THE UNIVERSITY OF CALGARY

A STUDY OF THE EFFECTIVENESS OF COMPUTER ASSISTED INSTRUCTION FOR TEACHING INTRODUCTORY GEOMETRY TO SLOW LEARNERS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "A Study of the Effectiveness of Computer Assisted Instruction for Teaching Introductory Geometry to Slow Learners" submitted by Norma M. Ellis in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

Research has demonstrated that computer assisted instruction (CAI) is an effective method of teaching handicapped individuals, and also that it can be used successfully for remediation with students of 'average' ability. Further, it has been shown that students learned more quickly and time on task was higher when they were exposed to CAI than when they received traditional classroom instruction.

Although limited information on use of CAI with slow learners was found, a review of the available literature revealed that they can succeed if instruction is individualized, if they are allowed to proceed at their own pace, if they receive immediate and positive feedback, and if they are adequately motivated.

Bearing in mind these specific requirements of slow learners, and with knowledge of the rapid developments of microcomputers which are gradually increasing in popularity in the regular classroom, courseware in introductory geometry making extensive use of graphics was developed to deliver instruction to a group of slow learners.

The effectiveness of this courseware both as a tutorial to teach introductory geometry and as remediation in the topic was measured by conducting an experiment using a group of academically disadvantaged students in both cases.

The sample was selected from first and second year students in a Secondary Vocational School in the City of Calgary. Forty-four students were assigned to four experimental groups each of 11 students, while 40 students formed four control groups. All were given an achievement pre-test, the Provincially standardized School Subject Attitude Scale, and a sentence completion exercise.

All the experimental groups received the same courseware consisting of six CAI programs. The students worked 5 to 20 minutes per day for six days at the computer. The four control groups received no treatment. At the conclusion of the treatment all students wrote post tests that were parallel in form to the pre-tests.

Analysis of the pre-test and post test data indicated that the experimental groups experienced significant gains in achievement as a result of the treatment. There was a significant change in the students' attitude towards the concept 'geometry', but not in that towards the concept 'computer'. This finding was considered particularly significant since the duration of the treatment was quite short.

It was concluded that CAI is a viable and effective means of teaching introductory geometry to this student group. The results were sufficiently positive to warrant further investigation of the use of CAI with slow learners.

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CHAPTER I

INTRODUCTION

Computer Assisted Instruction (CAI) has been developed and researched for over 20 years. However, despite constant early predictions that its use would become widespread (Atkinson et al, 1978) and despite quite extensive research indicating its effectiveness, there is in fact very little CAI being used in schools today (Krueger, 1986).

One factor which slowed the development in the past was the lack of suitable hardware at a sufficiently low cost to be purchased widely by the schools. This situation has been changing over the years, with the introduction of microcomputers having a particularly significant effect. As the technology advances and hardware becomes even more powerful, probably at still lower costs, this factor will become minimal.

Another component in the slow progress of CAI has been the lack of author support systems to enable education specialists to produce courseware more quickly and easily than has been possible to date. This problem will be alleviated when authoring environments become more widely available, particularly on microcomputers (Brebner, Hallworth & McKinnon, 1985).

A further reason for the little general use of CAI is that most of the courseware which has been produced so far has been of the drill and practice type. In addition, material not in this category has been largely text bound and, therefore, not necessarily suited to all topic areas and all types of students.

As hardware and software continue to develop, the need arises for research on educational strategies with which CAI may ultimately prove to be very effective. Also needed is considerable research on the different types of CAI which are effective with particular groups of students.

One group of students which requires a different form of CAI than has generally been available to date, is that of slow learners. A report of the National Council of Teachers of Mathematics states that slow or disadvantaged learners have poor self images because they have had unsuccessful school experiences such as being ridiculed (by their peers) when they give incorrect answers, or belittled by thoughtless comments of an impatient teacher. They are easily overcome with frustration, especially when information appears irrelevant, or is presented too fast for them to assimilate. They are usually difficient in reading comprehension since they have limited vocabularies, and are unable to utilize abstraction. They are easily distracted and are not usually persistent, especially when their tasks in the classroom appear irrelevant and uninteresting. They are reluctant to participate unless actively encouraged. Their curiosity is aroused by introducing novelty and variety into their learning environment. Most of all they need consistency, positive reinforcement, individualized attention and immediate feedback in a success-oriented environment (Schulz, 1972).

In the past, CAI has been used effectively to cater to some of these needs by providing immediate feedback, consistent reinforcement, and individualization. It has not, however, addressed the poor reading skills of slow learners, or the need for novelty.

The use of the microcomputer is still a novel experience for many students, but research has shown that even after the novelty disappears computer assisted instruction is still an effective means of teaching (Bell, 1978) and for slow or disadvantaged learners it could provide the best opportunity for individualization, the much needed positive, constant, immediate feedback, and a reduced risk of failure.

This reduced risk of failure is of utmost importance to the disadvantaged learner because of previous experience with failure. The use of the microcomputer has been shown to be a high motivating factor (Bell, 1978; White, 1983) because it provides the students with extra drill and provides more than one attempt at answering each question. Hence, given the appropriate type of CAI material for this particular group it could prove to be a very effective tool.

In another report of the National Council of Teachers of Mathematics, one of the recommendations is that mathematics programs should take full advantage of the power of calculators and computers (Hill et al, 1980).

The purpose of this study, therefore, is to investigate the potential of CAI in mathematics for slow learners by designing a CAI package which makes use of the recently developed features of the technology.

This implies that the CAI package not be text bound but employs graphics where possible, that the reading level be kept low, that the material be made as novel as possible, that it be motivating, and that it provide sufficiently small steps in order that some success is assured as the student progresses through the materials.

Further, the study will assess the use of CAI both as a teaching tool and for remedial purposes.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

Before designing a specific piece of research on the use of microcomputer technology for teaching mathematics to slow learners using computer assisted instruction, it was necessary to investigate effective teaching strategies for slow learners and review previous research on CAI in mathematics. Of particular interest were CAI research studies concerned with slow learners and the related area of use of CAI with the mentally handicapped.

