12,4,4,2,10,7,8,5,9,8,12,9,9,2,8,3,5
36 DATA 4,9,6,6,5,11,3,9,6,10,3,4,4,11,2,5,10,11,6,7,7,9
37 DATA 3,6,4,10,8,10,4,8,3,11,6,11,5,8,3,7,5,7,6,8,7,11,7
38 DATA 10,2,9,2,4,4,12,8,8,11,12,5,5,12,12,4,5,2,2,11,11
39 DATA 8,11,3,3,10,10,2,7,3,12,2,11,10,12,3,8,9,10,6,9
40 DATA 7,12
```

```
1 CLEAR
2 'RETENTION TEST FOR MULTIPLICATION DRILLS BY BILL CAMIER
3 CLEAR 1000:DEFINT A-Z:DIMA(78),B(78)
4 CLS:PRINTCHR$(23)
5 PRINT"      RETENTION TEST"
6 PRINT"      *****":PRINT
7 PRINT "This is a MULTIPLICATION    DRILL and you should
      try and put the answers in as fast as possible.":PRINT
8 FOR I=1 TO 66: READ A(I),B(I): NEXT
9 PRINT "Enter your name here please "
10 INPUT N$
11 R= RND(66) : CLS : PRINTCHR$(23)
12 GOSUB 32
13 FOR I = R TO 66:GOSUB 16    :NEXT
14 FOR I = 1 TO R-1:GOSUB 16    :NEXT
15 GOTO 22
16 CLS:PRINTCHR$(23)
17 A1$=INKEY$
18 PRINT A(I)" X "B(I)" = ";
19 GOSUB 27 'SUB 290 IS FOR THE ANSWER
20 IF D=A(I)*B(I) THEN C=C+1 : GOSUB 32    : RETURN
21 IF D<>A(I)*B(I) THEN W=W+1:GOSUB32    :RETURN
22 CLS:PRINT:PRINTCHR$(23);"POST-TEST 1 report for ";N$
23 PRINT:PRINT"You did ";C+W;" questions."
24 PRINT:PRINT"      and"
25 PRINT:PRINT"YOUR SCORE IS ";INT((C*100)/(C+W)+.5);" % "
26 END
27 A1$="":B1$="":C1$=""
28 A1$=INKEY$:Z=Z+1:IFA1$=""AND Z<80THEN28    ELSE PRINTA1$;
      :D=VAL(A1$):IFA(I)*B(I)<10GOTO31
29 B1$=INKEY$:Z=Z+1:IFB1$=""ANDZ<120THEN29    ELSE PRINTB1$;
      :D=VAL(B1$)+10*VAL(A1$):IFA(I)*B(I)<100GOTO31
30 C1$=INKEY$:Z=Z+1:IFC1$=""AND Z<140THEN30 ELSE PRINTC1$;
      :D=VAL(C1$)+10*VAL(B1$)+100*VAL(A1$)
31 Z=0:CLS:PRINTCHR$(23);:RETURN
32 XL=10:XR=55:YT=25:YB=38'SETTING XR SETS LENGTH OF TIME
33 FORX=XLTOXR:FORY=YTTOYB:SET(X,Y):NEXTY,X:RETURN
34 DATA 9,12,5,10,9,11,7,7,8,9,4,6,2,3,5,6,2,6,3,10,4,7
35 DATA 5,12,6,12,2,12,4,4,2,10,7,8,5,9,8,12,9,9,2,8,3,5
36 DATA 4,9,6,6,5,11,3,9,6,10,3,4,4,11,2,5,10,11,6,7,7,9
37 DATA 3,6,4,10,8,10,4,8,3,11,6,11,5,8,3,7,5,7,6,8,7,11,7
38 DATA 10,2,9,2,4,4,12,8,8,11,12,5,5,12,12,4,5,2,2,11,11
39 DATA 8,11,3,3,10,10,2,7,3,12,2,11,10,12,3,8,9,10,6,9
40 DATA 7,12
```

APPENDIX B

SAMPLE RUN OF A DRILL PROGRAM (TREATMENT)

APPENDIX B
Sample run of DRILL 1A - Treatment Session

Instructional notes: the program takes approximately ten minutes to run. Because this is a simulation of a run it is necessary to give a "####" to indicate clearing of the video screen and a "*****" indicates a box being painted in. This box is a timer which gives the student a break between each number fact and allows the correct answer to be reinforced. The painting in of the box on the screen also directs attention to the next number fact coming up.

