THE UNIVERSITY OF MANITOBA

COMPARING THE EFFECTIVENESS OF TWO METHODS OF DRILL AND PRACTICE IN JUNIOR HIGH MATHEMATICS: COMPUTERIZED PROGRAMS AND WORKSHEETS

A THESIS SUBMITTED TO THE FACULTY OF GRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF EDUCATION.

by

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A dissertation submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

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ABSTRACT

The purpose of this study was to compare the effectiveness of two methods of Drill and Practice procedures. The methods tested were:

a) Worksheets

b) Computerized Drill and Practice Programs.

The students involved in this project were enrolled in Grade Seven at West St. Paul School in Winnipeg. All subjects, on the basis of their past performance and the pre test, were considered below average in mathematical ability. A total of 24 students were divided randomly into two matched groups. Both groups received regular classroom instruction supplemented by 10 minutes, per day, of drill exercises in the mode designated for the group. During the month of October, 1975, both groups completed a program dealing with:

a) Multiplication of Integers,

b) Multiplication of Decimals,

c) Division of Integers,

d) Division of Decimals.

The instrument employed for the pretest (before the commencement of the project), posttest (immediately after the completion of the taught topic) and the retention-test (after the Christmas recess) was the Brueckner Diagnostic Test and the test on Multiplication of Decimals devised by the author.

Matrix of Intercorrelations and 2X3 Analysis of

Variance for Repeated Measures were used to analyse the data.

The analysis indicated that there was no significant difference between the two groups.

ACKNOWLEDGEMENTS

I would like to express my appreciation and thanks to the principal, A.D. Sutton and staff of West St. Paul School without whose co-operation this project would have been impossible to conduct.

I would like to thank the members of my thesis committee Dr. Lars Jansson, Dr. Lauren Sandals and Prof. A.M. McPherson for their invaluable help and guidance during my research and writing of this thesis.

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CHAPTER I

INTRODUCTION

The objective of this study was to compare, at a grade seven level, the effectiveness of two methods of reinforcement of a learned mathematics material. The two methods being compared were: a) Worksheets

b) Computer directed Drill and Practice programs.

The author's interest in this field stems from the fact that in the present educational system, a considerable portion of the total class time in mathematics is devoted to drill. It may be considered a "necessary evil." Much of the time, neither teachers nor pupils enjoy this repetitious task, however, it must be done in order to achieve any degree of mastery of the material. Any innovation leading to improvement of the presently used methods is bound to be welcomed by all parties involved.

There are a number of reasons why the author has chosen worksheets and computer directed Drill and Practice programs as the focus of his study. The first method is probably the most frequently used. The second type holds promise for the future. It seems logical that computers, which in a relatively short period of time have invaded practically all facets of our life, will sooner or later make an impact on our educational system.

The author's main interest lies in Computer Assisted Instruction(CAI). He is convinced that this is the method of the near future.

Governments and private businesses have invested too much time and money in educational research and materials to let the whole field of CAI slip into oblivion. For example, International Business Machines (IBM) developed a student terminal which allows the student to receive audio messages and slide projections, in addition to teletype or Cathode Ray Tube (CRT) output. Mitre Corporation developed a system which, for relatively low cost of $450,000, (1972), offers a complete computer system serving 128 interactive student terminals (included in the price). There is a good possibility that this price will go even lower. Science Research Associates (SRA), a company specializing in production of educational materials, invested hundreds of thousands of dollars in the Arithmetic Proficiency Training Program which is currently available for rent (Krotochvil, 1972). Ford Foundation, as early as 1964, started providing financial assistance to projects involving computers in education. In the following six years as much as $1,090,000 had been spent by the foundation for that purpose. Universities and colleges across the United States and Canada for some time have been involved in research dealing with CAI and have obtained many dramatic and encouraging results.

The above mentioned are only some of the examples which imply that the Computer Directed Drill and Practice programs hold a great promise for the future, and which prompted the author to do research in this field.

In this study the author has tried to answer the following questions:

1) Are Computerized Drill and Practice programs as effective as worksheets?

2) Can we, in Manitoba, with our present resources duplicate some of the positive results obtained in the United States?

3) Is it possible to conduct meaningful CAI at a ratio of ten students to one computer terminal?

4) Does the mode of drill exercises have any bearing on the retention of the taught material?

Definitions of Terms

For the purpose of this study, the following definitions will be used:

1) Interactive Terminal - An Input/Output device linked directly to a computer via a telephone line or coaxial cable. The input on such a device is achieved through a teletype keyboard and the output is obtained on an electrical typewriter or CRT.

2) Datacom 100 - A type of interactive terminal in the form of a teletype.

3) Portacom - A brand name of a portable interactive terminal.

4) Drill and Practice Program - Self-governing computer program providing problems to be solved for the purpose of reinforcement of learned material.

5) Worksheets - Sheets of paper with a number of problems pertaining to a given topic used for reinforcement and practice of learned material.

6) Achievement - A numerical score obtained on a given test, in this case Brueckner Diagnostic Test and the test on Multiplication of Decimals developed by the author.

Summary

There is little doubt in the author's mind that the great technological advances being made continuously in the field of electronics are bound to, sooner or later, affect the process of education. When this happens, new methods will supplement, or even replace, old procedures.

This line of reasoning led the author to attempt to compare the effectiveness of an old and tried method, of drilling students in new material, such as worksheets, with a relatively new way such as computer assisted drill exercises.

The questions which the author tried to answer were:
1) how effective are the computerized drill and practice exercises compared to worksheets?
2) are we in Manitoba capable of providing our students, at the present time, with effective computer assisted drill and practice exercises?

The procedures followed and the results obtained in this project are stated in chapter three and four of this thesis. In chapter five the author discusses his findings and gives recommendations for the future considerations.

Chapter two presents the results of some of the published empirical research, performed at various universities and colleges in Canada, England and the United States.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Since the introduction of computers into the field of education in 1950's, scores of researchers have written reports on aspects of this relationship. The primary purpose of this chapter is to provide an uninitiated educator with some insights into the realm of Computer Assisted Instruction with respect to the following four areas:

1) Why CAI?

2) How is the computer used in CAI?

3) The opposition to and support of CAI.

4) Results of some projects conducted in CAI.

Why CAI?

Every year, more and more schools in Canada and the United States turn to computers for administrative and instructional purposes. How does one explain this trend in view of the relatively high cost of implementation and maintenance of a computer system? O'Neil and Pytlik (1972) list a number of reasons which cast some light on this phenomenon:

1) Computers make it possible to offer individualized instruction to a large number of students simultaneously. Consequently the student may work much more nearly at his own pace than in regular classroom.

2) Much of the teacher's routine classroom work such as

drilling, reviewing, and presenting straight forward material can be transferred to the computer.

3) Once an instructional program has been developed it can be used by many students and for many years.

4) Computers can continuously record and provide information on the achievement and progress of any student proceeding through a CAI course.

5) Since each student works individually, he feels free to make mistakes without fear of public embarrassment.

6) Correcting mistakes and misconceptions immediately after a student has made them reinforces and improves a student's learning process.

7) The computer is impartial and consistent - it has no favourites. It never becomes impatient with a student's lack of progress.

Atkinson and Wilson (1972, pp. 3-4) cite some factors which explain why this trend is more noticable in recent years. These are:

a) Great strides made by electronic technology reflected in better, more compact and cheaper computer systems.

b) Greater emphasis on individualization of instruction resulting in increased development of programmed instruction.

c) Increased financial aid to educational research from various levels of government and private foundations.

A good example of a project which in a very short time developed from a "humble" beginning to a gigantic operation is the system developed at the University of Illinois (Layman, May 1970). The objectives of this undertaking were:

1) To investigate the potential of CAI,

2) To design an economically viable system.

The project called PLATO I began in June, 1960 with a single station. In January, 1961 the second version (PLATO II) had already two terminals and in March of the same year the first remote terminal, located 30 miles from the computer, was used. The spring of 1961 saw implementation of the first instructional programs (French and Mathematics). When in fall of 1963 the third stage of PLATO went into operation, 32 stations were possible, this number grew to 100 by 1964. Late in 1964, the system was improved to allow on-line editing of programs. This meant that it was possible to upgrade a lesson while it was, actually, being used. The first complete college course was available on PLATO in fall of 1965. A grant from the National Science Foundation, received in March 1968, gave impetus to the fourth edition of the system (PLATO IV). The projected number of stations possible in this system was 4,096. The distance from the computer centre, at which those stations could be placed, grew from 30 to 150 miles.

In approximately 10 years, the PLATO project developed from a single station system to a network of over 1000 terminals. The number of instructional programs grew from two, in 1961, to 900 in 1970 and now encompasses such varied subjects as: Biology, Chemistry, Computer Science, Demography, Engineering, French, Chinese, English, Latin, Japanese, Russian, Spanish, Political Science, Mathematics, Physics and Experimental Psychology, to mention only some.

Kearsley (1976) in his study of CAI, found that there were 1837 programs in 137 subjects originating from 219 sources. These programs were written in 76 author languages and were controlled by 116 types of central processors. In duration these programs ranged from a few minutes to 695 (U.S. Army program) hours. Figures 1,2 and 3 represent a brief graphical summary of some of Kearsley's findings.

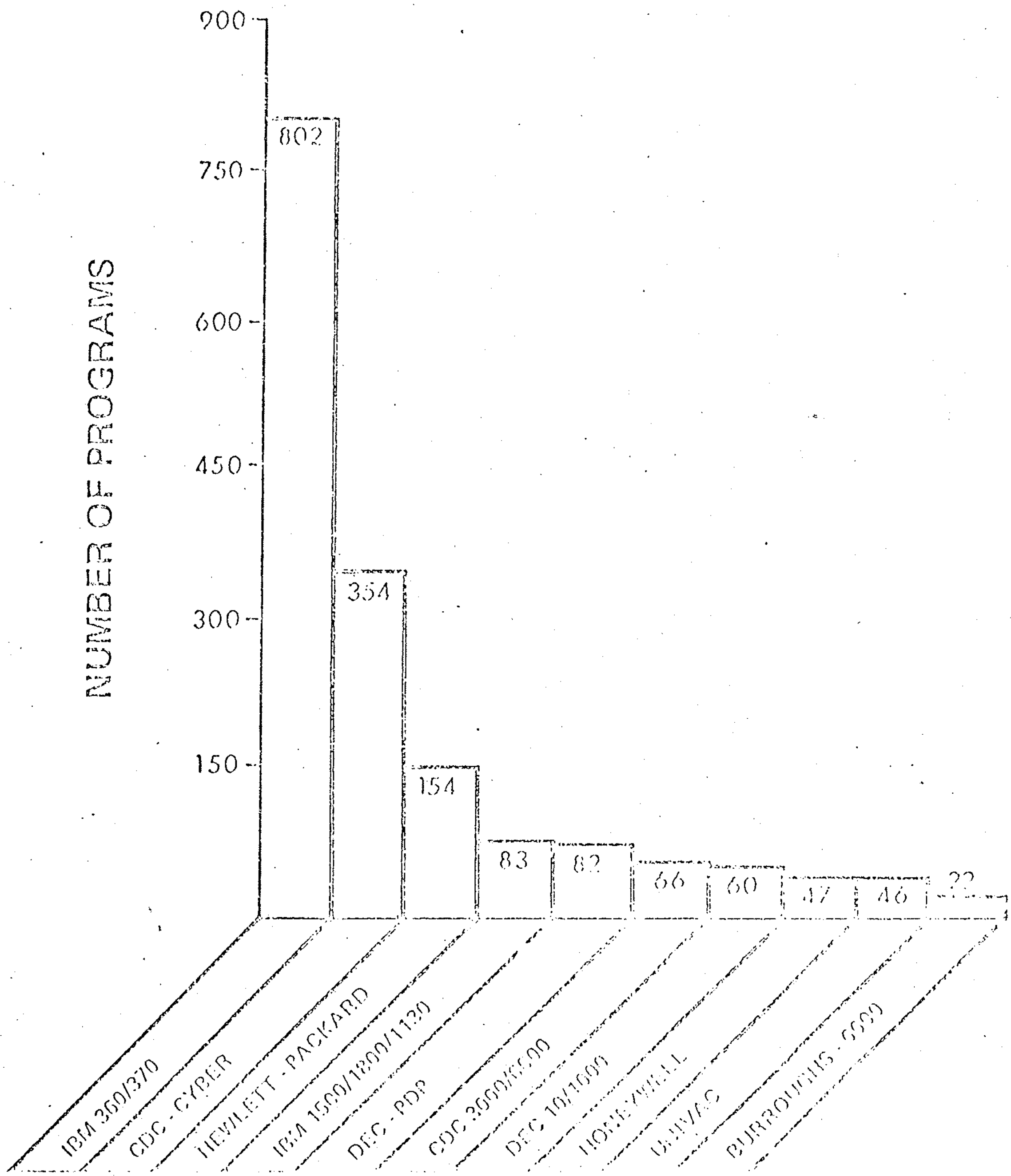
There is an indication of increased Computer Based Education (CBE) activity in the developing nations as shown by the growing number of their delegates present at conferences dealing with this topic (Kearsley, 1976). Table 1, lists the countries, and the number of their delegates present at the conference, dealing with computers in education, held in Marseilles in 1975.

How Are Computers Used In CAI?

There seems to be a general agreement, among the participants in CAI, that all computer programs will fall into one of the following categories, "instructional modes" as they are sometimes called (Stolurow, 1972):