Computers in Education

Prior to 1950, there were early forms of 'teaching machines' which were intended to save time for the teacher and deliver individualized instruction to the student. Pagliaro (1983) refers to Pressey's interest as early as 1926, in designing a mechanical device which would provide drill and practice items to the students in order to leave the teacher "freer for the inspirational and thought-stimulating activities which are presumably the real function of the teacher". Pagliaro (1983 also makes reference to later work by B.F. Skinner who advocated the mechanization of instruction in all schools "not as a replacement for, but as an adjunct to the teacher".

Later, as a result of the introduction and use of the electronic digital computer in education, educators found a new way of 'mechanizing' instruction. The earliest recorded use of the computer as an aid to instruction was in 1950 when the computer industry used CAI to train its employees. Electronic typewriters and Teletypes were linked to computers and information was presented in modules to the students. The response of each learner was mono-syllabic and the computer spent its time waiting for and evaluating each student's response. The computer language used was difficult and not understood by the layperson. By 1960 however, IBM had developed Coursewriter 1 which made it easier for educators to develop and write programs. Thus, the first in a series of languages designed specifically for ease of use in courseware development was now available. By the early 1960's, there were several large CAI research projects in existence. These projects were designed and developed using large mainframes or mini-computers.

Since then, several interactive languages have been developed and more recently authoring languages such as CAN, TUTOR, PILOT, and NATAL have been made available. Further, the technological changes which have taken place have moved the emphasis on hardware from mainframes to microcomputers. Although schools are not 'all mechanized' as Skinner had advocated, the development of the microprocessor has made it possible for educators to introduce the use of the microcomputer into the regular classroom. Projects such as the Minnesota Educational Computer Consortium (MECC), Total Information for Educational Systems (TIES), and PLATO which were originally designed for mainframes have since been converting their materials to micro-based systems (Hallworth & Brebner, 1980).

The present microcomputer-based systems have limitations, a major one being the difficulty of efficiently maintaining a file system for a number of students. The advantages, however, are many. They are less expensive to acquire; they are more easily installed; they require fewer support staff to maintain them (Hilles, 1984), and there are fewer incidences which involve 'downtime'.

Another advantage of the microcomputer is the availability of graphics which, prior to 1979, was only available on mainframes. With the introduction of interactive languages such as LOGO and BASIC, it is easier for educators to develop and write programs which incorporate the use of graphics, and which are suited to the specific needs of their classroom.

The computer cannot be viewed as just another electronic fad that will go away if the teacher ignores it long enough (Sadowski, 1983). Instead, it can be regarded as a helper and tool that can assist the teacher in providing much needed drill especially for the slow learner, presenting instruction, and/or keeping student records. Further, it can assist students in the development of strategies needed for problem solving (Moursund, 1971).

Instructional uses of the computer in education can be subdivided into three main categories. These are computer managed instruction, programming and problem solving, and computer assisted instruction. There are also administrative uses such as class scheduling, accounting procedures, inventories, and the specialized areas of computer counselling, and psychological testing. Of interest in this thesis is computer assisted instruction.

Computer Assisted Instruction

Computer Assisted Instruction refers to the use of computers in an interactive manner where the computer both presents material to, and receives, analyses and acts upon responses from each student on an individual basis (Hallworth & Brebner, 1980). CAI can include courseware described as tutorial, drill and practice, simulation, and games.

In tutorial mode, the computer assumes the responsibility for instruction. The interaction between student and computer allows the student to demonstrate understanding of the material that is presented, or to request further assistance. An ideal tutorial is tailored to the individual's needs, hence analysis of students' responses could lead to positive reinforcement, corrective feedback or additional instruction and further practice.

Drill and practice assumes that instruction in the concept, skill or process has already occured. The computer, therefore, is acting as drill master by providing either a fixed number of exercises or as many as are necessary to indicate mastery has been achieved.

> Ideally a drill and practice should provide random selection of exercises; record students' progress; tailor the exercises and feedback to the individual;...... and offer corrective feedback upon input of incorrect responses (Alberta Education, 1983).

Simulations include explorations of situations during which the user is required to make decisions. The results of these decisions are conveyed to the user without the experience of the real consequences resulting from misjudgements or miscalculations. To produce quality simulations, a great deal of time is required. But, where actual experience is ruled out due to high costs, time constraints or safety considerations, the time required to design, develop and write simulations is justified (Alberta Education, 1983). For example, pilots can be trained on computer simulated aeroplanes and students can learn population projection by simulating births, deaths, and demographic changes of previous years.

Finally, games which are of educational value must necessarily demonstrate identifiable subject matter and have specific goals. Instructional games encourage the development of strategy, and when random events are introduced this allows for the need for revision of these strategies. These games, for example 'Artillery Simulator', help the students to discover, observe, think, and plan systematically the steps to victory, and hence take the student beyond mere entertainment.

The development of the microcomputer, and the increase of its usage in the classroom, have caused educators to devote extensive effort in acquiring and/or developing suitable programs to help students obtain, review and apply knowledge through one, or a mixture, of several modes (Dence, 1980). In most instances, the goal is individualization of instruction. Increased use is evidenced by the many articles appearing in journals and magazines attesting to the success of projects demonstrating that the microcomputer can be an effective tool in helping students acquire important concepts, including mathematical ones.

Strategies For Teaching Slow Learners

There is still disagreement as to the definition of a 'slow learner'. There are many terms which are used interchangeably. These include 'culturally deprived', 'educationally disadvantaged', 'underachievers', 'low achievers' as well as the 'slow learners'. The inability of educators to agree on one specific term with any degree of precision is due in part to the fact that individuals so categorized vary greatly in characteristics and needs, and in part to the fact that each definition is based on different criteria which sometimes erroneously describe the student (Lucas, 1974). Some definitions, for example, are based on teacher grades, mathematical achievement, reading level, or IQ scores.

While all individuals thus categorized have much in common, they are nevertheless not alike (Schultz, 1972), and therefore the method of teaching these students should vary.

Teachers have adopted various strategies and techniques which have proven successful with slow learners. These include:

1. whole class instruction - needed for class demonstrations and presentations to and by students, for films and film strip presentation, for testing and contests,
2. group study - emphasizing cooperation,
3. tutorial help - provided usually by someone other than the teacher,
4. textbooks,
5. workbooks and programmed instruction units - especially for those who have difficulty using textbooks,
6. audio visual methods and academic games - to provide concrete illustrations and vivid explanations (Pikaart & Wilson, 1972),
7. computer assisted instruction - a more recent, innovative approach (Rogler, 1972).