Program begins.####

DRILL 1A

This is a MULTIPLICATION DRILL and you should try and put the answers in as fast as possible.

Enter your name here please?.....JOE

####

####

3 X 7 =?..27

3 X 7 = 21

####

12 X 7 =? ...84

12 X 7 = 84

####

2 X 4 =?..8

2 X 4 = 8

####

3 X 9 =?..27

3 X 9 = 27

####

9 X 7 =?...

9 X 7 = 63

####

.... " writers note the program carries on in this fashion until 66 multiplication facts in total have been presented."

7 X 7 = 49

####

Drill 1A report for JOE

You did 66 questions

and

Your score is 47 %

READY

APPENDIX C

SAMPLE RUN OF PRETEST, POSTTEST, AND RETENTION TEST

APPENDIX C

Sample run of Pretest, Posttest, and Retention Test

Instructional notes: the program takes approximately ten minutes to run. Because this is a simulation of a run it is necessary to give a "####" to indicate clearing of the video screen and a "*****" indicates a box being painted in. This box is a timer which gives the student a break between each number fact and the painting in of the box on the screen also directs attention to the next number fact coming up.

Program begins.####

PRETEST

This is a MULTIPLICATION DRILL and you should try and put in the answers as fast as possible.

Enter your name here please?...BILL JONES

5 X 10 =?..5

9 X 11 =?..99

7 X 7 =?..49

8 X 9 =?..8

4 X 6 =?..24

2 X 3 =?..6

.... " writers note the program carries on in this fashion until 66 multiplication facts in total have been presented."

Report for BILL JONES
You did 66 questions
and
Your score is 71 %
READY

APPENDIX D

STUDENT'S SCORES WITH MEANS AND CORRELATION OF TEST SCORES

STUDENT'S SCORES WITH MEANS

Student:		Session (treatments) Marks										: Tests		
Number		1	2	3	4	5	6	7	8	9	10	Pre	Post	Rt'n
a1 2.5 sec Grp	2	73	70	76	76	83	77	74	77	85	82	63	83	76
	3	42	61	62	56	65	62	71	70	61	84	21	68	53
	4	67	74	67	76	73	62	85	86	86	88	62	85	77
	5	47	48	53	58	67	53	64	65	71	76	48	64	58
	12	28	23	36	34	36	42	48	50	58	65	18	59	50
	15	41	44	56	66	58	56	70	68	65	76	45	76	62
	17	36	58	73	68	76	68	76	83	83	92	53	83	83
	18	56	63	73	74	67	74	62	74	76	89	44	85	74
	20	44	53	71	68	77	79	55	79	88	89	47	80	68
Means		48	55	63	64	67	64	67	72	75	82	45	76	68
a2 6.0 sec Grp	1	64	68	67	67	70	74	79	85	80	76	39	45	35
	6	92	95	97	100	97	92	84	94	95	97	27	70	71
	7	80	91	91	88	97	89	88	97	94	94	45	71	50
	19	85	85	86	85	89	83	88	85	88	88	47	65	62
	21	89	86	91	89	98	95	97	98	92	98	52	61	62
	22	97	100	98	95	97	100	97	100	98	98	56	82	65
	23	77	86	89	85	91	89	95	95	91	95	32	50	48