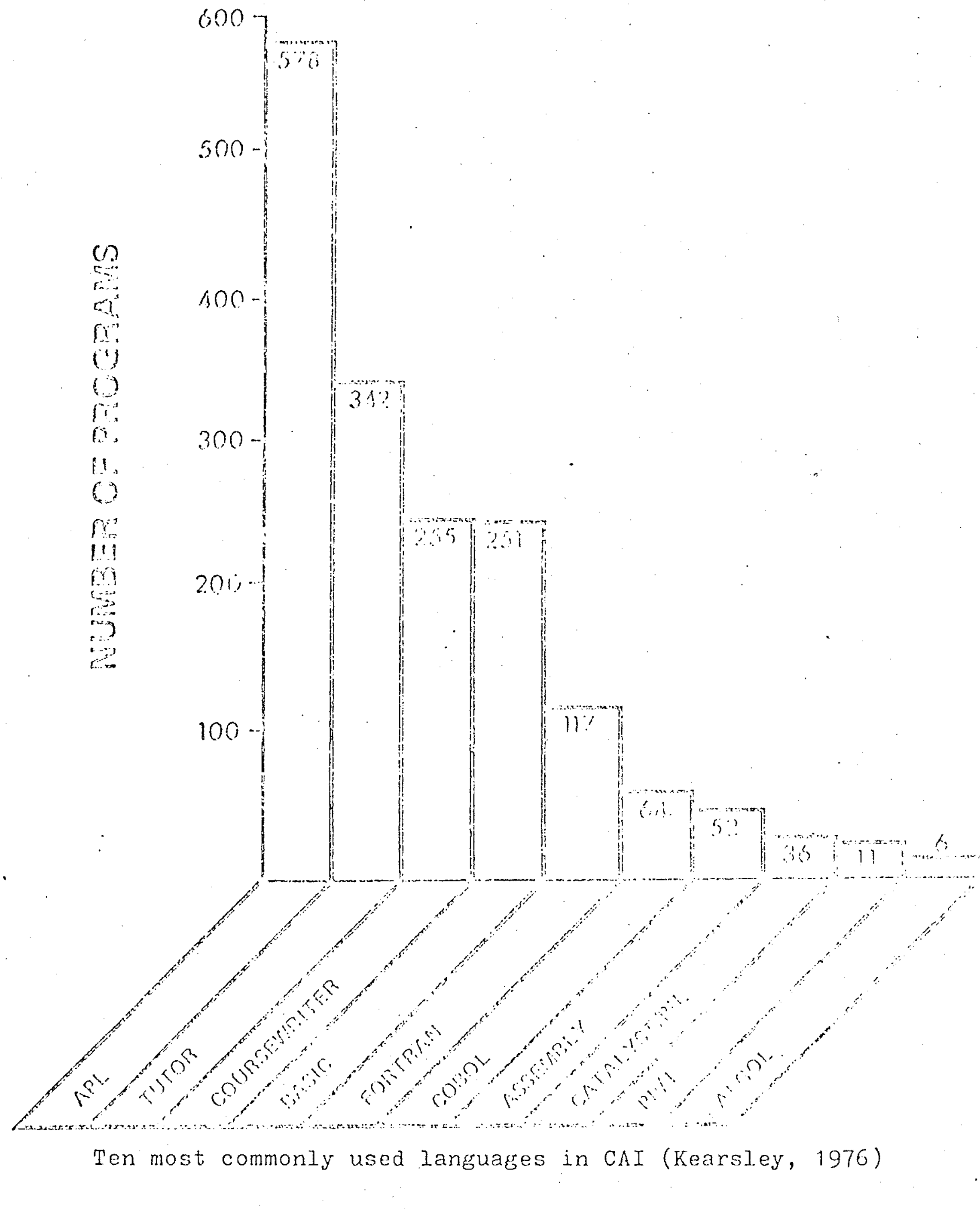
a)Problem Solving,

Figure 1



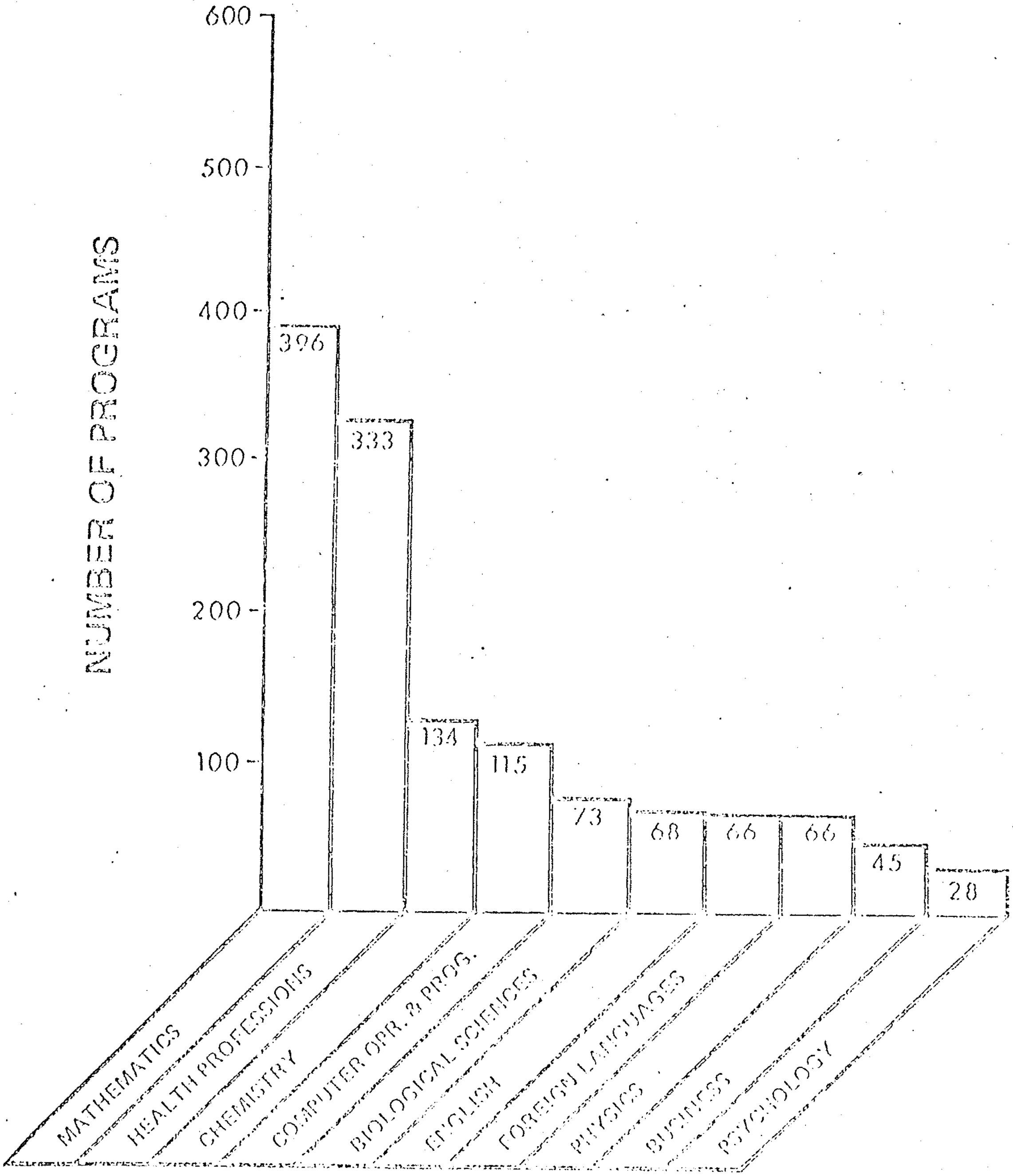
Ten most frequently used Central Processors (Kearsley, 1976)

Figure 2



Ten most commonly used languages in CAI (Kearsley, 1976)

Figure 3



Subjects in which computers are used for instructional purposes most frequently (Kearsley, 1976)

b) Simulation and Games,

c) Drill and Practice,

d) Tutorial,

e) Inquiry or Dialogue.

However, some educators consider combinations or variations of the above categories as separate modes and arrive at a higher number. Figure 4, lists ten of the seventeen modes identified by Kearsley (1976) in his research about CAI.

Other researchers (O'Neil and Pytlik), although they accept the five previously mentioned categories, subdivide them into two groups according to the way the computer is being used. These two categories are:

1) Programs where the computer serves as an aid to instruction.

2) Programs in which the computer assists instruction.

The first set includes such modes as:

a) Problem Solving,

b) Simulation and Gaming.

In the second category we find:

a) Drill and Practice,

b) Tutorial,

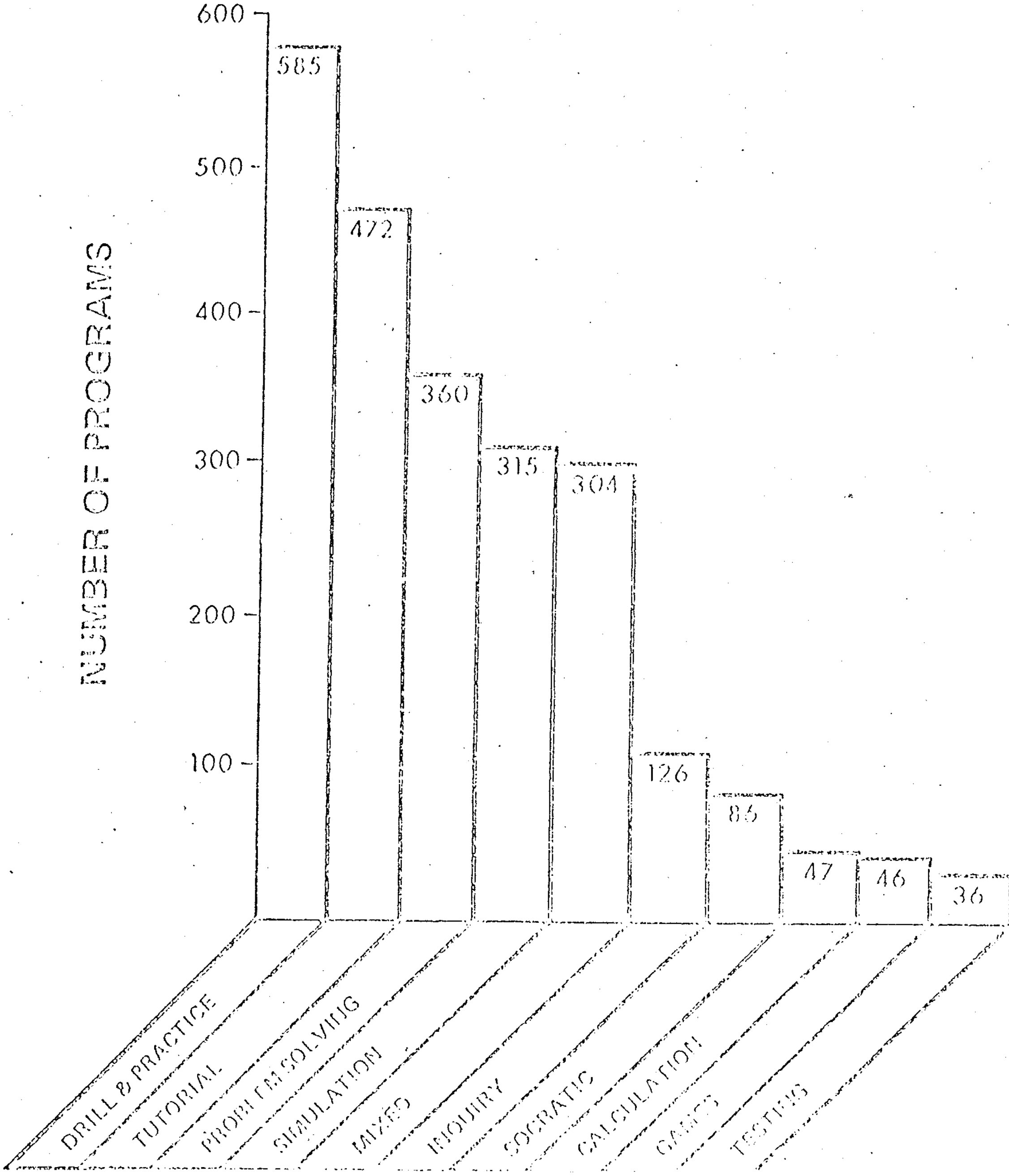
c) Inquiry or Dialogue.

In the following section the author will attempt to give a brief description of each of the before mentioned modes and the benefits derived from their use.

<u>Problem Solving</u>

In this method the student writes a computer program

Figure 4



Ten most frequently used modes of CAI
(Kearsley, 1976)

Table 1

Number of delegates by country at the second IFIPS world conference on computer education held in Marseilles in 1975. (Kearsley, 1976)

COUNTRY	1975	COUNTRY	1975
France	208	Ireland	4
Great Britain	97	Israel	3
West Germany	65	South Africa	3
U.S.A.	55	Cuba	3
Netherlands	48	Mexico	3
Sweden	35	Austria	2
Hungary	29	Cameroons	2
Switzerland	26	Iran	2
Denmark	24	Kenya	2
Japan	21	Malaysia	2
Canada	20	Argentina	1
Italy	19	Chile	1
Belgium	19	Costa Rica	1
Australia	17	Egypt	1
Czechslovakia	16	Greece	1
Spain	13	India	1
Rumania	12	Portugal	1
Brazil	11	Morocco	1
Poland	10	Thialand	1
Yugoslavia	6	Tunsia	1
Finland	5	Uruquay	1
Algeria	4	U.S.S.R	1
Iraq	4	Nigeria	1
		Peru	1

to solve a quantitative problem. Hooper and Toye (1975) mention this mode in their study of CAI in the United Kingdom. The benefits, which result from the use of this method are:

a) To write a program a student must make a step-by-step logical analysis of the problem and in so doing, acquires a better understanding of the principles involved.

b) Problems which normally would be too difficult or too long may be solved in a short period of time.

c) The computation itself does not overshadow the important principles being studied.

d) The time which would be consumed performing tedious, routine calculations may be used for more constructive tasks.

Simulation and Gaming

In this mode, the computer is being used to create situations which would otherwise be impossible to achieve. The student is expected to supply different variables and observe the outcome. Braun (1971) suggests the following criteria when simulation should be used:

1) When facilities or equipment needed to conduct an actual experiment are costly or complex and, as a consequence, where the experiment would probably not otherwise be performed (e.g. complex chemistry experiments).

2) When the actual experiment is hazardous and might endanger the experimenter (e.g. science experiments which involve radiation, high temperatures, explosive gases).

3) When time scales involved are either too short to allow easy measurement or too long to fit into the school year (e.g. biological studies in genetics - observing successive generations of a particular species).

4) When the sample size available in the real world is too small to permit generalizations (e.g. the study of rare diseases by medical students).

5) When the experimental technique is complex and must be developed over an extended period of time.

6) When it is impossible to experiment directly (e.g. studies of political, economic, and social systems, human genetics).

One example of a scientific simulation program, mentioned in the L.A.C.E. Catalogue of Secondary Education Programs, is LMLAND which simulates a lunar landing.

In the area of ecology one may be interested in the program POLUT, developed for the Huntington II Project (Digital Equipment Corporation, 1971). POLUT simulates the effect of certain variables on the quality of water resource.

Closer to home, here in Winnipeg, John Cowtan developed a program called WHEAT which very appropriately places a student in a position of a farmer and a Wheat Board agent. The student must first decide how much wheat to plant, later when the computer calculates a yield (using randomly selected weather conditions), the student must reach a conclusion on how much wheat to sell and how much to keep in reserve.

<u>Drill and Practice</u>

As the name implies, in this mode the computer is used to supplement regular instruction by supplying practice exercises to drill previously taught material. The benefits derived from this mode are:

a) The student works at his own rate.

b) The level of the problems is especially selected for the student's level of ability.

c) Since the student is interacting with a machine, fear of ridicule by his peers, caused by a wrong response, is eliminated.

d) The student's responses are immediately evaluated and reinforced.

One of the best known drill and practice systems is the system developed at the Stanford University by Patrick Suppes and Richard Atkinson (Ellis, 1974, p.44). The system has been used for some time throughout the United States and in each case with acclaim. It was designed to drill and review students on mathematical concepts previously introduced in classrooms by the teacher. The program covers grades one through six and the material for each grade is arranged in sequential concept blocks. There are approximately twenty-five such blocks for each grade. For each day of drill or review there are five levels of difficulty and the starting point of a student depends on his previous performance.

The University of Alberta developed a system which consists of 16 student terminals and one Proctor terminal (Fitzgerald et al, June 1970, p.89). The programs used in this system are designed to drill students in basic mathematical operations. From his terminal the proctor can control the proceedings on any student terminal.
The form of the problems is:

" a * b = c" where * = x, ÷, +, or -.

There are three types of questions:

Type I   a*b=?

Type II   a*?=c

Type III   ?*b=c

In every case the student is asked to supply the missing number. Forms of reinforcement are the correct answer and an audio message. The student has 30 seconds to respond to a question or prompting and a new question will follow.

Tutorial

In a tutorial system, the computer assumes the responsibility for teaching new material. The interaction, between a student and the computer, is supposed to resemble that between a patient tutor and his pupil.

Early tutorial systems were of "linear" type. That is, there was only one way of getting from start to the finish. Each student had to follow the same series of steps. Present programs are "branching" in nature which means that the student, depending on his ability, as indicated by his responses, may be directed into alternate routes to achieve the same goal. A good student may by-pass certain parts of the program while a poor student may be forced to do remedial material.

An example of a commercially available tutorial system is the Stanford Tutorial System developed by Richard C. Atkinson (Atkinson and Wilson, 1972, p.145). The system was developed at Stanford University with the co-operation of IBM. It consists of a central processor computer, disc-storage unit, proctor station and 16 student terminals. Each student terminal consists of a picture projector, a CRT, a light pen, a modified typewriter keyboard and an audio system. Each projector permits a display of over 1000 images which may be accessed randomly by the computer. Audio messages are synchronized with visual images and may last from a few seconds to over 15 minutes. This system is used to teach reading skills.

Dialogue

This is the most complex of all systems. In this mode the student can carry a genuine dialogue with the computer. The computer must accept the students response and using the key words, determine whether it is satisfactory. The ultimate objective of such a system is to develop it to a point where the computer will recognize the spoken word and respond audibly. O'Neil and Pytlik list some characteristics of a dialogue system which designers would like to incorporate into their programs. These are:

1) The computer can take into account not only the current question but also the previous portion of the conversation.

2) The user has the freedom of making any response, even if it is irrelevant.

3) The computer itself always responds with something relevant.

4) The computer can decide whether to delay information requested by the student.

5) Computer answers may be based on complex computations.

6) Verbal interactions should take place in common English.

7) Questions or interactions are permissible by the computer or the student at any time.

8) Non-verbal exchanges can include tables, graphs, pictures and sound.

An example of a dialogue system is the program ELIZA created by Joseph Weizenbaum at the Massachusetts Institute of Technology. In this system the computer simulates the questions and responses of a psychotherapist. Although this program is only in the developmental stage, it is a good indication of the future possibilities.

The Opposition To And Support Of CAI

The optimistic tone, of the first part of this chapter, may have suggested a wholehearted acceptance of CAI by all teachers and parents. This, however, is not the case. Many educators resist the "encroachment" of computers into the field of education. Some of their reasons are:

a) High cost of implementation and maintenance of a computer system.

b) Shortage of high quality CAI course material.

c) Teachers' jobs being taken over by computers.

d) Dehumanization of education.

e) a number of educators are not convinced of the effectiveness of CAI as an instructional technique.

The proponents of CAI counter these criticisms by pointing out that:

a) The cost of a system is relative and depends on the efficiency of use. The more effective the use, the lower the cost. The cost per student hour in the PLATO IV system was found to be 34¢, which favourably compares with the cost of 36¢ required for traditional instruction (Status of PLATO IV, March 1972). Also, new developments in the computer technology such as TICCIT (Time-shared Interactive Computer-Controlled Information Television) developed by MITRE Corporation will most likely reduce the cost to an acceptable level (Report of the Computer/ Communications Task Force. Vol. 2, 1972).

b) The extensive use of CAI will increase the expertise of educators in the field of computer programing and will generate more high quality course material.

c) The primary goal of CAI is not to replace a classroom teacher but to provide him with another tool, which if used to advantage, will allow greater individualization of instruction.

d) Research done by various educators seems to indicate very favourable response of students towards CAI (Hill, 1976; Hooper and Toye, 1975; Mitzel, 1968). In a project carried out by S. Hunka at the University of Alberta Edmonton (1974) it was found that out of 268 elementary students, 261 of them liked working on a computer terminal. The teachers involved noticed better attitude toward mathematics, especially in poor students. There seemed to be greater motivation. Out of 125 parents, 116 felt it was a valuable experience. The most startling results were obtained by Hess and Tenezakis (1971) in their experiment designed to explore student attitudes toward CAI and to compare them with attitudes toward other sources of information and instruction. The two year project involved 189 grade 7-9 students of predominantly Mexican-American working class background. The results indicate more favourable image of the computer than the teacher. The computer has outscored the teacher in all respects even in such "human" characteristics as "softness" and "warmth". Figure 5 provides the graphical summary of the findings.