By adopting any or all of the above strategies or techniques, the teacher is consciously attempting to arrange a successful learning environment for the slow learner. The slow learner needs to be motivated (Karlin & Berger, 1969) and CAI is effective in improving motivation and attention (ETS, 1982). Perhaps, the motivation can be attributed, in part, to the technology itself which can provide sensory interaction, images, sound, and dynamic graphics which enhances learning (White, 1983) and awakens interest.

There are other features of CAI which help to motivate the slow learner. When well written software is used, students are kept alert to answer questions and problems presented (White, 1983); they are provided with supportive feedback; they are given partial credit which is positively worded; and they are usually provided with specific information for correcting errors (Campanini, 1981).

Slow learners lack a high level of generalization and are usually unable to learn material incidentally when compared to 'average' learners. Instruction, therefore, needs to be presented in a systematic fashion with not too much reliance on incidental learning (Paschal, 1967).

When slow learners are compared with other students within the 'norms' the former are found to be less self-motivated, less persistent, more peer and adult motivated because they find it difficult to learn through conventional methods.

In the method of instruction which includes use of text books which present mathematical rules followed by examples and drill, materials have to be carefully selected as texts vary in the clarity with which they explain a particular concept, process or skill. Further, since frequently the slow learner has difficuty with reading and comprehension, this method will often fail.

Slow learners do better when taught and tested in ways that respond to their individual preferences (Dunn, 1979). Dunn found also that when slow learners were able to succeed through use of appropriate resources at their level, they became more motivated, more persistent and more able to make choices. Further, when motivation is stimulated, students become involved emotionally and practically in the learning process. They should be provided with encouragement, and feedback while they are learning rather than after task completion.

Individualization has been found to be of particular value to students from poor backgrounds and for delinquent male adolescents. These students categorised as 'disadvantaged' usually have low verbal skills, are frequently absent, frequently have behaviour problems, and are found to require other than the traditional group oriented instruction geared to "average and above average" ability (NIE, 1980).

Many of the strategies required for teaching slow learners are found in programmed instruction and CAI. All the salient features of programmed instruction as well as more powerful capabilites are present in CAI. It is the most advanced form of automated learning (Brebner et al, 1984).

Gibson (1971) identified computer based learning as the most promising form of programmed instructional techniques for teaching mathematics. It can be used as a device for achieving individualization of instruction based on performance and ability. It can also be used for providing immediate item by item evaluative feedback to each student and teacher, and it can be used as a device for identifying erroneous conceptions and preventing new materials from being presented until the student demonstrates a thorough understanding of current material (Gibson, 1971). CAI was found to be more effective with low ability students than with students of high or middle ability (Taylor, 1974).

It appears likely, therefore, that CAI is an effective means of teaching mathematics to slow learners.

CAI in Mathematics

Stanford Project

The first major project that pioneered the development of CAI in mathematics was recorded at Stanford University's Institute of Mathematical Studies in Social Sciences (IMSSS) in the fall of 1966. The project began as an investigation into the use of CAI in the teaching of mathematics and reading skills. Suppes, who together with Atkinson designed the programs, was concerned that even in outstanding educational systems there were still many students who would have difficulty mastering simple concepts. His programs were therefore designed as supplementary material intended to allow for individualization or remediation for slow learners, hence reducing rather than eliminating differences. Suppes' programs were not designed as instructional; instead, they provided much needed practice to the students while reviewing basic skills and concepts. This project resulted in the production of some of today's most widely used applications.

Initially, the hardware consisted of two computers, namely an IBM 1800 and a Digital Equipment Corporation PDP-1. The CAI programs were implemented in the basic machine code of the computer with a time-shared operating system. The students worked at terminals which were remotely connected to the computers using telephone lines.

In the first year of the program 1500 students participated. By 1969 some 6000 students had used the programs. After two years over 7000 students across the United States had been exposed to drill and practice in mathematics from the Stanford project. Suppes found conclusive evidence that achievement was significantly better for his experimental groups. Thirty-one of forty-one groups using the Stanford CAI programs gained more that one grade level during one year (Suppes et al, 1973). Further, he found that when students were given immediate feedback and allowed to correct their errors they tended to learn faster.

The Brentwood Project

In 1967 the Brentwood Project went into operation. This research project was sponsored by the National Science Foundation (NSF) and the United States Office of Education. The laboratory was built on the grounds of Brentwood Elementary School in East Palo Alto, California, by the Institute of Mathematical Studies in Social Sciences, Stanford (Suppes & Morningstar, 1972). It contained an IBM 1500 computer, one teacher station, and 17 student stations. This was a feasibility study into the use of individualized tutorial CAI over an extended period of time as an integral part of the elementary school reading and mathematics curriculum. Material not covered by the computer was covered by the teacher.

In the first year of the project 49 grade one students participated and this was increased to 88 in the second year. Content was presented through the use of audio and visual displays and student responses were made from a standard keyboard or by using a light pen.

Lessons included counting, numerals, addition and subtraction, sets, and geometry and linear measurements. Instructions were kept simple and each lesson contained less than 10 exercises. The problem was first presented with audio instructions but the later exercises were not. Students who did not meet pre-set criteria at the end of the lesson were directed to remediation which was the same content and problems, but paced more slowly. Failure at this level would direct the student to get assistance from the teacher. Suppes (1972) reported that students completed different amounts of work at the end of the year because they were working at their own pace.

All student responses were recorded and evaluated. From analysing and evaluating approximately 3 million student responses Suppes (1972) concluded that the individual needs and differences of the student can be met by the use of CAI.

PLATO

Also in the 1960's, and about the same time as the Stanford project, PLATO (Programmed Logic for Automatic Teaching Operations) was being developed as a cooperative research project directed by Donald Bitzer. It consisted of members from the

University of Illinois, the National Science Foundation (NSF), and later, Control Data Corporation (CDC). The PLATO computer based education system is the largest and most complex computer system and its courseware is some of the most innovative. PLATO was developed in order to provide CAI via a large computer. It had 1000 terminals connected to a Control Data Corporation (CDC) Cyber 73-24 computer in Urbana, Illinois. The central computer was estimated to produce four million instructions per second. Though the largest concentration of terminals was in Illinois, some were located throughout the United States. Communication between the central computer and the remote terminals occured over telephone lines for distant sites and by microwave for nearby locations. The display screen for a PLATO terminal was a plasma panel. It could relay dynamic graphics and perform such tasks as illustrating principles in physical sciences or simulating laboratory experiments. Hence, lessons varied from simple repetitive drills which gave students practice in basic concepts to tutorial programming preparation, to complex simulations. Students input messages through keysets similar to those on electric typewriters. Teachers also used the system to develop lessons written in a special authoring language called TUTOR.