	25	71	71	74	70	82	80	79	80	83	100	44	62	44
Means		82	85	87	85	90	88	88	92	90	93	43	63	55
a3 open Grp	8	100	100	100	100	98	100	100	100	100	100	61	80	85
	9	94	98	94	98	98	100	97	95	100	100	58	80	71
	10	94	100	95	100	100	98	98	98	100	100	59	85	82
	11	92	94	94	94	97	95	97	98	100	100	55	70	61
	13	85	79	86	85	86	91	91	83	86	82	20	55	44
	14	97	98	97	97	100	100	98	100	98	98	58	74	65
	16	89	91	94	88	97	88	88	89	92	89	18	48	27
	24	98	100	100	98	97	98	100	98	100	100	39	74	55
Means		94	95	95	95	97	96	96	95	97	96	46	71	61

CORRELATION OF STUDENT'S TEST SCORES

VARIABLE X Pretest	VARIABLE Y Posttest	PREDICTED Y FROM X
63	83	81.0
21	68	56.5
62	85	80.4
48	64	72.3
18	59	54.8
45	76	70.5
53	83	75.2
44	85	69.9
47	80	71.7
39	45	67.0
27	70	60.0
45	71	70.5
47	65	71.7
52	61	74.6
56	82	76.9
32	50	62.9
44	62	69.9
61	80	79.9
58	80	78.1
59	85	78.7
55	70	76.4
20	55	55.9
58	74	78.1
18	48	54.8
39	74	67.0

Mean of X = 44.44 Mean of Y 70.2
 S.D of X = 14.1027 S.D of Y = 11.9834
 Number of pairs (n) = 25
 Correlation coefficient (r) = .687 **
 * P < .05 r critical = .396
 ** P < .01 r critical = .505
 Degrees of Freedom (df) = 23
 Slope (M) of regression line = .583607
 Y intercept (B) for the line = 44.2645

VARIABLE X Pretest	VARIABLE Y Retention Test	PREDICTED Y FROM X
63	76	74.8
21	53	43.9
62	77	74.0
48	58	63.7
18	50	41.7
45	62	61.5
53	83	67.4
44	74	60.8
47	68	63.0
39	35	57.1
27	71	48.3
45	50	61.5
47	62	63.0
52	62	66.7
56	65	69.1
32	48	52.0
44	44	60.8
61	85	73.3
58	71	71.0
59	82	71.8
55	61	68.9
20	44	43.2
58	65	71.0
18	27	41.7
39	55	57.1

Mean of X = 44.44 Mean of Y 61.12
S.D of X = 14.1027 S.D of Y = 14.6487
Number of pairs (N) = 25
Correlation coefficient (R) = .707 **
* P < .05 r critical = .396
** P < .01 r critical = .505
Degrees of Freedom (DF) = 23
Slope (M) of regression line = .735026
Y intercept (B) for the line = 28.4554

VARIABLE X	VARIABLE Y	
Posttest	Retention Test	PREDICTED Y FROM X
83	76	74.9
68	53	58.8
85	77	77.0
64	58	54.4
59	50	49.0
76	62	67.4
83	83	74.9
85	74	77.1
80	68	71.7
45	35	34.0
70	71	60.9
71	50	62.0
65	62	55.5
61	62	51.2
82	65	73.8
50	48	39.4
62	44	52.3
80	85	71.7
80	71	71.7
85	82	77.0
70	61	60.9
55	44	44.8
74	65	65.2
48	27	37.2
74	55	65.2

Mean of X = 70.2 Mean of Y = 61.12
 S.D of X = 11.9833 S.D of Y = 14.6487
 Number of pairs (N) = 25
 Correlation coefficient (R) = .881 **
 * P < .05 r critical = .396
 ** P < .01 r critical = .505
 Degrees of Freedom (DF) = 23
 Slope (M) of regression line = 1.07672
 Y intercept (B) for the line = -14.4656

APPENDIX E
SUMMARY TABLE OF STUDIES THAT INVOLVE C.A.L.