Results of Empirical Studies

To do justice to all researchers involved in the field of CAI would be a task worthy of doctoral dissertation.

Figure 5

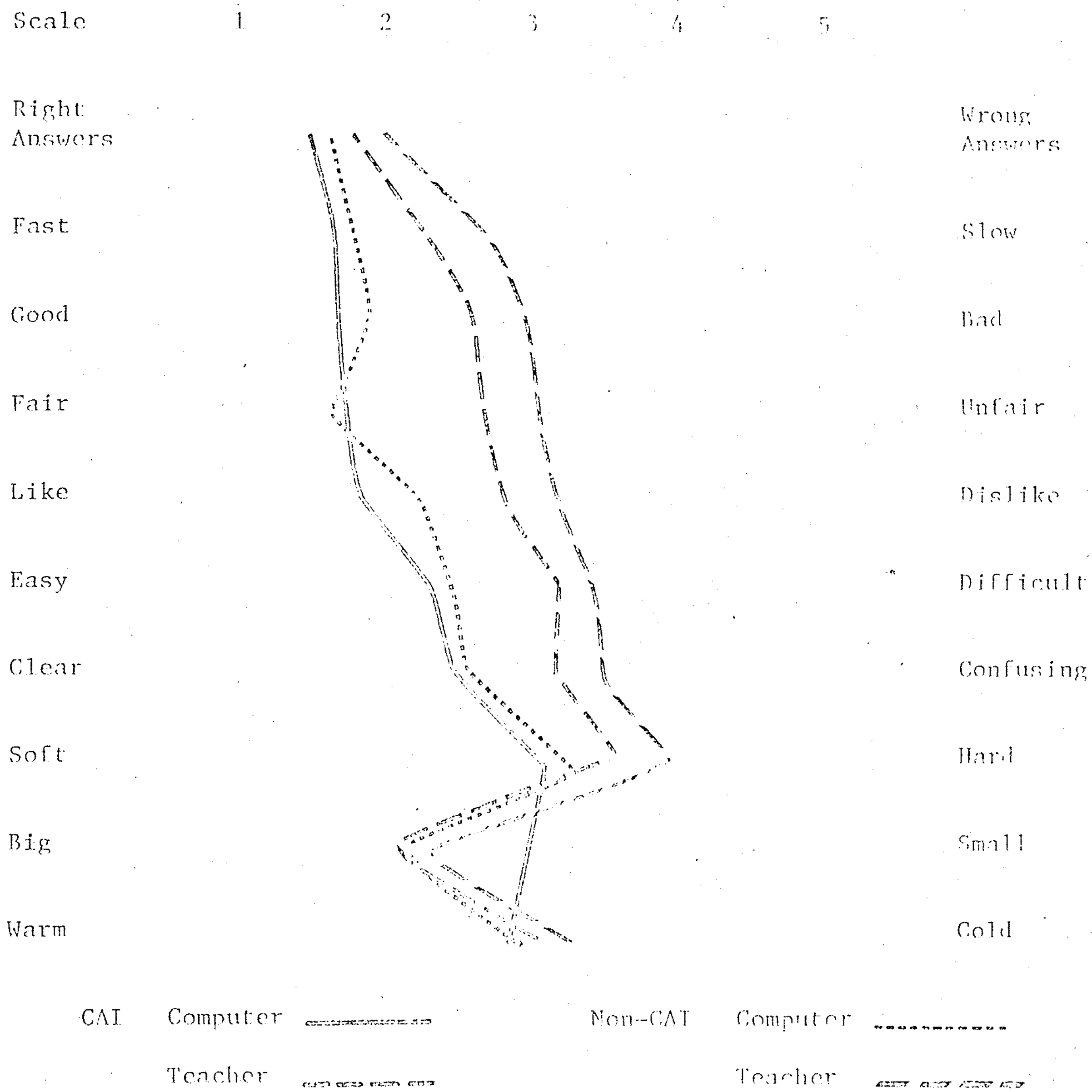


Image of computer and teacher held by CAI and non-CAI groups
(Hess and Tenezakis, 1971)

However, the purpose of this review is to provide the reader with information on various aspects of computerized education. Hence, the author decided to present in this section some representative studies, including those in which the CAI was found ineffectual.

Almost all studies of CAI drill and practice have shown it to be effective when compared with traditional classroom instruction.

Suppes and Morningstar (1972) report the results of a study in which Stanford Drill and Practice system was used to supplement instruction in arithmetic in California and Mississippi. Fifteen hundred students in Grades 1-6 participated in this study. The results of this program have been almost spectacular. In Mississippi, Grade one students gained 1.14 grade levels in just three months of work as compared with .26 grade levels for the control group. Grade three students in California and Mississippi gained, respectively 2.28 and 2.03 grade levels in computational ability.

In a study in Waterford, Michigan it was found (Arnold, 1970; Scrivens, 1970) that students whose normal classroom instruction in arithmetic was supplemented by CAI Drill and Practice, gained significantly in achievement, more than students who received normal classroom instruction only. The difference in gains between the CAI and non-CAI students were .3 grade levels for grade two, .5 for grade three, .4 for grade four, and .5 for grades five and six.

In a project run in the summer of 1969 in Kansas City, Missouri, a group of 500 grade eight students was assigned to two modules of CAI per week. The objective of this study was to evaluate the effectiveness of remedial math drills. The results, reported by Taylor (1972) indicate that they were effectively increasing basic skills.

The same researcher reports the results of another study. This one was conducted in Wakulla County, Florida. The study, conducted in a poor district, involved a group of elementary students who were 1.5 years below standard grade level in mathematics and reading. The students were assigned to three sessions each week, of 15-25 minutes, on the computer terminal. The study which ran from 1968 to 1970 indicates improvement in performance which was most significant in the 2nd and 3rd grade.

In a study conducted in Montgomery County Elementary School, (Rockville, Maryland) 58 matched pairs of grade six students worked on operations with Whole Numbers, Sign-on Fractions, and Percent. The experimental group received their drill via computer terminal (½ hour per week). This work was a part of regular classtime. The results indicated significantly higher achievement for the experimental group (Dunn, 1974).

Suppes and Ihrke (1969) report the results of a project which involved a group of 32 bright four graders. The students received approximately 15-25 minutes of computer assisted drill problems per day. The program was in the form of concept blocks each containing exercises at five levels of difficulty. The results of the pretest determined the starting point of the computerized drill for that day. The results have been very satisfactory. Most scores were above 80% correct. This group was 1.5 years above their grade level on computation and 2.8 years above on concepts. The comparison group was at the grade level for computation and 1.6 years above on concepts.

Brightman (1972) summarizes sixteen studies in which the effectiveness of the CAI was being evaluated; in every case, without exception, the CAI was shown superior to the traditional method.

There seems to be a direct relationship between the number of sessions on the terminal and the achievement of a student. This is the conclusion from a study conducted in 15 schools for the deaf in the District of Columbia (Suppes, and others, 17 May 1973). The participants in this study were 385 hearing-impaired students enrolled in elementary and secondary schools (grades two to six). The objective of this project was to determine the effectiveness of a computer assisted elementary mathematics program on the acquisition of computational skills. The students were drilled in their areas of deficiency. The curriculum was composed of 14 sequential mathematical strands. Five groups of 77 students each were assigned to 10, 30, 70, 100, and 130 six to ten minute sessions on the computer.

The results indicated that the computer assisted curriculum enabled the hearing-impaired students to achieve gains expected of normally hearing pupils and that greater number of sessions on the computer were beneficial to all students.

Atkinson and Suppes (1967) have found that in reading, students of higher ability progressed more rapidly than slower students mainly because the screening test, inherent in the program, allowed the students to skip entire lessons.

Suppes and Morningstar (1972) found that CAI appears to be most effective with low ability pupils. This conclusion was further corraborated by Martin (1973).

Hooper and Toye (1975) in their report on Computer Assisted learning in the United Kingdom state..."some of the lower performance groups made most striking gains and they were working more quickly, as well as more accurately".

Interesting, though confusing, results are reported by researchers attempting to correlate students' sex with their achievement.

Martin (1973) in his summary of TIES Research Project, reports an interesting observation in CAI: boys gained more than girls; under normal teaching, girls tend to do better than boys. The results, however, are not conclusive because Street (September, 1972) also studied the teaching of arithmetic through CAI and found that girls gained more.

In reading, Atkinson (April, 1968), and Fletcher and Atkinson (December, 1972), found that boys and girls achieved about the same. Under normal conditions girls usually achieve better.

Not all results of the studies conducted in CAI favour the computer groups.

In a project conducted in the Montgomery County High School (Dunn and others, 1974), 137 students enrolled in Geometry classes were divided into two groups. The CAI group consisted of 67 students and the control group 70. In evaluating the results, it was found that there was no difference in achievement between the two groups. However, there was one variable which was not controlled and that was the class size. In experimental sample the students were divided into two classes of 33 and 34 students, whereas, the control group consisted of three classes of 23 students.

The same author reports the results of the algebra study in which the objective was to test the difference CAI may make between low and high achievers. One class of each ability level was taught in the traditional manner while a second class of the same level used CAI. The same teacher was involved in all cases. The results indicate that there was no difference between the CAI and the control groups.

Street (1972) reports the findings of a large study in Kentucky in which a group of 1600 students received CAI drill and practice as a supplement to normal instruction in arithmetic. This group was compared with 1000 pupils who had their instruction supplemented with programmed instruction, films, filmstrips and other media. The same amount of money, per student, was spent for supplementary materials as for CAI. At the end of the year, there was almost no difference in achievement between the two groups.

In a study mentioned earlier in this chapter (p.32-34), Suppes and Morningstar (1972) report that in a project comparing the effectiveness of CAI with regular classroom teaching, the administrators of one of the non-CAI schools, decided to give their students a better chance by providing them with 25 minutes of extra classroom drill time per day. These students achieved better than the CAI students, which seems to indicate that 25 minutes of classroom drill is more effective than 5-8 minutes of computer assisted program.

Crawford (1970) studied the effectiveness of CAI as a remedial math technique for underachieving students. Two groups of students received regular classroom instruction but the experimental group also received CAI. Although, a significant gain was shown, there was no significant difference between the post test scores of the two groups. The major weaknesses of the study mentioned were:

a) Insufficient staff preparation.

b) Absenteeism of students.

c) Frequent equipment breakdowns.

d) Short period (eight weeks) of evaluation.

Berthold (1974) compared the effectiveness of the following methods:

a) Teacher alone.

b) Teacher-Computer.

c) Computer alone.

The sample consisted of eleven minimally brain damaged children. Each method was used for a period of two weeks. Most significant gains were recorded after the instruction by teacher alone and teacher-computer combination. Both methods were judged to be superior ($p < .05$) to the computer alone. The reasons for the inferiority of the computer alone were:

1) The teacher was more flexible in his modes of instruction than teletype.

2) The full adaptability of the program was not utilized between sessions to meet the needs of the students.

Summary

From the review of literature, it is apparent that CAI is a credible means of instruction.

The results of the studies indicate the effectiveness of this method and the benefits inherent in it seem to outweigh the drawbacks.

The fear, expressed by some educators, of the dehumanizing nature of CAI, appears to be ameliorated by the results of the research in that area.

Improvements in electronics and computer technology keep lowering the costs of computer systems. This makes CAI more economical and more acceptable to the taxpayer.

CHAPTER III

INVESTIGATION

The Problem

This study tried to answer the following questions:

1) Are computerized Drill and Practice programs as effective as worksheets?

2) Can we in Manitoba, with our present resources duplicate some of the positive results obtained in Computer Assisted Instruction in the United States?

3) Is it possible to conduct meaningful CAI at a ratio of ten students to one computer terminal?

4) Does the mode of drill exercises have any bearing on the learning and retention of the taught material?

The Sample

The subjects involved in this study were grade seven students attending the West St. Paul School in Seven Oaks School Division #10 in Winnipeg. All the subjects, on the basis of their past performance and the scores obtained on a series of tests given in September 1975, were placed in the lowest quartile of the total population of grade seven students in the school. The ages of students ranged from 12 to 14 years.

Twenty-four students were divided into two matched groups in the following manner. First, all the students were given three sections of the Brueckner Diagnostic Test and an especially prepared test on Multiplication of Decimals. The three sections dealt with the following topics:

a) Multiplication of Integers,

b) Division of Integers,

c) Division of Decimals.

The test on Multiplication of Decimals was prepared by the author especially for this study. On the basis of the total score obtained on the above mentioned tests, the students were arranged in order of decreasing achievement. The first student in the column was randomly assigned to one of the two groups, the second student was then placed in the other group. The third student was again randomly assigned to one of the groups and the fourth was placed in the other group. This procedure was followed down the list. In this manner two groups of twelve students each were obtained. However, during the project, two subjects from the "Computer" group moved out of the district leaving that group with only ten members.

The results of this first series of tests were used as a pretest . The mean score was calculated for group and a t-test was performed to insure that the means from the total pretest scores of the two groups were not significantly different ($p < .05$).

Statistical Hypotheses

If two groups of grade seven students, matched accordingly to their mathematical ability, receive regular classroom instruction in:

a) Multiplication of Integers

b) Multiplication of Decimals

c) Division of Integers

d) Division of Decimals

and if this instruction is supplemented by ten minutes/per day of appropriate drill exercises which members of one group (Computer) would receive in a form of computerized drill and practice programs while the members of the other group (Worksheet) via worksheets then:

1) There will be no significant difference in achievement between the two groups in multiplication of integers.

2) There will be no significant difference in achievement between the two groups in multiplication of decimals.

3) There will be no significant difference in achievement between the two groups in division of integers.

4) There will be no significant difference in achievement between the two groups in division of decimals.

5) There will be no significant difference in achievement between the two groups on total scores.

Limitations

A number of limiting factors will be discussed and the significance of each limitation should be considered when the results are evaluated. These factors may be divided into two classes.

1) Sample limitations

2) Physical limitations

Sample Limitations

The small size of the population tested makes it unlikely that the conclusions would be applicable to general population.

Physical Limitations

There are a number of factors which could be placed in this category:

a) Computer terminal being located in the physical education office.

b) Only one computer terminal for ten subjects.

c) Only one teacher to supervise the project on top of his regular duties.

d) Only one month's time to conduct the study

At the very onset of the study it was discovered that, the only place where the computer terminal worked without any flaw was the physical education office located in the gymnasium. Since the gymnasium was occupied at all times, even closing of the office doors could not elliminate the distraction caused by the noise of physical activity in the hall.

The fact that there was only one terminal available, for this project, made it necessary to schedule the students throughout the day (Table 2). That meant pulling students out of their regular classes. The teachers affected were very co-operative, however, the students frequently arrived late or forgot to come altogether.

The problem of students coming late or not coming at all for their appointed time, could have been solved if there was a full time supervisor. However, the author was the only person overlooking this project and that was done on top of his regular duties. The remote location of the terminal made it impossible to check quickly whether everything was proceeding according to schedule.

The author feels that the results of this study would have been more reliable if the study could have been conducted over a longer period of time. More time, would have allowed better familiarization of students with the log-in and log-off procedures as well as eliminating the novelty of the experience.

<u>Instructional Programs</u>

The two computer drill and practice programs used in this study were written by the author. Program MULTJB was prepared especially for this project. The two programs are very similar in nature although they deal with opposite operations.

<u>MULTJB</u>

This is a drill program providing exercises in multiplication. It is self-governing. The program allows the student to choose:

1) the number of problems to do from 1 to 20
2) how many digits in each number
3) integers or decimals

4) if decimals, how many decimal places each of the numbers should contain.

All numbers are randomly generated. If a student makes a mistake he or she will receive a brief instruction on the operation in question and the same problem will be repeated. After a second mistake on the same problem the correct answer will be provided, the student will be credited with an error and a new question will be typed. In a case where a student makes three errors in a row he will be either sent to consult his teacher or will be given problems at a lower level of difficulty. That is, if the unsuccessfully attempted problems had two or more digits in their multiplier the next set of problems will contain multipliers with one less digit. In a case where the multiplier has only one digit the student will be referred to the subject teacher for further instruction. If a student answers correctly three consecutive questions, he or she will be allowed to either proceed with problems at the same level of difficulty or try some more challenging problems, in which case the student will again have to determine the characteristics of each number. At the end of the session, the students are informed about their performance: How many questions were attempted, how many were answered correctly, and what was the student's percentage score. An important feature of this program is the fact that if the multiplier consists of more than one digit then each part of the answer is judged individually, allowing the student to pinpoint where the mistake was made. For example:

```
  326
x  12
  652     first check
 326      second check
 3912     final check
```

DIVIDE

This is a self-governing program providing exercises in division. Like MULTJB, it allows the student to choose:

1) the number of problems to do from 1 to 15
2) how many digits in each number
3) how many decimals in each number
4) how many decimals in the answer

Unfortunately, however, the author could find no way to make the program check the intermediate steps, so the student's response was judged by the final answer;

Example: $.6\overline{)\;.7}$

=?