PLATO lessons were available in many different subject areas but the primary thrust was concentrated in language, mathematics, biology, chemistry and accounting. The objectives of the PLATO system included providing a large library of programs which would be immediately available to individual students, providing access to as many students as possible at the same time, and maintaining an automatic record of students' progress. In addition, any user of the system could communicate with any other user on the computer using a form of electronic mail.

PLATO is perhaps the most widely used system for CAI since it includes a broad range of subjects with modules in each extending from Elementary through to University levels.

Educational Testing Service completed an evaluation of students using PLATO mathematics in 1976 and compared the results with those of non-PLATO users. Those using PLATO showed a mean gain of 1.5 grade equivalents compared to 1.2 for the control group. A year later, as a result of improvements in courseware and in organization and management the PLATO students demonstrated a gain in grade equivalents of 1.8 against 1.2 for the non-users (Hallworth & Brebner, 1980).

An evaluation of the PLATO system in 1978 found that the impact on student attitude was generally favourable. Students liked the facts that they could make mistakes without embarrassment; that they received helpful comments on their work; that PLATO gave good examples and illustrations; that they could take part in their instruction at each step in the lesson; that they thought they received individual attention; that they felt free to express opinions and ask questions (Alderman et al, 1978). Although students in this study using PLATO did not demonstrate any appreciable difference in performance and achievement when compared to non-PLATO users, the system is widely accepted by students as well as teachers.

Computer Curriculum Corporation

In the late 1960's the Computer Curriculum Corporation (CCC) was formed by Patrick Suppes. It was set up initially as a commercial outlet for the elementary school materials in drill and practice developed in the Stanford Project. There are, therefore, strong similarities in the courseware. The courses were designed in strand structure, with a strand representing one content area of the curriculum, and consisting of a string of related items whose difficulty progressed hierarchically. This meant that students moved vertically through items in a lesson from one level of difficulty to the next or backwards for practice.

Of 16 available courses, three were specifically mathematics. These were mathematics for grades one to six; mathematics for grades seven and eight; and adult arithmetic skills. One lesson consisted of a mixture of exercises from different strands. A student was suitably placed only after completing the first 10 lessons in a course. After the placement was made, the student's performance was evaluated at the end of each lesson. If the students failed to meet pre-set performance criteria, they would either do more work at the same level or be moved back along the strand to easier items designed for remediation. Otherwise, the student was moved ahead indicating satisfactory completion of the unit. Students' performance on each strand was monitored by a management program associated with each course.

CCC programs and course materials are installed in areas of the United States where Federal funds were provided for educationally disadvantaged children. This meant that most frequently the students involved were of black, Mexican or Puerto Rican descent. Some of the places in which CCC systems are found include Texas, California, Mississippi, and New Mexico. The Los Nietos project in Los Angeles is operated in schools where 80 per cent of the population are from minority groups and the Chicago project serves mainly a black population (Hallworth & Brebner, 1980).

Macken and Suppes (1976) reported that students made extensive use of the computer terminals after school and that truancy, tardiness, and vandalism were reduced. Most students demonstrated enthusiasm, and difficult students demonstrated interest in the use of the computer. They further reported that students who had spent a mean of 11.8 hours doing mathematics and reading on the computer had a mean gain of 1.09 grade equivalents.

The University of Calgary

The University of Calgary was among the earliest in Canada to introduce a courseware development project. The initial computer system was the DEC TSS-8 which limited the earlier development of courseware because of the relative small storage capacity available. The two main areas of concentration were CAI for the mentally handicapped, and CMI and CAI in reading at the elementary school level (Hallworth & Brebner, 1980). Teacher education in the topic of CAI and its introduction into schools was also given major consideration.

Ontario Institute for Studies in Education

Also in Canada, in 1969, the Ontario Institute for Studies in Education (OISE), in conjunction with several colleges, began to develop courseware as a result of the information gathered by the Ontario Mathematics Commission. The Commission's report identified an urgent need for remedial mathematics at the college level. As a result, OISE began the development of a computer assisted learning project to meet the needs of individual students (Olivier, 1972).

In 1984 Dent reported that as a result of the use of computer assisted teaching in community colleges, the 'drop out' rate was drastically reduced from 75 per cent to 25 per cent. Those students who were still receiving traditional remediation maintained a 'drop out' rate of 75 per cent.

OISE was later involved in the most extensive CAI development effort by the Ontario Secondary Schools. The project was funded by the Provincial Ministry of Education and extended over a two year period from 1978-1980. The Computer-Assisted Remediation and Evaluation (CARE) project had two main objectives: to create and evaluate CAI sequences for intermediate mathematics grades 7 to 10 and to produce and validate test items suitable for inclusion in the Ontario Assessment Item Pool (OAIP). The courses were tutorial in nature, contained lessons, tests and branching strategies. All of the courses were designed to make extensive use of such computer dependent techniques as random problem generation, instant answer analysis and feedback, and detailed student progress reports (Gershman & Sakamoto, 1981).

TICCIT

The 1970's brought another large coorperative research project which made a significant contribution to the development of CAI. The initial developments were started by MITRE Corporation, aided by a federal grant, and in conjunction with the University of Texas. The responsibility of MITRE Corporation was hardware development, while software was developed at Austin, Texas, and later at Brigham Young University in Utah. The TICCIT (Time-shared, Interactive, Computer-Controlled, Information Television) system combined minicomputers and existing television technology in order to keep costs to a minimum. The system based on educationally oriented microcomputers originally consisted of 32 terminals with a minicomputer base and television display devices. The programs were in English and mathematics and intended for college level students.

Alderman (1978) evaluated TICCIT and reported that factors which contribute to the success of computer use in the classroon include providing immediate feedback to students on their performance; ensuring the students are active participants; and carefully designing and implementing the material. Also, the nature of the student population and the role played by the teacher are important.