IN MATHEMATICS

Fiorentino's Table of Studies that involve C.A.L. in Mathematics

STUDY	MODE	SUBJECT, GRADE, LEVEL, and 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)*EMR+
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,*EMR, +
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.H. refers to educatable mentally retarded children

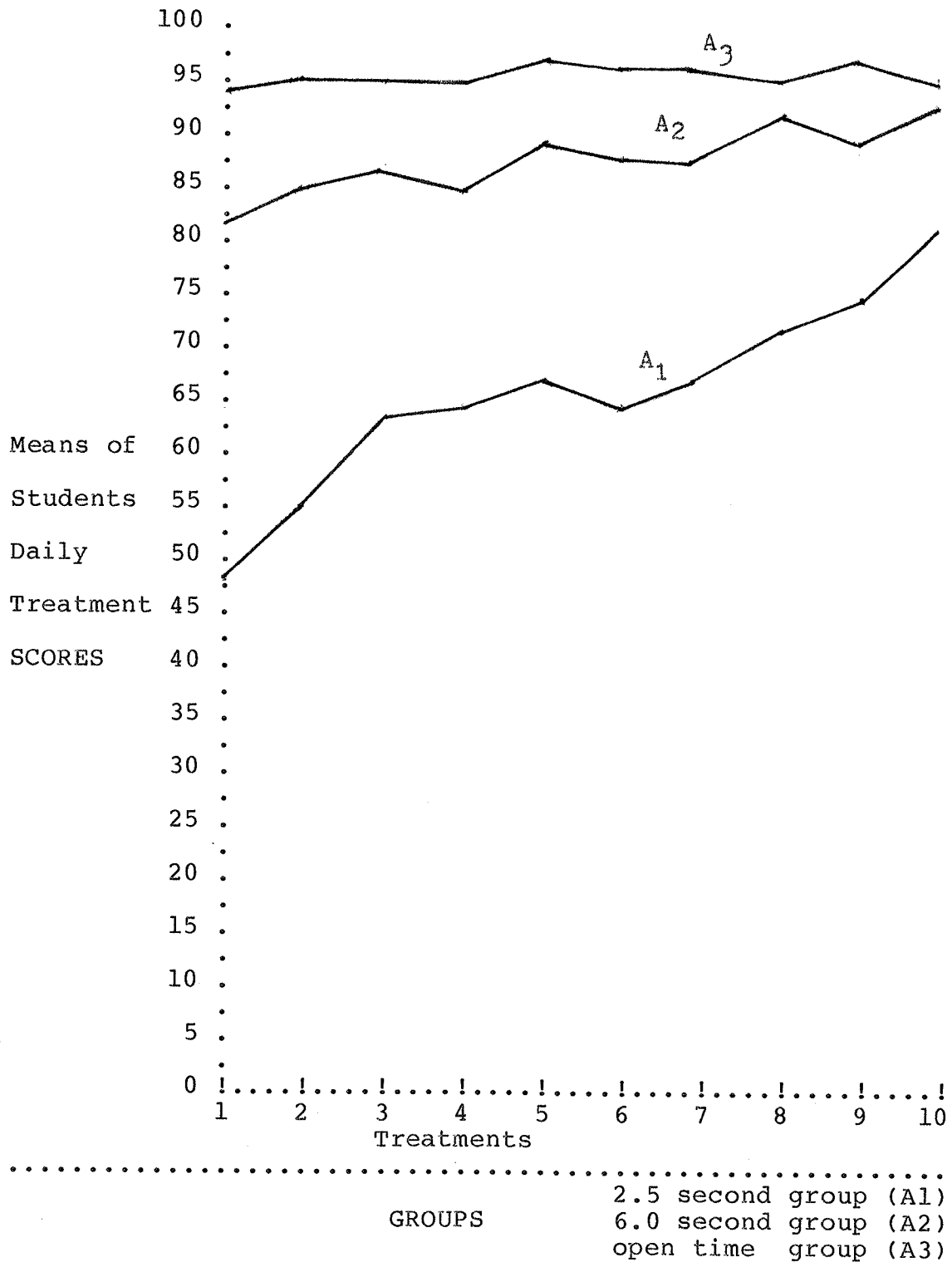
** In this and subsequent tables a "+" indicates that the CAL students achieved better than the non-CAL. "-" indicates that CAL students did less well, while "=" indicates the same level of achievement.