With respect to the treatment of students who need extra help or find the chosen exercises too easy, this program is quite similar to MULTJB. The only difference lies in the fact that whereas MULTJB at first decreases the number of digits in the multiplier and refers the student to consult his teacher only when the multiplier contains a single digit; DIVIDE does it as soon as the student makes three mistakes in a row. Another difference may be found in the treatment of wrong answers. In MULTJB a student receives brief instruction and then has a chance to answer the same question. In DIVIDE there is no instruction, the correct answer is given and the next question will be completely different from the one which was answered incorrectly.

Worksheets

Four sets of worksheets were used to provide the drill exercises for the second experimental group. Each set dealt with one specific operation. The questions were of various degrees of difficulty and were arranged in sequential order. Each worksheet had more questions than could be answered in 10 minute period of time. This was done to prevent better students from finishing early and then sitting idly for the remaining time. Each day a different worksheet from an appropriate set was used to eliminate the possibility of memorization of exercises.

Examples of the computer programs and some of the worksheets may be found in Appendices B and C respectively.

Measuring Instrument

The test that was chosen to assess the subjects' achievement was the Brueckner Diagnostic Test. This test was employed because it was the only one, to the author's knowledge, which has entire sections dealing with one specific operation. However, there was no section dealing with Multiplication of Decimals, therefore, the author developed that test. The author could not find any information about the validity or reliability of the test. However, Spitzer (Buros' The Fourth Mental Measurement Yearbook, #410) in his review of Brueckner Diagnostic Test states "...good test for ability to work with fundamental processes and accuracy of computation". Since the purpose of this study was to compare the achievement of the two groups of students, with respect of the above mentioned factors, and the same test was used by both groups for pretest, posttest, and retention-test, the author decided to use it.

All tests may be found in Appendix A.

Apparatus

The computer used in this study is owned by the Province of Manitoba at Cybershare Limited. It is a CDC 6500 model. One Portacom interactive terminal was made available by the Computer Services Branch of the Department of Education.

The terminal was placed in the Physical Education office located in the gymnasium hall in West St. Paul School. Since in that school the gymnasium is located at one end of the building while the author's classroom is situated at the opposite end, this arrangement made close and continuous supervision of students working on the terminal impossible. This unfavourable location had to be accepted simply because, that was the only place, in the entire school, where the terminal worked without any trouble.

Cost

The total cost of this project was shared jointly by the Computer Services Branch of the Department of Education and the West St. Paul School. The school paid for the Central Processor's time which amounted to $65.51. The Department of Education provided one Portacom terminal and paid all other expenses. These expenses consisted of ribbon and paper for the terminal, which was approximately $5.00, and the connect time which costs the Department of Education $1.00 per hour of use. Since the terminal was used approximately 3 hours and 45 minutes per day for 20 days, this cost amounted to $75. Total cost of the entire project was $145.51. On the average there were 15 students per day who used the terminal, therefore, the cost per student per day amounted to approximately $ .48.

The author realizes that the cost of similar undertakings conducted without such extensive support of the Department of Education would have to be higher. The cost of the connect time would rise from $1 to $4 per hour (this price includes the disk space) and the cost of renting the computer terminal would be an additional $55 per month. This would make the cost per student hour higher, and only more efficient use of the terminal would lower it to a more acceptable level.

Administration and Procedure

Pretest

The study commenced on October 1, 1975. It continued until the end of the month. The project was preceeded by a battery of tests, four in all, each dealing with a single topic. The operations tested were:

a) Multiplication of Integers,

b) Multiplication of Decimals,

c) Division of Integers,

d) Division of Decimals.

In this thesis this first set of results is referred to as the pretest .

All students wrote the same test and at the same time in one classroom. The raw scores of this and subsequent tests (posttest and retention-test) as well as their means and Standard Deviations may be found in the following chapter.

Procedure

Following the first series of tests the students were divided into two ability matched groups. The procedure employed in this process was described earlier. The two groups, for the purpose of this study, were named the "Computer" and the "Worksheet".

All students received their instruction from the same teacher at the same time. The daily period of 40 minutes was divided into four parts as follows:

1) Correction of assignment,

2) Introduction of new topic,

3) Answering of questions and assigning new homework,

4) Worksheet group works on worksheets.

While the students in the Worksheet group were working on their drill problems, the students in the Computer group were allowed to work on other subjects not related to the newly introduced topic.

Since there was only one computer terminal the students in the Computer group had to be scheduled in a special timetable. Each student was assigned to a daily slot of time 15 minutes in duration. The author has estimated that out of these 15 minutes, five minutes were spent on logging-in and logging-out procedure as well as waiting for the computer's responses.

The author was pleased with the co-operation of other teachers in the school. They allowed the student scheduled for that particular time to leave their regular class and go to work on the computer terminal. Without such helpful attitudes this whole project would have been impossible.

Table 2

Daily Time Schedule

AM Subject	Time	Subject	PM Time
1	8:40-8:55	6	1:00-1:15
2	9:00-9:15	7	1:20-1:35
3	9:20-9:35	8	1:40-1:55
4	9:40-9:55	9	2:00-2:15
5	10:00-10:15	10	2:20-2:35

To minimize any Hawthorne Effect, the students in the Worksheet group were allowed to use the terminal any time when it was not scheduled, however, they were not permitted to work on any math programs. Many students took advantage of this arrangement and tried the various programs available in the computer memory.

Posttest.

Immediately after the completion of each topic all students were given the same test as in the pre test. Since the students were not informed about their results in the previous test, and both groups of students received the same tests at the same time, the author feels that any "Test Learning" that would take place would be equivalent for both groups. This second set of results, in this study, is referred to as the "Posttest".

Retention-test

Approximately two months after the completion of this study, after the "Christmas Break", all students wrote the same Brueckner Diagnostic Test and the test devised by the author for the third and final time. This final set of scores is referred to as the "Retention-test".

Statistical Procedure

A simple correlation program was employed to see how the four parts (Multiplication of Integers, Multiplication of Decimals, Division of Integers, and Division of Decimals) correlated with one another.

A 2X3 Analysis of Variance for Repeated Measures Design was used having one between-subjects factor, three within-subjects factors and an interaction factor. The between-subjects (Variable A) factor had two levels corresponding to the two groups (Computer and Worksheet). The within-subject factors (Variable B) represented the pre, post, and retention tests measuring academic achievement over time.

This analysis was used for each of the following:

a) Multiplication of Integers,

b) Multiplication of Decimals,

c) Multiplication (Integers and Decimals),

d) Division of Integers,

e) Division of Decimals,

f) Division (Integers and Decimals),

g) Total (Multiplication and Division).

The results of this analysis may be found in the following chapter.

CHAPTER IV

RESULTS

In this chapter the author will present the results of this study.

The original intent of this study was to compare the Computer and Worksheets groups on their total scores, however, once the data was available, the author felt it may be interesting to see how the two groups compared on individual operations. Since the correlation matrices (tables 3 and 4) indicated that there was no significant correlation between the pretests on various operations, the author felt satisfied that the analysis of individual operations will not lead to the duplication of results.

The raw data tables may be found in Appendix D. The tables also indicate the mean values and standard deviations.

Figure 6 gives the graphical representation of the relationship between the means on pretest, posttest, and retention-test in each of the studied operations for the Computer and the Worksheets groups.

Another examination of the correlation coefficients produces rather surprising results. One would expect that since multiplication of integers is closely related to the multiplication of decimals and the division of integers to division of decimals, there would be significant correlation between the posttests and the retention-tests for both pairs of operations.

TABLE 3

Correlation Matrix

Computer group

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	.67	1.00										
3	.82	.92	1.00									
4	.31 *	.60	.45	1.00								
5	.80	.81 **	.93	.25	1.00							
6	.74	.79	.93 ++	.32	.83	1.00						
7	.16 *	.07	.18	.14	.25	.34	1.00					
8	.56	.69	.65	.56	.53	.75	.53	1.00				
9	.52	.62	.59	.18	.68	.62	.52	.78	1.00			
10	.36 *	-.02	.05	.41	.06	-.07	.25	.06	-.08	1.00		
11	.40	.55	.62	.11	.51	.79	.36	.75 **	.70	-.42	1.00	
12	.56	.25	.41	-.09	.40	.65	.48	.70	.64 ++	-.13	.74	1.00

* Pretest-pretest
** Posttest-posttest
++ Retention-test - retention-test

Mult. of Int.	Mult. of Dec.	Div. of Int.	Div. of Dec.
1- Pre-test	4	7	10
2- Post-test	5	8	11
3- Retention test	6	9	12

$p < .05$ r critical= .64 ; $p < .01$ r critical= .83 ; df(8)

TABLE 4

Correlation Matrix

Worksheet group

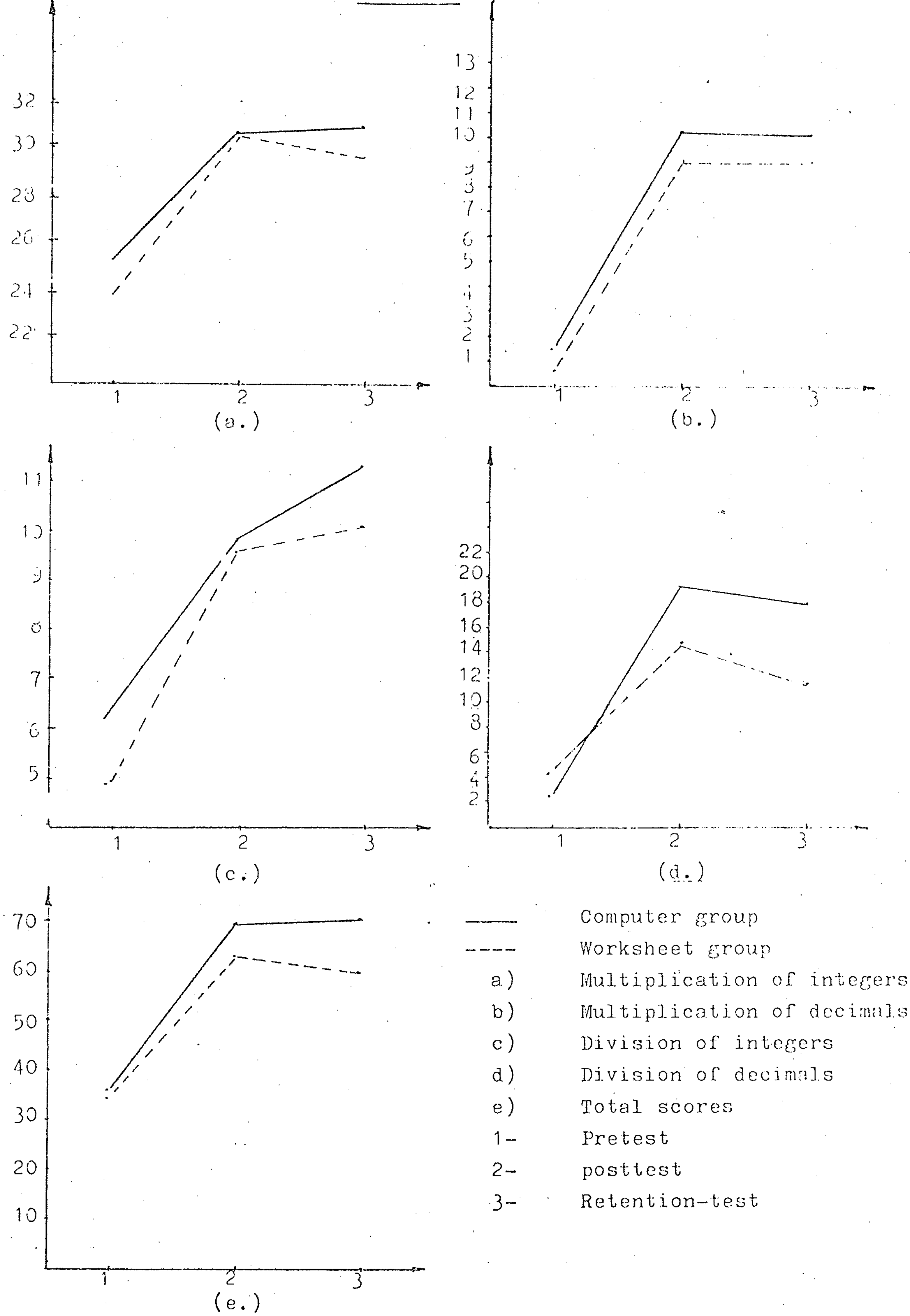
	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	.65	1.00										
3	.41	.31	1.00									
4	.35*	.17	.42	1.00								
5	.15	.35**	.09	.23	1.00							
6	-.03	.27	-.18++	-.64	.52	1.00						
7	.66*	.67	.29	.38	.13	.09	1.00					
8	.72	.60	.44	-.08	.49	.46	.59	1.00				
9	.64	.30	.33	.35	.01	-.02	.43	.63	1.00			
10	.36*	.19	.01	.28	-.27	-.10	.10	.22	.76	1.00		
11	.53	.44	.55	.27	.38	.43	.41	.61**	.52	.26	1.00	
12	.47	.14	.44	.38	.08	.16	.48	.49	.65++	.30	.64	1.00

* Pretest-pretest
** Posttest-posttest
++ Retention-test - retention-test

Mult. of Int.	Mult. of Dec.	Div. of Int.	Div. of Dec.
1-Pre-test	4	7	10
2-Post-test	5	8	11
3-Retention-test	6	9	12

$p < .05$ r critical=.56 ; $p < .01$ r critical=.75 ; df(10)

FIGURE 6


(a.)
(b.)
(c.)
(d.)
(e.)
Computer group
Worksheet group
a) Multiplication of integers
b) Multiplication of decimals
c) Division of integers
d) Division of decimals
e) Total scores
1- Pretest
2- posttest
3- Retention-test

This is true in case of the Computer group where the correlation coefficients of .81 between posttests in multiplication and .75 in division reinforce this expectation. However, corresponding coefficients obtained by the Worksheet group are .35 and .61 respectively. The difference is even more startling in the case of retention-tests. For the Computer group the correlation coefficients between the two retention-tests are .93 for multiplication and .64 in division. In case of the Worksheet group they are .18 and .64.

The possible explanation of these results is given in Chapter V.

Analysis of Variance

The analysis of variance summary tables, for all operations tested, are located on the following pages.

The critical value needed, to indicate a significant difference between the means, at the .05 level is 4.35 and at .01 level it is 8.00 (df=1,20).

The results indicate that there was no significant difference between the means obtained by the Computer and the Worksheet groups in any of the operations, thus, none of the five null hypotheses were rejected.

Both groups have shown a significant difference in achievement over time in all operations.

The table representing the Division of Decimals indicated a significant (at the .01 level) interaction between the two groups.

Table 5

Analysis of Variance Summary Table for Repeated Measures Design

Multiplication of Integers

Source of Variation	DF	SS	MS	F Ratio
A (Treatment)	1	12.272	12.27	0.105
Subj. w. groups	20	2341.64	117.08	
B(Increase over t.)	2	429.69	214.84	9.24**
AB	2	7.71	3.86	0.166
BX subj. w. groups	40	929.32	23.23	
Totals	65	3725.81		

(1,20) * $p < .05$ F=4.35
** $p < .01$ F=8.0

(2,40) * $p < .05$ F=3.23
** $p < .01$ F=5.18

Table 6

Analysis of Variance Summary Table for Repeated Measures Design

Multiplication of Decimals

Source of Variation	DF	SS	MS	F Ratio
A (Treatment)	1	8.91	8.91	0.455
Subj. w. groups	20	391.31	19.57	
B (Math scores)	2	957.56	478.78	60.809**
AB	2	2.86	1.43	0.181
BX subj. w. groups	40	314.94	7.87	
Totals	65	1679.25		

(1,20) * $p < .05$ F= 4.35

** $p < .01$ F= 8.0

(2,40) * $p < .05$ F= 3.23

** $p < .01$ F= 5.18

Table 7

Analysis of Variance Summary Table for Repeated Measures Design

Division of Integers

Source of Variation	DF	SS	MS	F Ratio
A (Treatment)	1	8.61	8.61	0.144
Subj. w. groups	20	1196.31	59.82	
B (Math scores)	2	349.38	174.69	13.604**
AB	2	2.94	1.47	0.114
BX subj. w. groups	40	513.63	12.84	
Totals	65	2074.81		

(1,20) * $p < .05$ F= 4.35

** $p < .01$ F= 8.0

(2,40) * $p < .05$ F= 3.23

** $p < .01$ F= 5.18

Table 8

Analysis of Variance Summary Table for Repeated Measures Design

Division of Decimals

Source of Variation	DF	SS	MS	F Ratio
A (Treatment)	1	158.14	158.14	3.596
Subj. w. groups	20	879.56	43.98	
B (Math scores)	2	2359.29	1179.64	64.406**
AB	2	197.43	98.71	5.390**+
BX subj. w. groups	40	732.63	18.32	
Totals	65	4214.94		

(1,20) * $p < .05$ F= 4.35

** $p < .01$ F= 8.0

(2,40) * $p < .05$ F= 3.23

** $p < .01$ F= 5.18

Box' Conservative Test

(1,39) + $p < .05$ F= 4.09

++ $p < .01$ F= 7.33

Table 9.