Chicago Project

Another notable project began in Chicago in 1971. It was federally funded and is one of the many projects offered by the Public School Board to schools in low economic areas where academic achievement is below average. By the end of the 1977-78 school year, 59 schools had been involved. Fifty-four of these were elementary, and the other five were concerned with education of the physically handicapped. The courseware used in this project was the CCC material in reading, mathematics and language arts.

Mathematics courseware was available for achievement levels 1.0 through 7.9. All the computational skills of elementary mathematics except geometry were emphasized in the 14 available strands.

In the annual evaluation of 1975-76 it was reported that CAI had a high cost effective ratio when compared to other activities. Although there was no significant differences in the students' attention to task and attitude towards the activities, the mean gains in achievement appeared to be better retained across age groups than in other activites.

The arrangement between CCC and the Chicago School Board permitted the alteration of the supplied curriculum. The system used was the UNIVAC 1110 which made modification simple once the package was implemented. Modifications that were made enabled the users to tie the CAI more closely to the curriculum that was being taught (Hallworth & Brebner, 1980).

Smaller Projects

A review of CAI literature involving smaller projects and conducted by individuals without large research grants and restricted to shorter periods of time, covering 1960 to present, reveals a minimal number of significant studies related specifically to CAI and junior high school mathematics. The following is a an overview of the literature that was found.

Crawford - 1970

Crawford (1970) investigated the effects of drill and practice in seventh grade remedial arithmetic. In addition to conventional instruction, the CAI group received 3-15 minutes at a terminal each day for 8 weeks, while the control group only received conventional instruction. The experimental group demonstrated a significant gain in scores but there was no significant difference in the post test means of the two groups. On analysis of the attitude questionaire applied, the CAI group displayed a general improvement in attitude towards mathematics.

Gibson - 1971

Twenty students (9 boys, 11 girls) participated in the investigation into the use of computer assisted instruction in mathematics for disadvantaged seventh grade youth. The junior high school in Los Angeles was populated predominantly (95%) by black students. Academic assessment was done by using the Iowa Test of Basic Skills and the Wide Range Achievement Test. Based on prior test results, daily performance of students and the recommendation of the teachers at the centre, the 20 students were selected from among the 50 who were already receiving remediation in mathematics. The 20 students in the experimental group received supplementary sessions on the computer over a two month period during the 1968-69 academic year.

At the end of the investigation, every student was interviewed and was required to complete a written questionaire. The purpose was to determine student satisfaction or dissatisfaction with computer instruction. Student comments included 'it helped me understand better', 'it's faster than writing',and 'it gives the answer when you are wrong'. The students did not like the timed questions, and they felt that the response time of 10 seconds per question was too short.

At the end of the two month period, a comparison of the pre-test and post test scores using the standardized achievement tests revealed no significant gains by the students who received the supplementary CAI lessons over those who did not. There were however, significant gains found when tests created by the researcher and directly related to the material were used. The researcher found increased interest in mathematics and a higher degree of motivation among the students in the experimental group.

<u>Smith</u> - <u>1973</u>

This investigation was carried out with 320 junior high school students in San Francisco. Smith was investigating the impact of CAI on student attitude. The students involved were performing 2-3 years below their grade level. The CAI lessons used were drill and practice programs designed in the Standford project. For these low achieving students, therefore, this was remediation. The students received continuous feedback and were allowed to work on each lesson with the system prescribing problems individually for each student on the basis of performance.

When the project was evaluated Smith concluded that while other forms of CAI may have produced substantially different sets of results, the one used was found to be an efficient and effective method of remediation and seemed to facilitate and promote realistic student attitudes toward mathematics. It was found to eliminate fear of failure by individualizing the content and pacing the instruction. It also eliminated fear of subjective evaluation because evaluation by computer was based strictly on performance rather than on personal characteristics or social relationship with the teacher.

No consistent increase in attitude was found. However, students demonstrated more positive attitudes and were sorry when the project ended.

<u>Leavitt</u> - <u>1975</u>

Leavitt (1975) investigated the use of CAI in introductory algebra. Two groups of grade nine mathematics students totalling

38 participants were randomly assigned to an experimental and a control group. The experimental group received the CAI treatment for 30 minutes per day while the control group was taught by Unit Packs of individualized lessons in their regularly scheduled class periods. The CAI programs were devised in such a way that they provided instruction, drill, and tests for each concept.

The CAI group scored significantly higher on the criterion referenced achievement test, completed the lessons in approximately one-third the time required by the Unit Pack group, and expressed a more positive attitude both toward CAI and toward the computer at the end of the experimental period. The results indicated that CAI is an effective means of individualizing instruction in introductory algebra.

Woetowich - 1980

Woetowich (1980) did a study of the use of CAI for teaching integer arithmetic and the effect of some adaptive instructional strategies. The courseware consisted of tutorials followed by drill and practice. One group received adaptive courseware and the other a parallel set of programs. Both treatments were found to be effective in teaching integer arithmetic to the group of grade 7 and 8 students who participated in the experiment. However, no conclusion was reached as to the effectiveness of one treatment over the other.

Gerzanick et al - 1982

Gerzanick et al (1982) reported on a project involving a microcomputer remedial instruction laboratory in Bristol Public Schools, Connecticut. One laboratory was established in each of three schools. Students were selected from among those who did not perform well on the State proficiency test. They were further tested to determine specific skill deficiences. They were then scheduled for remedial courses called 'D-Track' as part of their 10th grade course selection. Courses were in mathematics and language arts and the the students were permitted 1-3 periods per week, alloted according to need for each subject. Because there were more eligible students in mathematics, they were match-paired with students who did not receive any time in the laboratory. Laboratories were opened for additional visits by students as a device to measure motivation. It was thought that more visits during study halls would equate to higher interest.

Each laboratory was equipped with six Commodore PET microcomputers, three cassette drives, one dual disk-drive and one printer. Later, an Apple II was added to each of the three locations. About 150 remedial mathematics software programs, 200 language arts programs and two major courseware packages in reading levels 3-12 were purchased, reviewed, and distributed to each laboratory. Project staff were assigned to implement and operate the program. They administered tests, kept records, sequenced material for the students, and prepared progress reports for teachers as well as students.