APPENDIX F

TABLE OF MEANS OF GROUPS DAILY TREATMENT SCORES

Figure Three

Means of Groups Daily Treatment Scores



APPENDIX G

INDIVIDUAL TEST PERFORMANCES FOR STUDENTS

FIGURE Four Individual Test Performances of Students
Plotted over Time for the 2.5 Second Group.

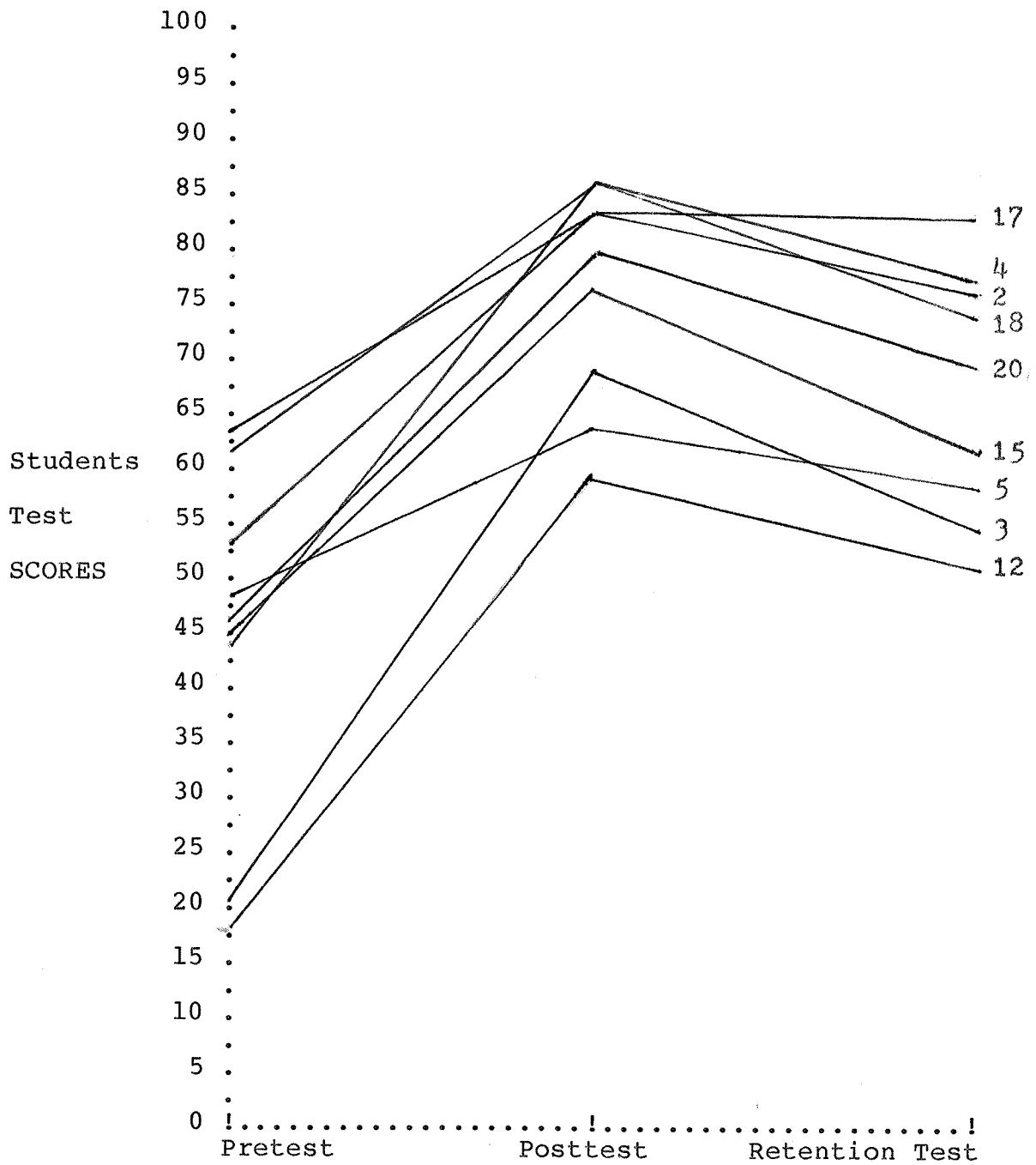


FIGURE Five Individual Test Performances of Students
Plotted over Time for the 6.0 Second Group

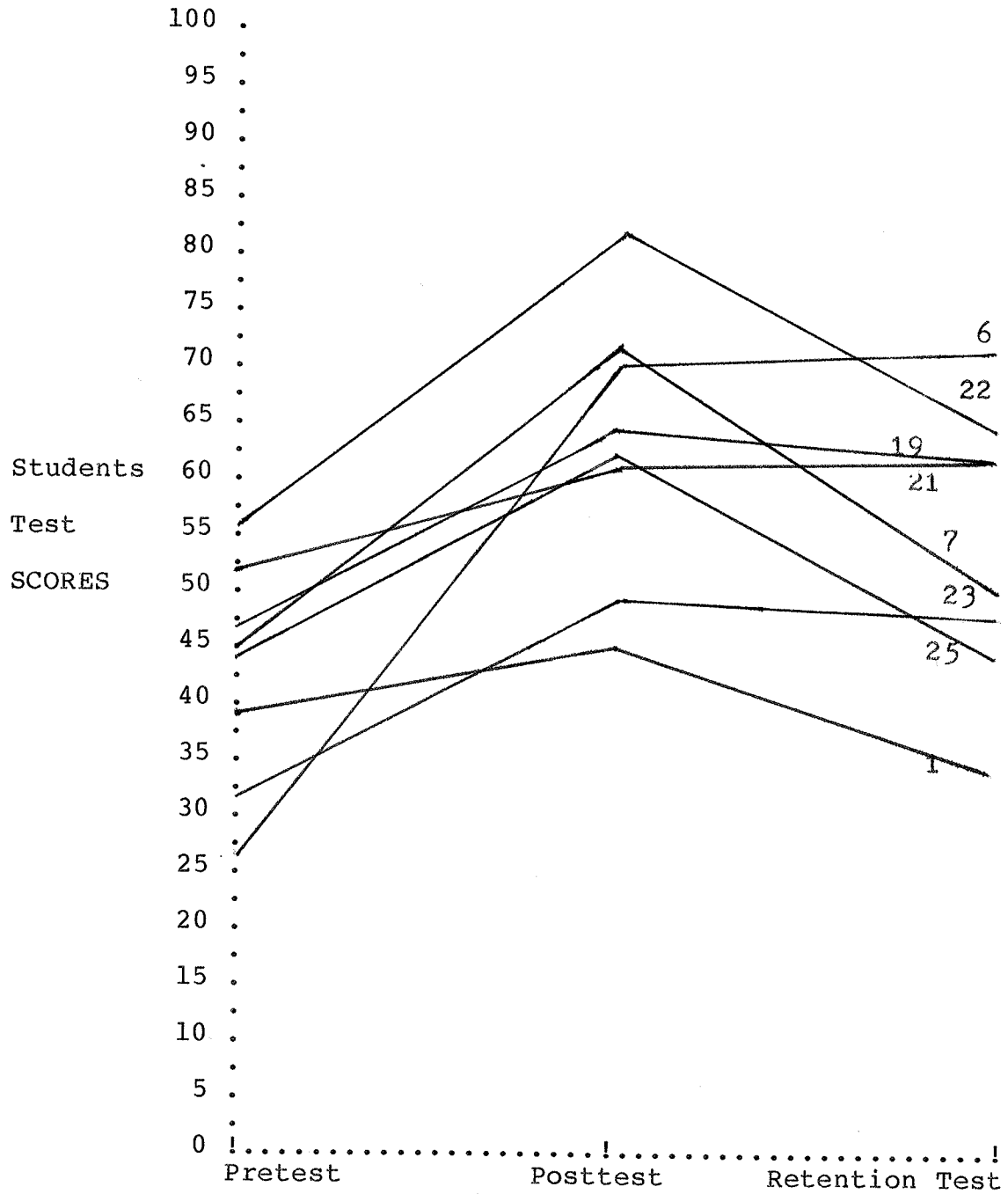


FIGURE Six Individual Test Performances of Students
Plotted over Time for the Open Group