Analysis of Variance Summary Table for Repeated Measures Design

Total (Multiplication and Division)

Source of Variation	DF	SS	MS	F Ratio
A (Treatment)	1	541.03	541.03	0.896
Subj. w. groups	20	12451.62	622.58	
B (Math scores)	2	14098.55	7049.23	77.622**
AB	2	163.32	81.66	0.899
BX subj. w. groups	40	3632.63	90.82	
Totals	65	30661.91		

(1,20) * $p < .05$ F= 4.35

** $p < .01$ F= 8.0

(2,40) * $p < .05$ F= 3.23

** $p < .01$ F= 5.18

That interaction is graphically shown by figure 6d. The graphs showing the progress of individual students in this operation may be found in Appendix E. Box (1953) has indicated that "the heterogeneity of both the variances and co-variances in a design having correlated observations will generally result in a positive bias in the usual F test", that is, the F value determined from the F table will tend to be somewhat higher than the exact value (Winer, 1962, p.123). To minimize the effect of such bias, the author administered the Box' Conservative Test and found that the interaction was now significant only at the .05 level.

In order to determine the cause of this interaction, the test for simple main effects was used. In this analysis the author tried to find answers to the following questions: a) Is there a significant difference between the groups at: 1) the pretest level

2) the posttest level

3) the retention-test level

b) In the Computer group is there a significant difference between: 4) Pretest and Posttest

5) Posttest and Retention-test

c) In the Worksheet group is there a significant difference between: 6) Pretest and Posttest

7) Posttest and Retention-test

The results of this analysis are shown in Table 8.

Table 10

Analysis of Variance Table for Simple Main Effects

Source	DF	SS	MS	F Ratio
Between Groups				
1. Pretest	1	14.85	14.85	1.85
2. Post test	1	105.60	105.60	3.09
3. Retention test	1	235.20	235.20	13.38**
Within Groups				
Computer				
4. Pre & Post test	1	1411.20	1411.20	61.27**
5. Post &Ret. test	1	11.25	11.25	.48
Worksheet				
6. Pre & Post test	1	693.38	693.38	35.13**
7. Post &ret. test	1	80.66	80.66	2.90
8. Interaction	2	197.43	98.71	5.39**

In #1,2, and 3 df=1,20 $*p < .05$ F critical= 4.35
$**p < .01$ F critical= 8.10
In #4 and 5 df=1,18 $*p < .05$ F critical= 4.41
$**p < .01$ F critical= 8.28
In #6 and 7 df=1,22 $*p < .05$ F critical= 4.30
$**p < .01$ F critical= 7.94
In # 8 df=2,40 $*p < .05$ F critical= 3.23
$**p < .01$ F critical= 5.18

Examination of the data reveals that:

a) there was no significant difference between the two groups at the pretest and posttest levels, however, there was a significant difference in retention-test scores (.01 level). The possible explanation of this result is given in the following chapter.

b) Although both groups have shown a significant gain over time this increase is greater for the Computer group.

c) Both groups have obtained lower scores on retention-tests, however, even though the difference between the post and retention-tests is not statistically significant for either of the two groups there is a greater drop change in case of the Worksheet group.

Summary

The results of this study indicate, that although both groups have shown significant increase in achievement over time, there was no significant difference between the means obtained by the Computer and the Worksheet groups in any of the operations tested.

Significant interaction between these two groups occurred in division of decimals. To determine the cause of this interaction, the test for simple main effects was used (Table 10). The test revealed a significant (.01 level) difference between the means obtained by these two groups on the retention-test.

CHAPTER V

DISCUSSION

Introduction

This study was conducted to answer two basic questions:

1) Are computerized drill and practice programs as effective as worksheets?

2) Can we in Manitoba, duplicate some of the positive results obtained in Computer Assisted Instruction elsewhere?

Twenty-two grade seven students were divided randomly into two groups. Both groups received regular classroom instruction followed by 10 minutes of drill exercises in an appropriate, for the group, mode.

The author approached this experiment with a hypothesis that there will be no significant difference in achievement between these two groups on any of the operations tested.

Discussion

The statistical analysis of the data obtained in this study supported acceptance of all null hypotheses. There was no significant difference, in achievement, between the Computer and the Worksheet groups, in any of the operations tested or in the overall performance. However, looking at these results from another point of view, the results have demonstrated, that even with our present resources, the computer directed drill and practice programs are as effective as worksheets.

As one might have expected, both groups have shown very significant increase in achievement, in all operations, over time (between the pretest and posttest).

It is interesting to note that graphs "a" and "c" in figure 6 indicate, that while in the Computer group there was practically no difference between the means on the posttest and retention-test, the corresponding means obtained by the Worksheet group showed marked decrease. In division of integers (graph 6c), both groups show increase in competency between the post and retention-tests, however, in case of the computer group, this increase is more prominent.

Only one operation has shown a significant (.01 level) interaction. This occurred in division of decimals. To pinpoint the cause of this interaction, the author has employed a test for simple main effects. The result of this analysis indicates that this was due to the significantly higher (.01 level) result, obtained by the Computer group, on the retention-test. This result is in agreement with the previously stated observation that the scores on the retention-tests are generally in favour of the Computer group. The author can see two possible explanations of these results:

a) One reason may be the fact that there is a great similarity in appearance between tests and worksheets. Students working on worksheets were doing this paper and pencil work 28 times prior to the retention-test as compared with only eight times for the members of the Computer group (pretest and posttest). This repetition may have caused boredom and a lax attitude on the part of the Worksheet group.

b) The second reason could be higher motivational value of computer assisted drill exercises. The author tried to avoid the Hawthorne effect by allowing the members of the Worksheet group to use the terminal whenever it was not in use. However, the novelty of the experience could have motivated the students in the computer group to greater effort, which was reflected in higher retention of the learned material.

Conclusion

The results of this study have shown educational relevance and support for the use of CAI as a possible means for providing reinforcement drill and practice exercises. Some of the findings suggested by the results are: a) Computer Directed programs written by teachers and university students are effective enough to produce positive results.

b) Teachers are willing to co-operate when it comes to allowing students to leave their class to take part in such projects.

c) With very short instructions, students are capable of performing their own logging-in and logging-off procedures.

d) Although CAI is not the cheapest way of providing reinforcement exercises there are certain beneficial factors which may justify this expense. These are:

1) Students working at their own pace,

2) The level of difficulty of provided exercise problems is suitable for each student,

3) Immediate feedback on performance,

4) Remedial instruction provided when and where needed.

Recommendations

On the basis of his experiences derived from this study, the author feels that there are three important recommendations that should be considered by anyone trying to perform similar experiments. These are:
a) the sizes of samples should be larger
b) the computer terminal should be located in a place which does not provide any unnecessary distractions
c) there should be a full-time supervisor (a teacher, volunteer or a senior student) who overlooks such projects. Implementation of these recommendations would make the results more reliable.

Summary

Over all, the results of this study did not show statistical significance.

Graphical representation of the relationship which existed between the means, on the pretest, posttest, and the retention-test, and the Computer and the Worksheet groups, indicates better, although not statistically significant results, in favour of the computer group.

In view of numerous physical limitations, faced by the Computer group, the fact that its' achievement was at least as good as that of the Worksheet group, raises hope for the future.

The small size of the samples as well as other physical limitations, make the results of this study unreliable.

The author feels that more efficient use of the terminal combined with the inherent positive characteristics of CAI such as:

a) high motivational value of this mode of reinforcement,

b) high degree of individualization of instruction,

c) immediate feedback on performance,

d) reinforcement provided when and where needed,

make this method of presenting drill exercises a possible alternative to worksheets and a viable change to the traditional methods of providing reinforcement material.

EPILOGUE

New Developments and Their Implications

Until recently the two major obstacles which prevented widespread use of computers were:

a) high cost,

b) large size.

New developments in microelectronics, reported in the September (1977) issue of Scientific American such as:

1) Large Scale Integration

2) Photolitography

3) Batch Processing of Wafers

4) Dry Plasma Etching

5) Refinement in Circuit Structure

removed these obstacles and placed the computer within the reach of not only small businesses, but also private individuals.

This great step forward in computer technology is reflected in the dramatic cost reduction. A computer which 15 years ago, sold for 20 million dollars, can be purchased now for $1000. By 1985, a medium sized computer will cost about $100 (Holton, Scientific American, September, 1977, p.84). By 1980, everyone will be able to own a personal computer with the capability of present mini-computers and the size of a large textbook.

A good example of this trend toward cheaper and smaller data processors is the Apple II computer.

It can be purchased for $1298. It is programmable in BASIC, has 8K byte memory with the possibility of adding more. It has a cassette interface, keyboard, speakers and composite video output.

John Burry in his article "Here Come the (Home) Computers" (A Canadian Family Magazine, Volume 5, Number 5, Fall 1977; p. 32) predicts that in two years everyone will be able to purchase a mini-computer"...at your local department store for just a few hundred dollars.". This computer will be able to control the home physical environment (temperature and humidity), store such information as mailing lists, financial transactions, birthdays etc., provide entertainment in form of music and/or games, and be used as a teaching tool. Burry feels, that the only reason why computer manufacturers do not put them on a market at this time is the general public's mistrust of computers. To overcome this problem the producers decided on a gradual approach. First they want the consumer to get use to the idea of playing with computers (this is where all those video games come in).

In the near future, Commodore Business Machines, a manufacturer of hand-held calculators, intends to introduce a home/business computer called PET (Personal Electronic Translator). This computer should retail in Canada for about $700. It will consist of a keyboard input, video output, and a built-in cassette recorder which will serve to store programs and data.

With 4000 bytes of memory built in for programming, it can handle 12,000 bits of information. If necessary, the user will be able to plug in optional 16,000 bit units. As recently as two years ago a computer of equivalent capability would have cost approximately $10,000 and required a space of an average size bedroom. PET is a little larger than a breadbox.

These are only some examples of the general trend toward cheaper and more compact computers.

It is actually at present less costly and less troublesome to own a minicomputer than to rent the least expensive interactive computer terminal. This fact makes it possible for schools to acquire a minicomputer using the funds from their regular budgetary allotment. Garden City Collegiate Institute in the Seven Oaks School Division in Winnipeg purchased a PET computer as part of their Audio-Visual equipment. If PET performs up to the expectations West St. Paul may be the next school in the division to buy one. And then, it is possible that there will be at least one minicomputer in every school. When this happens teachers will have a very powerful tool to help them in their task to prepare their students for the future life in a computerized societty.

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APPENDICES

APPENDIX A

Brueckner Diagnostic Test

SCORE (Score is number of examples wrong or incomplete)	Diagnose one set of examples in a class period				
	SET I (All Grades)				
	a	b	c	d	e
1	8 7	32 3	20 4	51 3	912 4
2	430 2	700 5	601 3	2019 6	507 7
3	3060 9	98 5	516 6	581 8	578 9
	SET II				
4	12 21	432 21	430 43	612 50	312 700
5	432 805	4002 69	78 63	54 75	369 78
6	849 490	709 796	9008 123	6070 824	628 705
	SET III				
7	$.02 4	$.06 9	$3.20 5	$16.40 80	$.10 90
8	$.05 14	$30.60 265	$46.00 46	7865 2300	7859 958
9	7006 1004	9070 3069	8053 4609	2597 8000	4005 7000
TOTAL SCORE					

In set III the emphasis was placed on correctnes of digits. Students were told to disregard the decimal point.

2.3 .5	3.62 .01	1.002 2.2	25 .2
2.04 .02	35.2 1.21	.09 .03	2.025 2.22
.025 .01	2.34 .001	15.010 .201	.0231 2.055

There was no test dealing exclusively with multiplication of decimals, therefore, the author was forced to devise this test.

[redacted]

DIVISION PROCESS

EXAMPLES

One Figure Division

Row	Score (Score is 0 if wrong or incomplete)	a	b	c	d	e
		SET I —				
1.		2)64	2)482	2)608	3)560	4)806
2.		3)216	2)816	4)185	3)905	4)246
		SET II —				
3.		3)902	5)254	2)819	4)96	6)972
4.		7)94	5)867	3)282	4)347	8)3720
Total Score						

Row	Score	a	b	c	d	e
		SET I —				
1.		20)40	20)44	21)42	32)69	20)54
2.		40)160	35)105	29)275	63)428	14)74
		SET II —				
3.		300)600	400)840	320)640	212)896	431)975
4.		800)4800	320)1600	582)1877	364)2269	152)1234
Total Score						

DIVISION PROCESS

A. Dividing by whole numbers.

Can you work all these division examples?

1. 4) 8.4	2. 3) 7.47	3. 8) 16.896
4. 2) .8	5. 4) .76	6. 6) .972
7. 4) .12	8. 6) .042	9. 24) 1.2
10. 8) 4	11. 8) 6	12. 25) 2
13. 25) 64	14. 33) 87	15. 25) 8.725

B. Dividing by decimals.

16. .3) 3.6	17. .3) 18.63	18. .4) 1.2
19. .3) 6	20. .2) 10	21. .4) 3
22. .7) 4	23. .11) 1.21	24. .11) 1.342
25. .11) 3.3	26. .12) 6	27. .12) 9
[illegible] 1.25) 6.75	29. 6.48) 7.128	30. .834) 91.74

APPENDIX B

Sample Computer Programs and Results

```
HELO MY NAME IS KRONOS ,WHAT IS YOUR FIRST NAME ? CHUCK

WHAT IS YOUR LAST NAME CHUCK? CLARK

WHAT GRADE ARE YOU IN CHUCK ? 7

 I AM VERY PLEASED YOU CAME CHUCK.

USE PAPER AND PENCIL TO CALCULATE THE ANSWER AND THEN
TYPE IT IN ONE LINE AT A TIME WHEN I ASK YOU FOR IT.

HOW MANY PROBLEMS WOULD YOU LIKE TO TRY ? 6

WOULD YOU LIKE TO WORK WITH DECIMALS? YES OR NO ? NO
HOW MANY DIGITS DO YOU WANT TO MULTIPLY
? 2

HOW MANY DIGITS DO YOU WANT TO MULTIPLY BY
? 1
```

```
VERY WELL CHUCK ,HERE WE GO.



   ******* PROBLEM # 1    *******

                 75
                  9
           X-----------
              ? 675

VERY GOOD  THE ANSWER IS  675


   ******* PROBLEM # 2    *******

                 93
                  6
           X-----------
              ? 558

 EXCELLENT THE ANSWER IS  558


   ******* PROBLEM # 3    *******

                 46
                  2
           X-----------
              ? 92

 EXCELLENT  THE ANSWER IS  92
EXCELLENT CHUCK YOU HAVE TRIED  3  PROBLEMS
OUT OF THESE YOU ANSWERED  3  CORRECTLY

YOUR MARK IS  100 PERCENT.
***************************

IT WAS A PLEASURE TO WORK WITH YOU
IT SEEMS TO ME THAT YOU KNOW THIS OPERATION VERY WELL.

WOULD YOU LIKE TO TRY SOME M88ELDWERIODBTORNQ0QCYE3
YES OR NO ? YES

        ::::::::::::::::::::::::::::::
         ****** NEXT  TRY  *********
        ::::::::::::::::::::::::::::::


HOW MANY PROBLEMS WOULD YOU LIKE TO TRY ? 5

VERY WELL CHUCK ,HERE WE GO.
```

```
******* PROBLEM # 4    *******

              93
              46
       X----------
           ? 4278
SORRY CHUCK, THIS IS NOT CORRECT
CHECK YOUR MULTIPLICATION AND TRY AGAIN.


              93
              46
       X----------
           ? 4278
THE ANSWER SHOULD BE  558


******* PROBLEM # 5    *******

              55
              64
       X----------
           ? 220
          ? 330
     -------------
          ? 550
NO CHUCK, THIS IS NOT CORRECT.

CHECK YOUR ADDITION AND TRY AGAIN.

     -------------
          ? 33220
NO CHUCK, THIS IS NOT CORRECT.
 THE ANSWER SHOULD BE  3520


******* PROBLEM # 6    *******

              82
              32
       X----------
           ? 164
          ? 246
     -------------
          ? 2624

 OUT OF SIGHT THE ANSWER IS  2624
```

```
****     PROBLEM # 7     *******

                75
                81
          X-----------
               ? 75
             ? 620
        --------------
             ? 6075


 RIGHT ON THE ANSWER IS  6075
WELL CHUCK. IT COULD BE BETTER.


YOU HAVE TRIED  7  PROBLEMS AND OUT OF THESE
YOU GOT  5  CORRECTLY.

YOUR MARK IS  71.408
                          +-+-+-+-+-+-+-+-+-+-+-+-+-

YOU SHOULD DO MORE WORK ON SUCH PROBLEMS  SO COME
TO SEE ME AGAIN.

GOOD BYE CHUCK.

COME TO SEE ME AGAIN.
```

```
HELO MY NAME IS KRONOS ,WHAT IS YOUR FIRST NAME ? BENNY

WHAT IS YOUR LAST NAME BENNY? H

WHAT GRADE ARE YOU IN BENNY ? 7

 I AM VERY PLEASED TO

USE PAPER AND PENCIL TO CALCULATE THE ANSWER AND THEN
TYPE IT IN ONE LINE AT A TIME WHEN I ASK YOU FOR IT.

HOW MANY PROBLEMS WOULD YOU LIKE TO TRY ? 5

WOULD YOU LIKE TO WORK WITH DECIMALS? YES OR NO ? NO
HOW MANY DIGITS DO YOU WANT TO MULTIPLY
? 2

HOW MANY DIGITS DO YOU WANT TO MULTIPLY BY
? 2

VERY WELL BENNY ,HERE WE GO.

   ******* PROBLEM # 1    *******

                 96
                 14
            X-----------
               ? 2436
SORRY BENNY, THIS IS NOT CORRECT
CHECK YOUR MULTIPLICATION AND TRY AGAIN.

                 96
                 14
            X-----------
               ? 564
THE ANSWER SHOULD BE  384
```

```
 ******* PROBLEM # 2   *******

                65
                44
           X----------
             ? 60
SORRY BENNY. THIS IS NOT CORRECT
CHECK YOUR MULTIPLICATION AND TRY AGAIN.



                65
                44
           X----------
             ? 60
THE ANSWER SHOULD BE  260



 ******* PROBLEM # 3   *******

               60
                94
           X----------
             ? 240
           ? 540
        --------------
           ? 0 .
              780
NO BENNY, THIS IS NOT CORRECT.

CHECK YOUR ADDITION AND TRY AGAIN.
        -----?--------
              780
NO BENNY, THIS IS NOT CORRECT.
 THE ANSWER SHOULD BE  5640
THIS IS NOT TOO GO4!+NNY. YOU HAVE MADE THREE MISTAKES
IN A ROW

YOU HAVE TO BE MORE CAREFULL IN YOUR WORK.

LETS TRY SOMETHING EASIER.


 ******* PROBLEM # 4   *******

                43
                 9
           X----------
             ? 407
NO BENNY, THIS IS NOT CORRECT.
 THE ANSWER SHOULD BE  387
```

THIS WAS NOT SO GOOD BENNY.