An evaluation at the end of 18 months concluded that the computer assisted remediation students achieved significantly higher test scores than those who were not receiving computer assistance. They made 389 extra visits, an average of 13.5 additional visits per student. The researchers concluded that this was convincing evidence of increased student interest in improving their basic skills. Subjective results reported include positive changes in skill performance, and attention span.

The researchers concluded that the students in the program showed positive growth in basic skills, and were motivated and interested in their progress. The students who only received the traditional remedial program continued to fail and had poor self-images.

Curda - 1985

Curda (1985) investigated the effects of teaching estimation skills by CAI to upper elementary students. Two sets of software were used. Each of the 17 programs per set was designed to provide all of the instruction. One set of courseware taught estimation techniques while the other set taught multiplication by the conventional method. Curda carried out the experiment twice, first with a group of 24 grade six students from an area considered above average socio-economically, and secondly with a group of 39 grade six students from a below average socio-economic area. Students worked on terminals connected to the Computer Applications Unit's Digital Equipment Corporation PDP 11/70 computer at the University of Calgary for a period of four weeks. Both groups showed gains from pre-test to post test.

CAI with the Handicapped

The following are some of the research studies which investigated the effectiveness of CAI with developmentally handicapped persons.

Sandals - 1973

Sandals (1973) investigated the effectiveness of CAI in teaching banking skills to 15 developmentally handicapped adults. At the end of the treatment, subjects demonstrated a significant improvement in general knowledge of banking concepts. Two months after the study was completed retention was still very good. Further, subjects were able to transfer learned information by completing banking forms similar to those used in the study.

Strain - 1974

Strain (1974) developed CAI courseware to train 17 handicapped adults in sequencing arithmetic skills needed to make a single item purchase. Significant improvement was noted in speed, accuracy, and consistency of response by the subjects involved to simulated buying problems presented by the computer. The subjects were able to successfully transfer the learned skills to situations involving real items. A retention test, given a week after the training was completed, still indicated significant improvement over pre-test results.

Holz - 1976

Holz (1976) designed CAI courseware to teach social sight vocabulary to mentally handicapped adolescents. All of the 19 subjects in the study received the same amount of visual instruction, that is, they were shown the same number of slides and presented with the same information on the CRT screen. In addition, 10 of the 19 subjects received audio messages throughout their training.

Statistical analysis indicated that CAI offers an effective method of improving social sight vocabulary of mentally handicapped adolescents. Both groups of subjects demonstrated significant improvement in comparison of pre-test over the post test scores. Further the group which received the auditory modality improved significantly more than the group which did not. Holz concluded that this type of training would be more effective if the auditory modality was included.

England - 1979

England (1979) designed and wrote programs to teach budgeting to a group of developmentally handicapped adults. The 24 subjects who completed the project demonstrated improvement in their application of the skill on the computerized task. A retention test given to investigate the subjects' abilities to transfer their learning proved inconclusive.

Strain - 1980

Strain (1980) conducted another study with developmentally handicapped adults. Courseware was designed to train the subjects in two methods of coin computation skills. Eighteen subjects received CAI lessons for method one, which was pre-training of arithmetic skills followed by drill and practice work in coin computation. Method two, involving the simultaneous presentation of arithmetic and related coin computation, was delivered to another group of 18 subjects, also by computer.

Both groups showed significant improvement from pre-test to post test. However, there was no clear indication as to the effectiveness of one method over the other.

Faulkner - 1982

Faulkner (1982) completed a study of time training for the handicapped by CAI. The courseware consisted of tutorial and drill and practice programs with corresponding slide presentations. Achievement was measured by pre-test and post tests comparisons. All students in the experiment received CAI training on time telling to the hour and half hour. The experimental group then received training on the time concepts of 'early', 'on time', and 'late' and their application to specific work or, work related, activities which corresponded to the the hours of a working day. The control group received no structured instruction on time concepts.

At the end of the investigation, the experimental group showed significant improvement in their understanding of time concepts over the control group. It was concluded that time telling skills and time concepts can successfully be taught using multi-media CAI to developmentally handicapped adults.

Sandals et al - 1980

Sandals et al (1980) reported on a computer assisted learning project established in Manitoba, Canada for children with special needs. The project, funded by both the Provincial Ministries of Education and Health and local Manitoba school divisions, is responsible for computer assisted applications to learning in 12 separate educational programs.

The program sites included schools for the physically handicapped, the hearing impaired, retarded adolescents, a community college program for hearing impaired adolescents, three elementary schools through their resource program, three junior high schools, and one high school mathematics and language arts program.

The report listed four main objectives which included using the computer as an adjunctive resource tool in the elementary and secondary schools especially for special needs children; investigating the use of the computer as a long-term study over a six year period; teaching social skills that will be general to as many schools and special needs children as possible; and investigating innovative applications of microcomputer technology in computer assisted learning.

Of 300 BASIC drill and practice programs, 180 primarily covered skills in language arts and mathematics. Skill areas range from kindergarten to grade ten with each skill arranged hierarchically and each skill area having a developmental segment of drills. Also available, were limited numbers of programs in French, science and basic life skills (e.g. banking skills). All programs are indexed to a subject area and skill level in the Computer Assisted Learning Manual (CALM). The manual also provides program descriptions, objectives, instructional considerations and sample questions. The monthly report on student progress indicates drills completed and achievement attained.

Each school had a teacher coordinator who also managed the operation of terminals in the school. The coordinator was assisted by 'proctors', research assistants and students. From May to August the Provincial Government Works program provided students who each worked 40 hours per week. Their job during this time included improving the efficiency of the project by writing new programs, incorporating the use of random access slide projectors, and making system changes which helped to improve the maintainance of the student records. At the end of the summer, each school was provided with a letter indicating all the system changes as well as the related documentation.

The project had been managed on an annual budget of approximately $4000.00 per school. Costs included hardware, system costs, and software development and program field testing.

Although formal assessments were incomplete at the time of the report, teachers from various schools participating in the project reported their observations and informal conclusions.

They noted that special education students in one school now felt a part of the 'mainstream' as they like the others in the school, were using computers. In one school, mathematics appeared to be more appealing to the students. This was attributed to the self pacing of instruction, active participation of the students, and the immediacy of the feedback provided.

In schools where CAI was used on a regular classroom basis in language arts and mathematics, it was found to have a significant effect in strengthening and reinforcing skill areas and concepts previously taught. It also provided practice for orthopedically handicapped students as it reinforced their typing skills and provided immediate reinforcement.

Mathematics students in another school complained about not getting enough time on the terminals. Some of these students, it was observed, demonstrated significant improvements in social as well as academic skills.

Brebner et al - 1984

An on-going project established by the Faculty of Education Computer Applications Unit, University of Calgary, in conjunction with the Vocational and Rehabilitation Research Institute (VRRI) was reported by Brebner, Clark, and Johnson (1984). At the time of the report the project was in its 12th year and was previously reported in 1976 and 1980 respectively. This specific study was related to cashier training of handicapped adults on a special multimedia computer terminal, used in order to simulate the job as closely as possible using CAI.

The terminal configuration was at the VRRI and was connected to a PDP 11/70 computer which supported BASIC and was located in the Computer Applications Unit (CAU). Features of the language included single character input and file handling capabilities. The trainees were first introduced to the special input device which consisted of a cash register including price keys, beverage code keys, total and correction keys. The goal was to teach the order in which items on a tray are entered into the cash register. This sequence of entry was determined by surveying cashiers at several locations in Calgary.

Two groups of trainees used the courseware for 15 days on a daily basis. Fifteen trainees received structured courseware and 14 trainees received unstructured material. Two tests were given at the conclusion of the experiment. One was given on the simulated task as in the pre-test and the other was given on the actual cash register in the cafeteria.

Both groups showed significant improvement from pre-test to post test. The courseware was effective in teaching the trainees how to operate a cash register. It was also concluded that the small number of errors committed on the post test seemed to suggest that the trainees would be able to adequately operate a real cash register with real food items after the training.

No formal statistics on comparisons between groups were carried out because when the mean number of errors made on the tests were compared, differences found were minimal. The underlying patterns of errors which constituted the totals were also similar.

CAI with Slow Learners

Grant - 1977

An investigation into the effectiveness of two CAI presentations to re-teach the decimal operations of addition, subtraction, multiplication, and division to slow learners at the Junior High School level was done at the University of Calgary by Grant (1977).

Grant selected his sample from a group of grade eight students. Those whose skills in whole number operations were deficient and those who were competent in decimal skills were excluded from the study. Students who received below 50 per cent and those who scored above 60 per cent on the pre-test were, therefore, not included. Of 173 students who wrote the pre-test 93 were considered as suitable candidates. From this group, 60 were randomly assigned to three groups of 20 students each.

Group one received CAI in which the practical applications and need for the skills were emphasized. Group two also received CAI but emphasis was placed on skills without the applications. Group three received no treatment. Most of the students completed the programs over a four-day period with extra time allowed for those who had been absent or ill. Fifty-seven students completed the treatment. A retention test parallel in form to the pre-test and post test was administered 21 days after the post test.

Both treatment groups showed significant increases in achievement when compared with the control group. However, no significant difference was found between the two groups which received the treatment. On the retention test significant differences were also present between treatment and control groups, but again, no difference was found between the treatment groups.

Grant concluded that both treatments were effective in achieving the objective of teaching the decimal skills, but the results were inconclusive concerning the effectiveness of one method over the other.

Summary

The foregoing review of research indicates that in order to develop software that is effective with the slow learner some essentials points must be considered. The major consideration is that of individualizing and pacing content to suit the ability of the student. The students might even be given the opportunity to participate in pacing themselves through the lessons. Other considerations include the provision of prescriptions based on student performance; and the provision of constant and immediate feedback. Further, there is the fact that by providing encouragement and feedback as they are learning rather than afterwards, the students become more motivated and more persistent. Of importance also is the need for the students to have several chances at answering a question prior to providing the correct answer.

Golf Classic (Kraus, 1982), a commercial game designed to review estimation of angle measure and length estimation, was found to be frustrating to most of these students because they were not provided with an opportunity to change an input once the return key had been pressed. This indicates the need for designing courseware specifically for slow learners.

The literature found also indicated that the slow learner's poor performance in mathematics may not only be caused by low innate ability. If, therefore, students so labelled are adequately motivated, and provided their mathematics instruction is appropriately presented at their level of knowledge and performance, they may be able to do better.

Further research information on mathematics instruction using CAI revealed that students learnt more quickly than they did with traditional classroom instruction. They were more motivated, they demonstrated more positive attitudes to mathematics, and outside of the classroom they talked more about what they were learning.

Information has been found to suggest that the slow learner's need for patience, and self-paced, individualized instruction can now be satisfied by the use of the computer to deliver instruction.

There is also an indication that with the present development of the microcomputer with its dynamic graphics capability and with the availability of high level computer languages, it is now possible and easier for researchers and teachers to design and develop their own materials.

The research has shown that handicapped students have been taught social and vocational skills through the use of CAI. Also, that although CAI proved successful with 'average and above average' students, it was most effective when used as remediation with below average achievers.

Following the review of the literature, it was concluded that there was need for well paced material that would teach as well as remediate introductory geometry to slow learners. In three ERIC searchers conducted only one document dealing specifically with teaching the slow learner using CAI was found.

In view of the lack of research information in this particular area for this particular group of students it was decided to explore the effects of designing a set of programs to teach introductory geometry to slow learners.

CHAPTER III

COURSEWARE DESCRIPTION

Introduction

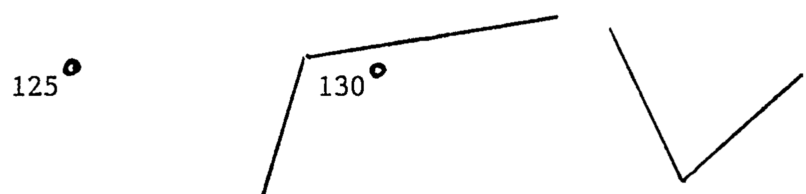
This chapter includes a description of the courseware which was developed. It also contains details of the hardware on which the programs were implemenented and information about the computer management programs used to maintain data on each student.

The Objectives of the Courseware

The main objective in the development of the courseware was to design a set of programs which would teach the content chosen as well as serve as remediation to those students who had already received instruction in that aspect of the curriculum. The content area chosen was introductory geometry. In a mathematics program that is paced for slow learners, geometry is frequently omitted in order to place emphasis on 'basic operations and skills'.