YOU MISSED THREE SIMPLE QUESTIONS IN A ROW
YO SHOULD GO AND TALK ABOUT YOUR DIFFICULTIES WITH
YOUR TEACHER.

GOOD BYE BENNY.

COME TO SEE ME AGAIN.

```
HELO MY NAME IS KRONOS ,WHAT IS YOUR FIRST NAME ? KEVEM

WHAT IS YOUR LAST NAME KEVEM? KINASCHUK

WHAT GRADE ARE YOU IN KEVEM ? 7

 I AM VERY PLEASED YOU CAME KEVEM.

USE PAPER AND PENCIL TO CALCULATE THE ANSWER AND THEN
TYPE IT IN ONE LINE AT A TIME WHEN I ASK YOU FOR IT.

HOW MANY PROBLEMS WOULD YOU LIKE TO TRY ? 6


WOULD YOU LIKE TO WORK WITH DECIMALS? YES OR NO ? NO
HOW MANY DIGITS DO YOU WANT TO MULTIPLY
? 2


HOW MANY DIGITS DO YOU WANT TO MULTIPLY BY
? 2



VERY WELL KEVEM ,HERE WE GO.



   ******* PROBLEM # 1    *******

                   92
                   27
           X-----------
                ? 644
             ? 184
```

```
              --------------
                 ? 2484

 VERY GOOD  THE ANSWER IS  2484


   ******* PROBLEM # 2   *******

                      14
                      28
              X-----------
                 ? 28112
            --------------
                 ? 392

 EXCELLENT THE ANSWER IS  392


   ******* PROBLEM # 3   *******

                      37
                      26
              X-----------
                   ? 222
                 ? 74
            --------------
                 ? 962

 EXCELLENT  THE ANSWER IS  962
EXCELLENT KEVEM YOU HAVE TRIED  3  PROBLEMS
OUT OF THESE YOU ANSWERED  3  CORRECTLY

YOUR MARK IS  100  PERCENT.
**************************

IT WAS A PLEASURE TO WORK WITH YOU
IT SEEMS TO ME THAT YOU KNOW THIS OPERATION VERY WELL.


WOULD YOU LIKE TO TRY MORE PROBLEMS? YES OR NO? NO
GOOD BYE KEVEM.

COME TO SEE ME AGAIN.
```

```
 75/10/09. 11.00.01.
PROGRAM   MULTJB

HELO MY NAME IS KRONOS ,WHAT IS YOUR FIRST NAME ? CHUCK


WHAT IS YOUR LAST NAME CHUCK? CLARK

WHAT GRADE ARE YOU IN CHUCK ? 7

 I AM VERY PLEASED YOU CAME CHUCK.

USE PAPER AND PENCIL TO CALCULATE THE ANSWER AND THEN
TYPE IT IN ONE LINE AT A TIME WHEN I ASK YOU FOR IT.

HOW MANY PROBLEMS WOULD YOU LIKE TO TRY ? 5


WOULD YOU LIKE TO WORK WITH DECIMALS? YES OR NO ? YES
HOW MANY DIGITS DO YOU WANT TO MULTIPLY
? 2


 HOW MANY DECIMAL PLACES DO YOU WANT IN THIS NUMBER ? 1
HOW MANY DIGITS DO YOU WANT TO MULTIPLY BY
? 1

HOW MANY DECIMAL PLACES DO YOU WANT IN THIS NUMBER  ? 1


VERY WELL CHUCK ,HERE WE GO.




   ******* PROBLEM # 1   *******

                  8.6
                   .1
          X-----------
               ? .86

 VERY GOOD  THE ANSWER IS  .86


   ******* PROBLEM # 2   *******

                  7.6
                   .6
          X-----------
```

```
                ? 4.56

 EXCELLENT THE ANSWER IS  4.56


   ******* PROBLEM # 3    *******

                   5.7
                    .8
           X------------
               ? 4.56


 EXCELLENT  THE ANSWER IS  4.56
EXCELLENT CHUCK YOU HAVE TRIED  3  PROBLEMS
OUT OF THESE YOU ANSWERED  3  CORRECTLY

YOUR MARK IS  100  PERCENT.
*************************

IT WAS A PLEASURE TO WORK WITH YOU
IT SEEMS TO ME THAT YOU KNOW THIS OPERATION VERY WELL.


WOULD YOU LIKE TO TRY MORE PROBLEMS? YES OR NO? YES
WOULD YOU LIKE TO TRY SOME MORE DIFFICULT PROBLEMS?
YES OR NO ? YES


        ::::::::::::::::::::::::::::::
         ****** NEXT  TRY  *********
        ::::::::::::::::::::::::::::::


HOW MANY PROBLEMS WOULD YOU LIKE TO TRY ? 3


VERY WELL CHUCK ,HERE WE GO.



   ******* PROBLEM # 4    *******

                  3.6
                  6.7
           X-----------
                ? 252
              ? 216
        --------------
              ? 24.12


OUT OF SIGHT THE ANSWER IS  24.12
```

```
 75/10/14. 14.25.41.
PROGRAM   DIVIDE

THIS IS A DRILL IN DIVISION FOR REMEDIATION.

HI, THERE. WHAT IS YOUR FIRST NAME? DONALD

WHAT IS YOUR LAST NAME, DONALD? YOUNG

HOW MANY PROBLEMS (FROM 1 TO 15) WOULD YOU LIKE TO DO ? 5

DO YOU WANT TO WORK WITH DECIMALS ? YES

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

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

HOW MANY DECIMAL PLACES (FROM 0 TO  2 ) IN DIVIDEND ? 0

HOW MANY DIGITS (FROM 1 TO  2 ) IN THE DIVISOR? 1

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


                 -------
      3          ) 53

= ? 176←.66

VERY GOOD, DONALD. THAT IS CORRECT. THE ANSWER IS  17.6667 .


                 -------
      4          ) 36

= ? 9

EXCELLENT, DONALD. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS  9 .


                 -------
      1          ) 59

= ? 59
```

```
EXCELLENT, DONALD. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS  59 .


               -------
     8         )  56

= ? 7

EXCELLENT, DONALD. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS  7 .


               -------
     7         )  97

= ? 13.85

EXCELLENT, DONALD. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS  13.8571 .

THE DRILL IS OVER, DONALD.

NUMBER OF PROBLEMS ATTEMPTED:  5

NUMBER OF PROBLEMS CORRECT:  5

PERCENTAGE:  100

WOULD YOU LIKE TO DO SOME MORE PROBLEMS ? YES

HOW MANY PROBLEMS (FROM 1 TO 15) WOULD YOU LIKE TO DO ? 5

DO YOU WANT TO WORK WITH DECIMALS ? YES

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

 JOB ACTIVE.

HOW MANY DIGITS (FROM 1 TO 9) DO YOU WANT IN DIVIDEND ? 1

HOW MANY DECIMAL PLACES (FROM 0 TO  1 ) IN DIVIDEND ? 1

HOW MANY DIGITS (FROM 1 TO  1 ) IN THE DIVISOR? 1

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


               -------
     .6        )  .7

= ? 1.16
```

EXCELLENT, DONALD. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS 1.1667 .

```
                 -------
      .7        ) .7
```

= ? .1

SORRY, DONALD. THAT IS WRONG. THE ANSWER IS 1 .

```
                 -------
      .7        ) .8
```

= ? 1.14

TREMENDOUS, DONALD. THAT IS RIGHT. THE ANSWER IS 1.1429 .

```
                 -------
      .9        ) .9
```

= ? 1.

VERY GOOD, DONALD. THAT IS CORRECT. THE ANSWER IS 1 .

```
                 -------
      .4        ) .4
```

= ? .1

SORRY, DONALD. THAT IS WRONG. THE ANSWER IS 1 .

THE DRILL IS OVER, DONALD.

NUMBER OF PROBLEMS ATTEMPTED: 10

NUMBER OF PROBLEMS CORRECT: 8

PERCENTAGE: 80.

WOULD YOU LIKE TO DO SOME MORE PROBLEMS ? NO

GOOD-BYE, DONALD. HAVE A NICE DAY.

```
 75/10/10. 13.54.23.
PROGRAM   DIVIDE

THIS IS A DRILL IN DIVISION FOR REMEDIATION.

HI, THERE. WHAT IS YOUR FIRST NAME? CHUCK
WHAT IS YOUR LAST NAME, CHUCK ? CLARHK


HOW MANY PROBLEMS (FROM 1 TO 15) WOULD YOU LIKE TO DO ? 5


DO YOU WANT TO WORK WITH DECIMALS ? YES


HOW MANY DECIM L LACES (FROM 0 TO 5) WILL YOU
HAVE IN YOUR ANSWER ? 1


OWMANY DIGITS (FROM 1 TO 9) DO YOU WANT IN DIVIDEND ? 33
CHOOSE MORE CAREFULLY.

HOW MANY DIGITS (FROM 1 TO 9) DO YOU WANT IN DIVIDEND ? 3

HOW MANY DECIMAL PLACES (FROM 0 TO  3 ) IN DIVIDEND ? 0


HOW MANY DIGITS (FROM 1 TO  3 ) IN THE DIVISOR? 1

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




                 -------
        4        ) 271

= ? 67.75

EXCELLENT, CHUCK. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS  67.75 .


                 -------
        8        ) 299

= ? 37.37

EXCELLENT, CHUCK. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS  37.375 .



                 -------
```

```
        5        )  249

= ? 49.80

EXCELLENT, CHUCK. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS  49.8 .

                 -------
        8        )  780

= ? 97.50

EXCELLENT, CHUCK. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS  97.5 .

                 -------
        1        )  16

= ? 16.00

THREMENDOUS, CHUCK. THAT IS RIGHT. THE ANSWER IS  16 .

THE DRILL IS OVER, CHUCK.

NUMBER OF PROBLEMS ATTEMPTED:  5

NUMBER OF PROBLEMS CORRECT:  5

PERCENTAGE:  100

WOULD YOU LIKE TO DO SOME MORE PROBLEMS ? NO

GOOD-BYE, CHUCK. HAVE A NICE DAY.

CP          0.558 SECS.
```

```
RUN

 75/10/17. 10.58.17.
PROGRAM   DIVIDE

THIS IS A DRILL IN DIVISION FOR REMEDIATION.

HI, THERE. WHAT IS YOUR FIRST NAME? KEVEN

WHAT IS YOUR LAST NAME, KEVEN ? KINASCHUK

HOW MANY PROBLEMS (FROM 1 TO 15) WOULD YOU LIKE TO DO ? 6

DO YOU WANT TO WORK WITH DECIMALS ? YES

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

HOW MANY DIGITS (FROM 1 TO 9) DO YOU WANT IN DIVIDEND ? 3

HOW MANY DECIMAL PLACES (FROM 0 TO  3 ) IN DIVIDEND ? 1

HOW MANY DIGITS (FROM 1 TO  3 ) IN THE DIVISOR? 1
HOW MANY DECIMAL PLACES (FROM 0 TO  1 ) IN DIVISOR? 0



                 -------
      8         )  22

 = ? 2.5
THAT IS NOT CORRECT. THE ANSWER IS  2.75 .


                 -------
      1         )  94.2

 = ? 94.2

EXCELLENT, KEVEN. THAT IS ABSOLUTELY CORRECT.
THE ANSWER IS  94.2 .


                 -------
      2         )  56.3

 = ? 28.15

SUPERB, KEVEN.  28.15  IS THE CORRECT ANSWER.
```

```
                 -------
      9        )  30.7

= ? 3.41

SUPERB, KEVEN.  3.4111  IS THE CORRECT ANSWER.


                 -------
      5        )  69.5

= ? 13.9

VERY GOOD, KEVEN. THAT IS CORRECT. THE ANSWER IS  13.9 .


                 -------
      7        )  69.7

= ? 9.11
THAT IS NOT CORRECT. THE ANSWER IS  9.9571 .

THE DRILL IS OVER, KEVEN.

NUMBER OF PROBLEMS ATTEMPTED:  6

NUMBER OF PROBLEMS CORRECT:  4

PERCENTAGE:  66.6667

WOULD YOU LIKE TO DO SOME MORE PROBLEMS ? NO
GOOD-BYE, KEVEN. HAVE A NICE DAY.
```

APPENDIX C

Sample Worksheets

MULTIPLICATION #1 Name_ _ _ _ _ _ _ _

1 x 6	10 x3	1 x4	7 x9
5 X 6	68 x 3	89 x 7	15 x 4
27 x 9	25 x 8	209 x 9	1000 x 10
476 x 2	329 x 7	480 x 3	6026 x 64
4281 x 21	9536 x 46	3221 x 15	98424 x 96
1901398 x 965	7576031 x 596	6956125 x 260	

MULTIPLICATION # 6 Name__________

65 x23	37 x 28	4.7 x2.9	88 x 54
951 x 3.6+	407 x .05	2.58 x 64	39.7 x 2.5
34.57 x 2.56	2.075 x 3.01	2.999 x .001	
45.67 x .089	3.679 x 54.3		

MULTIPLICATION #9

Name _ _ _ _ _ _ _

3.5 x 2.1

4.6 x .7

2.8 x 9.7

3.9 x 1.2

4.56 x 2.0

8.7 7 x 6.5

9.58 x .01

.587 x 3.2

3.567 x 2.45

89.64 x 21.5

999.2 x 1.11

78.567 x 3.564

8799.3 x 4.598

3.7895 x 35.75

DIVISION #2 Name_ _ _ _ _ _ _ _ _

$5\overline{)1230}$	$7\overline{)245}$	$9\overline{)2361}$
$12\overline{)2460}$	$18\overline{)1980}$	$37\overline{)5679}$
$121\overline{)12516}$	$358\overline{)45987}$	$282\overline{)70593}$
$100\overline{)10}$	$200\overline{)605}$	$1000\overline{)10}$

DIVISION # 3 Name_ _ _ _ _ _ _ _ _

3) 12.6	5) 12.45	9) 38.297
11) 156.4	76) .5934	25) 2.100
10) 1	100) 1	1000) 1
10) 25	10) 136	10) 3567
100) 25	100) 136	100) 35877.

DIVISION # 4 Name_ _ _ _ _ _ _ _

5) 35.55	7) 39.49	8) 9.36
12) 789.64	93) 9.393	53) 25.64
131) 356.73	256) 57.298	455) 9.000

DIVISION #5

Name _ _ _ _ _ _ _

.5) 10	.3) 25	.4) 75
.9) 87	.6) 35.7	.2) 35.5
.35) 70	.12) 56	.38) 76
3.5) 70	1.2) 56	3.8) 76

DIVISION #6

Name_ _ _ _ _ _ _ _

2.5) 10

3.6) 11.80

.45) 9.56

7) 5.6

.9) 35.67

1.1) 1235

3.123) 5.678

.189) 5

APPENDIX D

Raw Score Data, Means and Standard Deviation Tables

TABLE 11

Raw Data, Means and Standard Deviations

Computer Group

	MULTIPLICATION						DIVISION					
	INTEGERS			DECIMALS			INTEGERS			DECIMALS		
	Pre.	Post	Ret.	Pre.	Post	Ret.	Pre.	Post	Ret.	Pre.	Post	Ret.
1	30	37	36	1	12	11	1	9	10	3	15	16
2	19	32	32	0	11	10	4	6	11	0	20	8
3	28	31	31	0	11	11	7	15	22	2	25	29
4	30	35	27	2	12	12	0	9	11	0	25	20
5	22	29	37	0	9	9	13	11	17	0	22	21
6	17	15	12	0	0	1	1	0	0	5	4	4
7	27	28	33	2	11	12	9	10	8	3	18	22
8	31	28	34	0	12	12	12	10	13	7	21	23
9	28	41	38	11	11	12	9	17	15	6	21	15
10	18	23	22	0	11	9	5	10	5	0	23	21
$\bar{X}$	25.0	29.9	30.2	1.6	9.0	9.9	6.1	9.7	11.2	2.6	19.4	17.9
S.D	5.4	7.3	8.0	3.4	4.6	3.3	4.7	4.6	6.2	2.7	6.2	7.4

TABLE 12

Raw Data, Means and Standard Deviations

Worksheet Group

	MULTIPLICATION						DIVISION					
	INTEGERS			DECIMALS			INTEGERS			DECIMALS		
	Pre.	Post	Ret.	Pre.	Post	Ret.	Pre.	Post	Ret.	Pre.	Post	Ret.
1	20	33	37	1	9	7	2	5	0	0	15	6
2	28	38	37	0	10	10	7	19	15	6	14	7
3	20	26	27	2	2	0	7	0	8	4	6	10
4	7	22	24	0	12	12	0	3	2	3	14	9
5	22	27	25	0	10	12	7	10	7	0	18	9
6	26	36	37	1	6	12	8	12	19	8	24	20
7	39	35	40	2	12	6	7	15	20	8	25	16
8	18	22	27	0	8	5	0	4	12	5	9	8
9	24	23	20	0	2	9	1	7	10	7	12	10
10	25	28	27	1	12	10	6	16	19	5	17	18
11	25	38	9	0	12	12	6	8	7	5	11	6
12	30	32	36	0	12	11	7	15	7	0	15	17
$\bar{x}$	23.7	30.0	28.8	.6	8.9	8.8	4.8	9.5	10.5	4.3	15.0	11.3
S.D.	7.6	6.1	9.0	0.8	3.3	3.7	3.1	6.0	6.6	3.0	5.5	5.0

TABLE 13

Raw Data, Means and Standard Deviations
Total Scores

Computer

	Pre.	Post	Ret.
1	35	73	73
2	23	69	61
3	37	82	93
4	32	81	70
5	35	71	84
6	23	19	17
7	41	67	75
8	50	71	32
9	54	90	80
10	23	67	57
$\bar{X}$	35.3	69.0	69.2
S.D.	10.3	15.[illegible]	20.1

Worksheet

	Pre.	Post	Ret.
1	23	62	50
2	41	81	69
3	33	34	45
4	10	51	47
5	29	65	53
6	43	78	38
7	56	87	82
8	23	43	52
9	32	44	49
10	37	73	74
11	36	69	34
12	37	74	71
$\bar{X}$	33.3	63.4	59.5
S.D.	11.1	16.2	16.0

APPENDIX E

Analysis of Variance Summary Tables for

Repeated Measure Design

Multiplication (Integers and Decimals)

Division (Integers and Decimals)

Table 14

Analysis of Variance Summary Table for Repeated Measures Design

Multiplication (Integers and Decimals)

Source of Variation	DF	SS	MS	F Ratio
A (Treatment)	1	21.31	21.31	0.218
Subj. w. groups	20	1957.56	97.88	
B (Math scores)	5	6586.89	3317.38	164.389**
AB	5	10.44	2.09	0.103
BX subj. w. groups	100	2018.00	20.18	
Totals	131	20600.88		

(1,20) * $p < .05$ F= 4.35

** $p < .01$ F= 8.0

(5,100) * $p < .05$ F= 2.30

** $p < .01$ F= 3.20

Table 15

Analysis of Variance Summary Table for Repeated Measures Design

Division (Integers and Decimals)

Source of Variation	DF	SS	MS	F Ratio
A (Treatment)	1	120.08	120.08	1.309
Subj. w. groups	20	1834.81	91.74	
B (Math scores)	5	3027.97	605.59	40.748**
AB	5	247.03	49.41	3.324 +
BX subj. w. groups	100	1486.19	14.86	
Totals	131	6596.13		

(1,20) * $p < .05$ F= 4.35

** $p < .01$ F= 8.0

(5,100) * $p < .05$ F= 2.30

** $p < .01$ F= 3.20

Box's Conservative Test

(4,99) + $p < .05$ F= 2.46

++ $p < .01$ F= 3.51

APPENDIX F

Listing of the MULTJB Program

```
00100 DIM A(10),N(10),R(10),L(10)
00110 LET C$(1)=EVERY GOOD E
00120 LET C$(2)=ETREMENDOUSE
00130 LET C$(3)=EEXCELLENT E
00140 LET C$(4)=EOUT OF SIGHTE
00150 LET C$(5)=ERIGHT ONE
00160 LET C$(6)=EWOWE
00170 LET C$(2)=EEXCELLENTE
00180 LET K$=EPROBLEMSE
00190 LET T$=ETHESEE
00200 LET J=K1=K2=K3=K4=1
205 LET K4=100000
00210 LET M=1
00220 LET C=C1=C2=C3=0
00230 LET C5=C6=C7=C8=0
00240 LET C4=1
00250 PRINTEHELO MY NAME IS KRONOS ,WHAT IS YOUR FIRST NAMEE:
00260 INPUT N$
00270 PRINT
00280 PRINT
00290 PRINTEWHAT IS YOUR LAST NAME EN$:
00300 INPUT L$
00310 PRINTEWHAT GRADE ARE YOU IN EN$:
00320 INPUT G
00330 PRINT
00340 IF G>3 THEN 00370
350 LET K4=6
00360 PRINT
00370 PRINTE I AM VERY PLEASED YOU CAME EN$E.E
00380 PRINT
00390 PRINTEUSE PAPER AND PENCIL TO CALCULATE THE ANSWER AND THENE
00400 PRINTETYPE IT IN ONE LINE AT A TIME WHEN I ASK YOU FOR IT.E
00410 PRINT
00420 PRINTEHOW MANY PROBLEMS WOULD YOU LIKE TO TRY E:
00430 INPUT C
00440 IF  C=1 THEN 02640
00450 IF C<1 THEN 01350
00460 IF C>19 THEN 01400
00470 PRINT
00480 LET C6=C6+C
00490  IF C4=0 THEN 00620
00500 PRINTEHOW MANY DIGITS DO YOU WANT TO MULTIPLYE
00510 INPUT K1
00520 LET P=0
00530 IF K1>5 THEN 01450
00540 PRINT
550 IF K4=6 THEN 620
00560 PRINTEHOW MANY DIGITS DO YOU WANT TO MULTIPLY BYE
00570 INPUT K2
00580 LET P=1
00590 PRINT
00600 IF K2>5 THEN 01450
00610 PRINT
00620 PRINT
00630 PRINT
00640 PRINTEOK. EN$E YOUR WISH IS MY COMMAND,HERE WE GOE
00650 PRINT
00660 LET C2=0
00670 PRINT
00680 LET M1=INT(RND(-1)*10**K1+.5)
00690 IF M1<10**(K1-1) THEN 00680
00700 LET M2=INT(RND(-1)*10**K2+.5)
00710 IF M2<10**(K2-1) THEN 00700
```

```
715 IF M2>K4 THEN 700
720 IF K4<>6 THEN 740
00730 IF M2>6 THEN 00700
00740 IF M2>M1 THEN 00680
00750 LET P=M1*M2
00760 LET A(1)=M2
00770 FOR J=1 TO K2
00780 LET A(J+1)=INT(A(J)/10**(K2-J))
00790  LET L(J)=A(J+1)
00800 LET A(J+2)=A(J)-A(J+1)*10**(K2-J)
00810 LET A(J)=A(J+1)
00820 LET A(J+1)=A(J+2)
00830 NEXT J
00840 LET A(J+1)=A(J)
00850 FOR J=1 TO K2
00860 LET R(J)=M1*L(K2-J+1)
00870 NEXT J
00880 LET C3=C3+1
00890 IF C3>C THEN 02320
00900 PRINT
00910 PRINT
00920 PRINT"    ******* PROBLEM "C3"   *******"
00930 PRINT
00940 PRINT
00950 PRINT
00960 FOR J=1 TO (20-K1)
00970 PRINT" ";
00980 NEXT J
00990 PRINT M1
01000 FOR J=1 TO (20-K2)
01010 PRINT" ";
01020 NEXT J
01030 PRINT M2
01040 PRINT"             X-----------"
01050 FOR I=1 TO K2
01060 FOR J=1 TO (18-K1-I)
01070 PRINT" ";
01080 NEXT J
01090 INPUT A1
01100 IF A1<>R(I) THEN 01510
01110 IF K2=1 THEN 01210
01120 NEXT I
01130PRINT"          --------------"
01140 FOR J=1 TO (18-K1-I)
01150 PRINT" ";
01160 NEXT J
01170 INPUT A
01180 IF A<>R THEN 01590
01190 PRINT
01200 PRINT
01210 PRINT "C$(M)" THE ANSWER IS "R
01220 LET M=M+1
01230 IF M<7 THEN 01300
01240 LET M=1
01250 LET C7=C7-1
01260 IF C7>0 THEN 01280
01270 LET C7=0
01280 PRINT
01290 PRINT
01300 LET C1=C1+1
01310 LET C8=C8+1
01320 IF C1=4 THEN 01760
01330 IF C1<C THEN 00680
```

```
01340 GO TO 02320
01350 PRINT≡SORRY ≡N$≡ YOU HAVE TO TRY SOME PROBLEMS≡
01360 PRINT≡PLEASE TRY AGAIN≡
01370 PRINT
01380 PRINT
01390 GO TO 00420
01400 PRINT≡WOW, THATS TOO MUCH ≡N$≡ TRY A NUMBER BETWEEN 1≡
01410 PRINT≡AND 20≡
01420 PRINT
01430 PRINT
01440 GO TO 00420
01450 PRINT≡SORRY ≡N$≡, TRY SOME SMALLER NUMBERS≡
01460 IF P=0 THEN 00500
01470 PRINT
01480 PRINT
01490 GO TO 00560
01500 IF C2=1 THEN 01570
01510 PRINT≡SORRY ≡N$≡, THIS IS NOT CORRECT≡
01520 PRINT≡CHECK YOUR MULTIPLICATION AND TRY AGAIN.≡
01530 LET C2=C2+1
01540 PRINT
01550 PRINT
01560 GO TO 00930
01570 PRINT≡NO ≡N$≡, THE ANSWER IS ≡R(I)
01580 GO TO 01700
01590 PRINT≡NO ≡N$≡, THIS IS NOT CORRECT.≡
01600 IF C7=1 THEN 01690
01610 PRINT
01620 PRINT≡CHECK YOUR ADDITION AND TRY AGAIN.≡
01630 LET C2=C2-1
01640 LET C7=C7+1
01650 IF C7>2 THEN 01690
01660 PRINT
01670 PRINT
01680 GO TO 01130
01690 PRINT≡THE ANSWER SHOUL BE ≡P
01700 LET C5=C5+1
01710 IF C5<3 THEN 00650
01720 IF K4=3 THEN 02140
01730 IF K2=1 THEN 02140
01740 LET K2=K2-1
01750 GO TO 02250
01760 PRINT≡THIS IS TREMENDOUS ≡N$
01770 PRINT
01780 PRINT≡YOU HAVE ANSWERED CORRECTLY FOUR QUESTIONS IN A ROW.≡
01790 PRINT≡IT SEEMS TO ME THAT YOU KNOW THIS OPERATION VERY WELL.≡
01800 PRINT
01810 PRINT
01820 PRINT≡WOULD YOU LIKE TO TRY MORE PROBLEMS? YES OR NO≡;
01830 INPUT A$
01840 LET C3=0
01850 LET C1=0
01860 LET Q=0
1870 IF A$=≡NO≡ THEN 2210
01880 LET Q=1
01890 IF A$=≡YES≡ THEN 01910
01900 GO TO 01960
01910 PRINT≡WOULD YOU LIKE TO TRY SOME MORE DIFFICULT PROBLEMS?≡
01920 PRINT≡YES OR NO≡;
01930 INPUT A$
01940 IF A$=≡YES≡ THEN 02020
01950 IF A$=≡NO≡ THEN 02050
01960 PRINT≡SORRY ≡N$≡ I CAN ONLY
```

```
01970 PRINT≡ANSWER. PLEASE TRY AGAIN≡
01980 PRINT
01990 PRINT
02000 IF Q=1 THEN 01820
02010 GO TO 01910
02020 LET K2=K2+1
2030 LET K4=10000
02040 LET C4=1
02050 PRINT
2055 GO TO 2070
02060 LET C4=0
02070 PRINT
02080 PRINT≡          !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!≡
02090 PRINT≡           ****** NEXT  TRY  ********* ≡
02100 PRINT≡          !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!≡
02110 PRINT
02120 PRINT
02130 GO TO 00420
02140 PRINT≡THIS WAS NOT SO GOOD ≡N$≡.≡
02150 PRINT
02160 PRINT≡YOU MISSED THREE SIMPLE QUESTIONS IN A ROW≡
02170 PRINT≡YOU SHOULD GO AND TALK ABOUT YOUR DIFFICULTIES WITH≡
02180 PRINT≡YOUR TEACHER.≡
02190 PRINT
02200 PRINT
02210 PRINT≡GOOD BYE ≡N$≡.≡
02220 PRINT
02230 PRINT≡COME TO SEE ME AGAIN.≡
02240 GO TO 02670
02250 PRINT≡THIS IS NOT TOO GOOD ≡N$≡. YOU HAVE MADE THREE MISTAKES≡
02260 PRINT≡IN A ROW≡
02270 PRINT
02280 PRINT≡YOU HAVE TO BE MORE CAREFULL IN YOUR WORK.≡
02290 PRINT
02300 PRINT≡LETS TRY SOMETHING EASIER.≡
02310 GO TO 00680
02320 LET P=C8/C6*100
02330 IF P>79 THEN 02480
02340 IF P<50 THEN 02560
02350 PRINT≡WELL ≡N$≡. IT COULD BE BETTER.≡
02360 PRINT
02370 PRINT
02380 PRINT≡YOU HAVE TRIED ≡C6≡ ≡K$≡ AND OUT OF ≡T$
02390 PRINT≡YOU GOT ≡C8≡ CORRECTLY.≡
02400 PRINT
02410 PRINT≡YOUR MARK IS ≡P≡ PERCENT.≡
02420 PRINT≡+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-≡
02430 PRINT
02440 PRINT≡YOU SHOULD DO MORE WORK ON SUCH PROBLEMS AND COME≡
02450 PRINT≡TO SEE ME AGAIN.≡
02460 PRINT
02470 GO TO 02210
02480 PRINT≡EXCELLENT ≡N$≡, YOU HAVE TRIED ≡C6≡ ≡K$
02490 PRINT≡OUT OF ≡T$≡ YOU ANSWERED ≡C8≡ CORRECTLY≡
02500 PRINT
02510 PRINT≡YOUR MARK IS ≡P≡ PERCENT.≡
02520 PRINT≡*************************≡
02530 PRINT
02540 PRINT≡IT WAS A PLEASURE TO WORK WITH YOU≡
02550 GO TO 01790
02560 PRINT≡THIS IS NOT SO GOOD ≡N$≡.≡
02570 PRINT≡YOU HAVE TRIED ≡C6≡ ≡K$≡ AND OUT OF ≡T$
02580 PRINT≡YOU ONLY GOT ≡C8≡ CORRECTLY≡
```

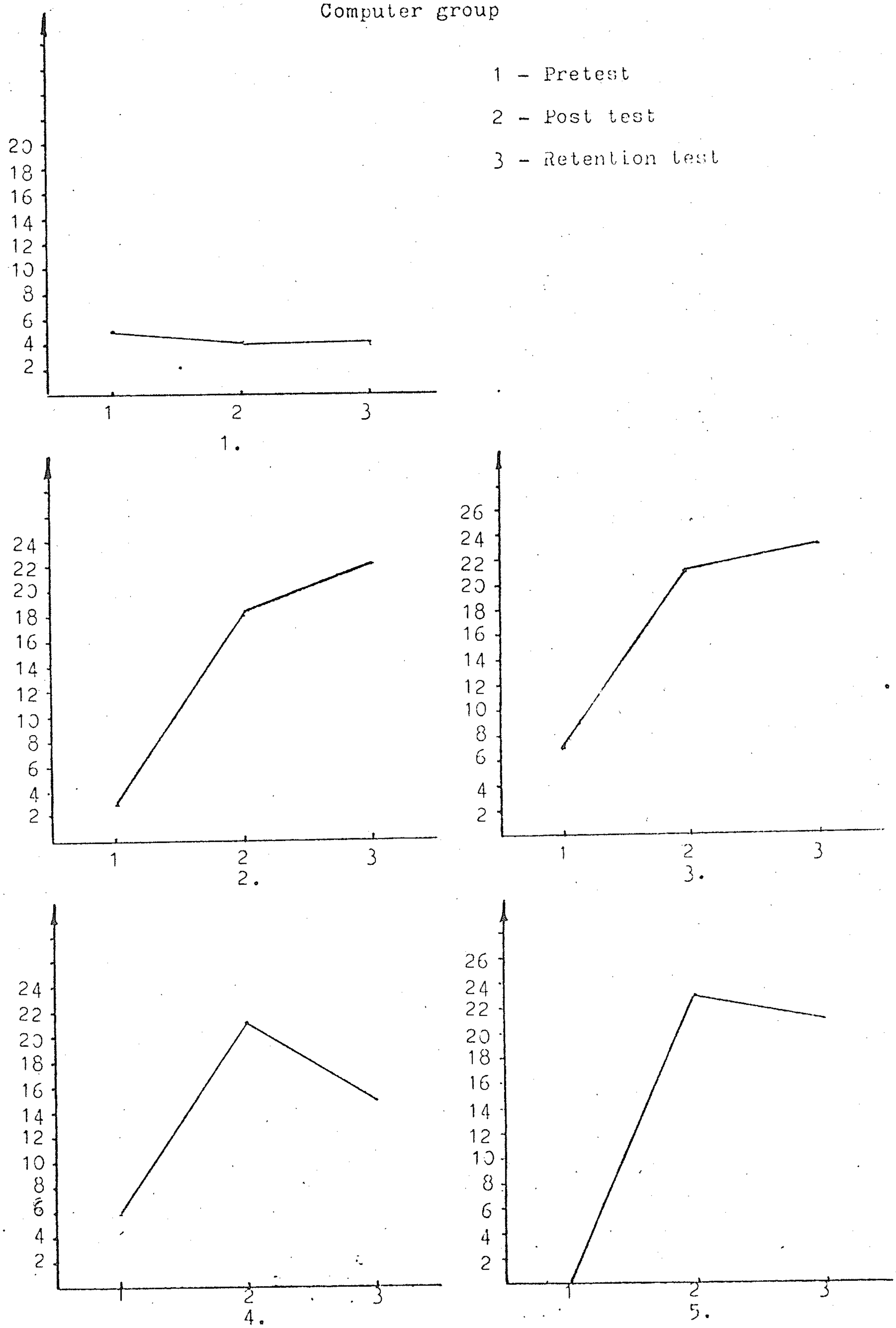
```
02590 PRINT
02600 PRINT≡YOUR MARK IS ≡P≡ PERCENT≡
02610 PRINT≡------------------------≡
02620 PRINT
02630 GO TO 02170
02640 LET K$=≡PROBLEM≡
02650 LET T$=≡THIS≡
02660 GO TO 00470
02670END
```

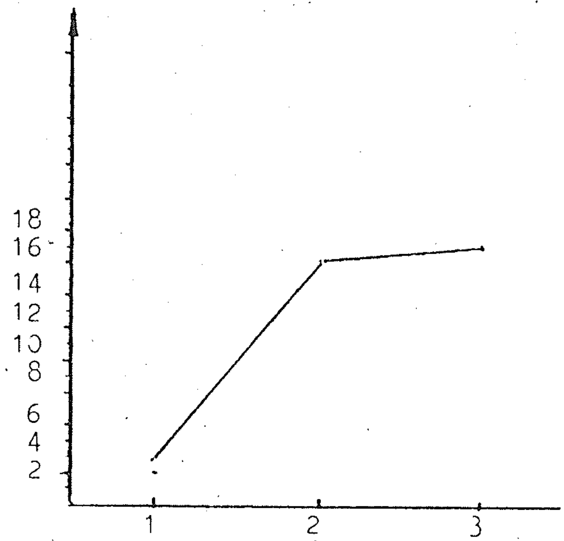
APPENDIX G

Graphs of individual results

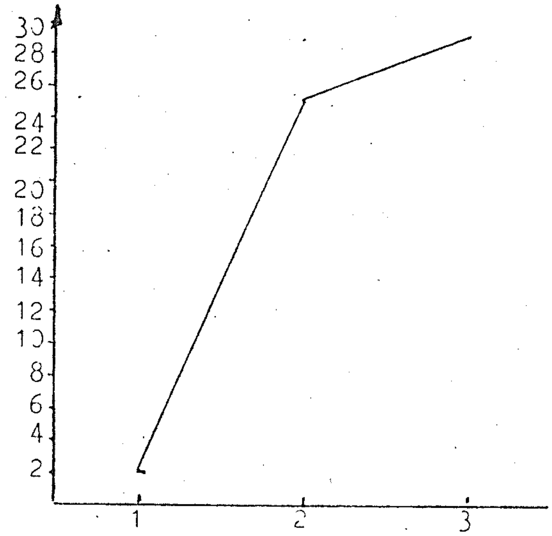
FIGURE 7

Computer group

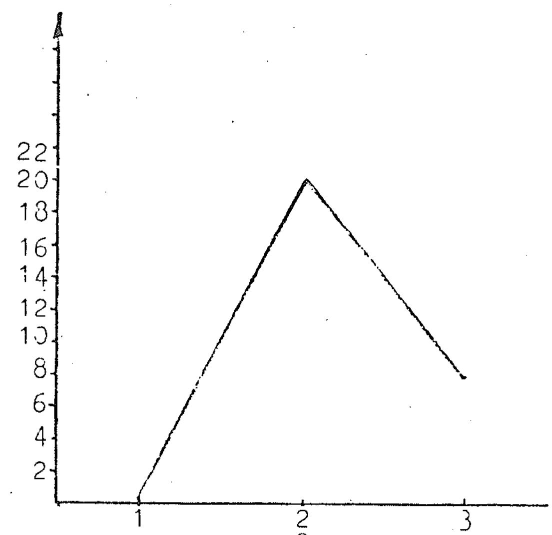



18
16
14
12
10
8
6
4
2
1
2
3

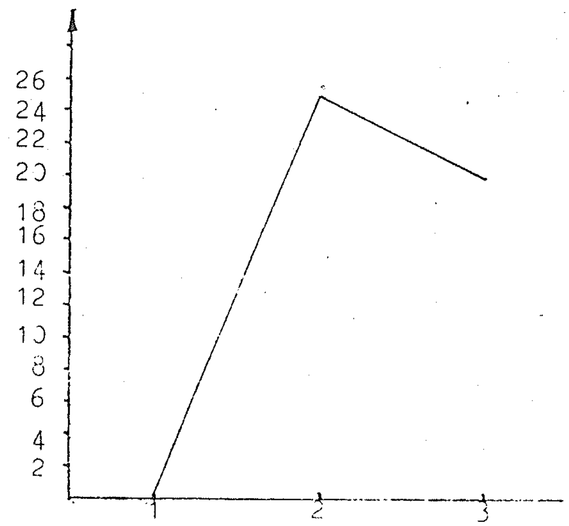
6.


30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
1
2
3

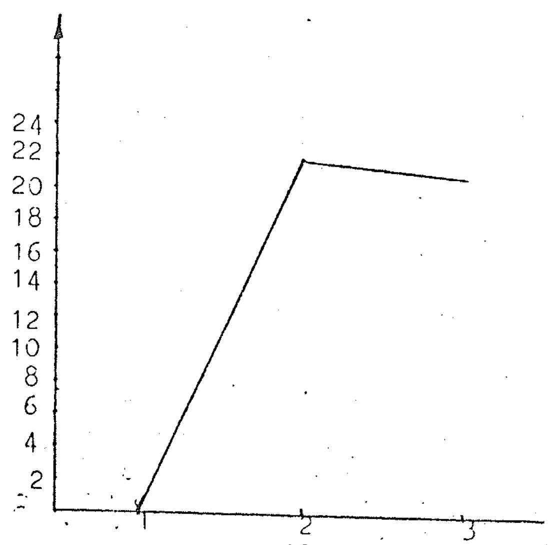
7.


22
20
18
16
14
12
10
8
6
4
2
1
2
3

8.


26
24
22
20
18
16
14
12
10
8
6
4
2
1
2
3

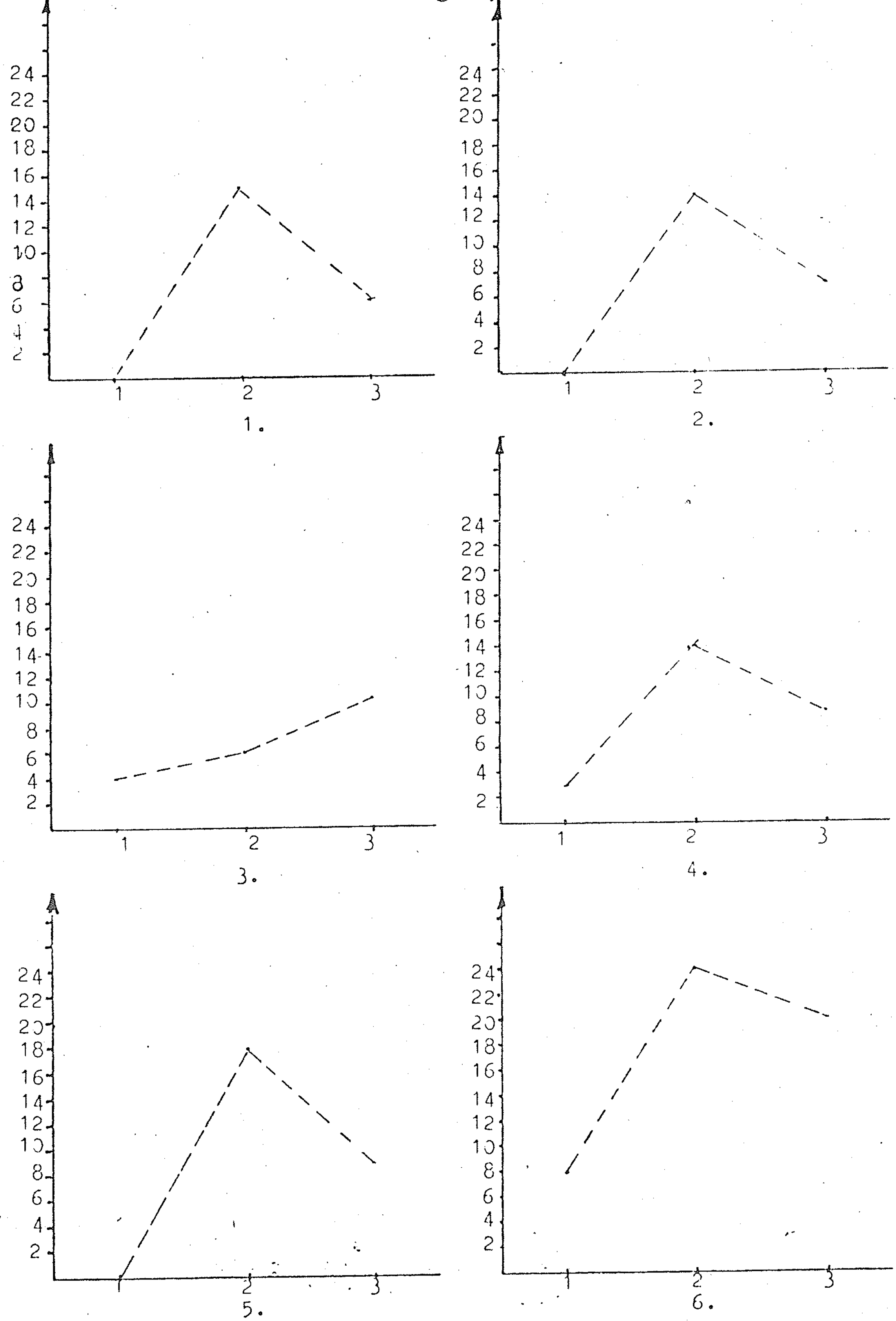
9.

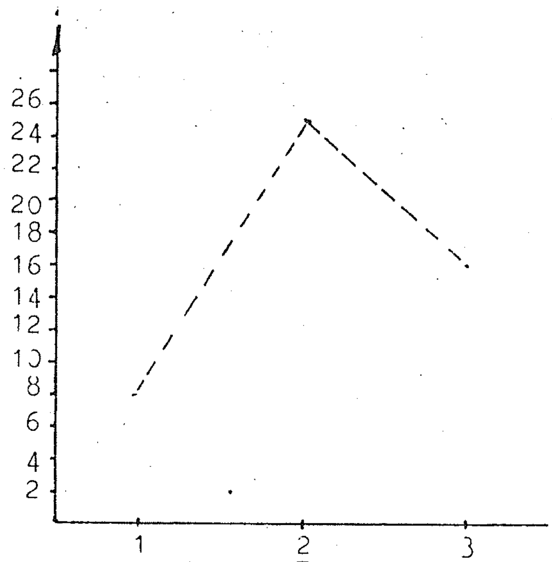

24
22
20
18
16
14
12
10
8
6
4
2
1
2
3

10.

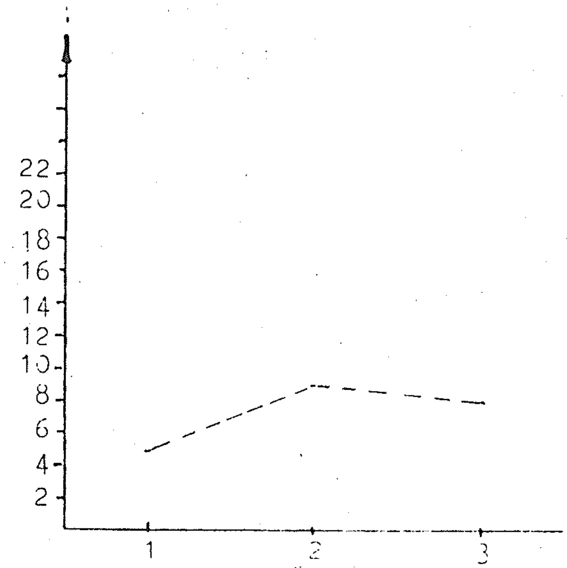
FIGURE 8

Worksheet group




26
24
22
20
18
16
14
12
10
8
6
4
2
1
2
3

7.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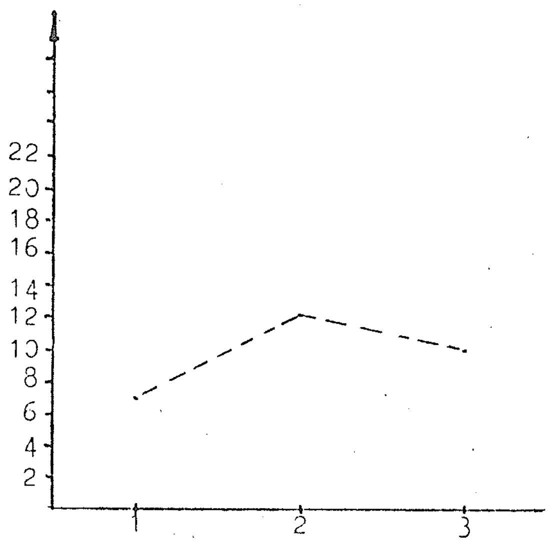
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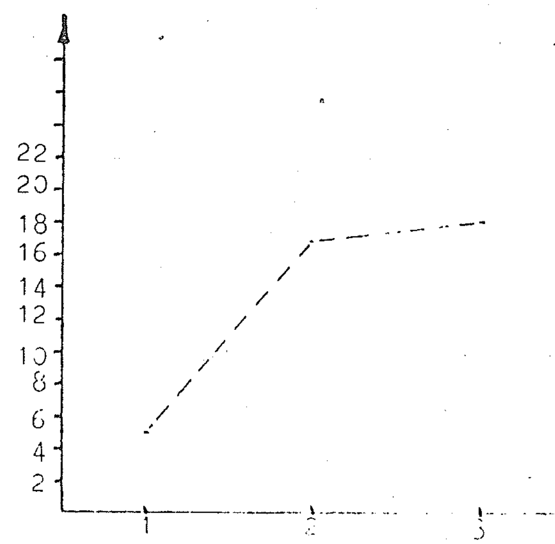
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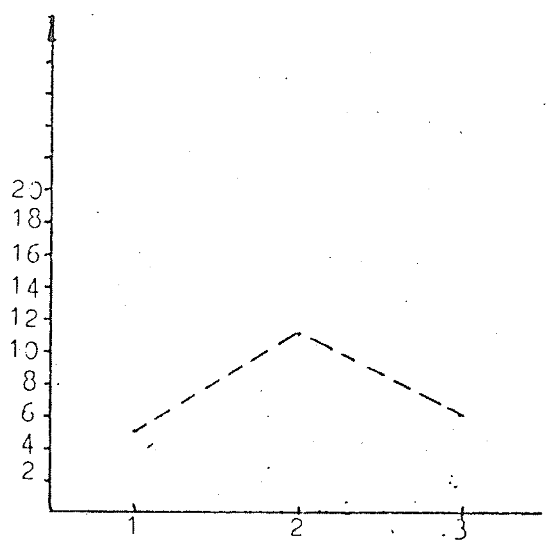
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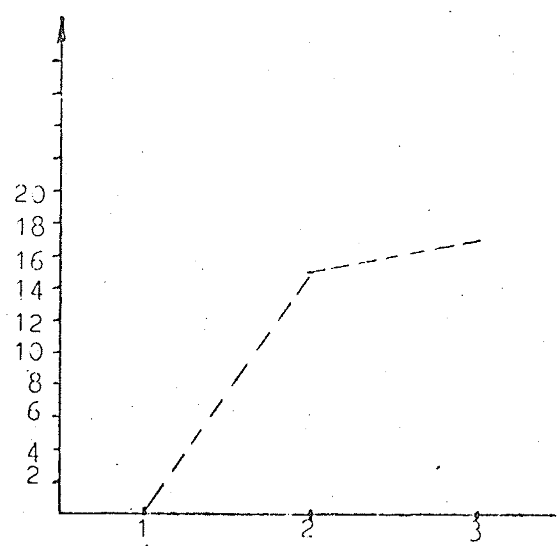
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