It has been observed by many teachers that most students entering a school for slow or disadvantaged learners have a strong dislike for mathematics but have an even stronger aversion to geometry. Another objective of the courseware design, therefore, was to create teaching materials which would motivate students to learn the content and then move on to further study of geometry.

Introductory geometry, in the experience of the experimenter, is not as interesting as it could be for slow learners because this section of the curriculum requires a great deal of memorization which is not a strong point of students categorized as 'slow'. Definitions require memorization and some amount of specificity in order to help eliminate ambiguities. For example, the student needs to remember that an obtuse angle is greater than 90 degrees but less than 180 degrees. The student must, therefore, be presented with obtuse angles of varying sizes both numerically as in 125 degrees, pictorially, and a combination of both in order to aid the memorization process. Figure 1 shows some examples of the three types of information needed by the slow learner.



(i) (ii) (iii)

Figure 1

Obtuse Angles

These provide the student with the visual concept of the obtuse angle and help to eliminate abstraction. It is, therefore, more likely that the student will remember the definition of an obtuse angle. By utilizing CAI, the student is provided with the opportunity of seeing pictures as well as the numeric values of these angles. The student is given constant interaction with the program, receives the immediate feedback which is needed by slow learners, and the risk of failure is greatly reduced because of the many opportunities provided to correct mistakes before the answers are presented.

The majority of text books on introductory geometry at this level assume that the student already knows the material, hence, it is presented as review. For example, School Mathematics 1 and Math Probe 1 follow an identical pattern for introducing all angle types together with their definitions. Examples are given and these are followed by some exercises. However, in the experience of the experimenter in teaching slow learners, this approach not only proved confusing to most of the students, but since they also have reading problems the approach was not even practical.

The Courseware

The courseware for a unit on introductory geometry included such items as labelling angles; identifing types of angles, for example acute, obtuse and right angles; defining angles; identifying complementary and supplementary angles; calculating complementary and supplementary elements of pairs of angles; and identifying pairs of angles which are either complementary or supplementary.

The programs were designed with as few distractions as possible and with a minimum reading requirement. Graphics were used only where necessary and care was taken that they did not provide any distraction from the learning situation. The content was divided into three main sections and programmed accordingly. Each section was designed in a linear format and was followed by a simple quiz in the next lesson. The idea of utilizing a quiz instead of a drill and practice session was to provide a form of motivation and reinforcement without any branching. Figure 2 indicates the hierarchy of the lesson presentation.

Lesson 1 - Tutorial 1

The approach used, was first to help the student identify, define and label angles. Labelling angles was restricted to two methods. The first was utilizing one large letter if only one angle was shown, and the second was utilizing three large letters if there was more than one angle at a point, as shown in figure 3. The students were given practice in labelling angles utilizing the appropriate number of letters in the appropriate sequence, that is, that the letter at the vertex was always correctly placed in the middle of the three letters used.

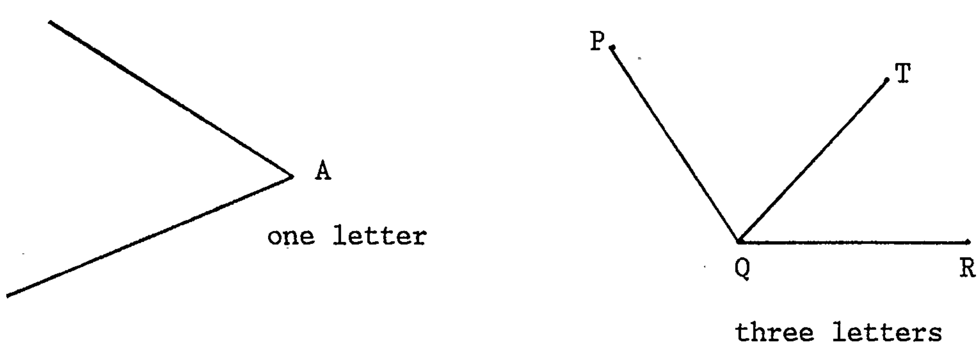


Figure 3

Labelling Angles

Flow Diagram Showing the Order of Presentation

of the Courseware

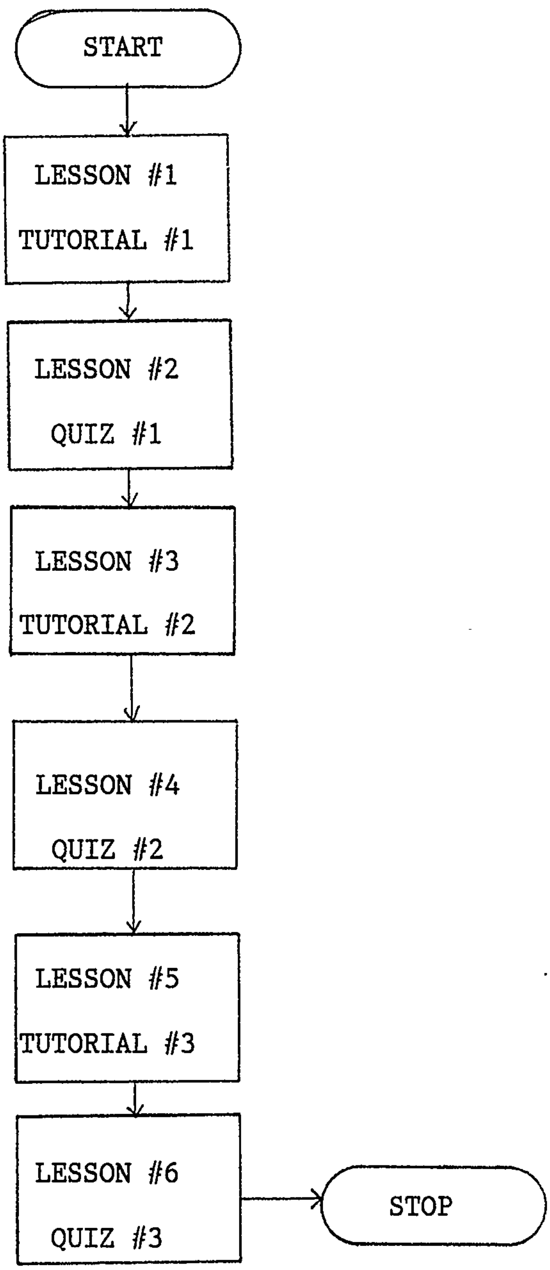


Figure 2

Care was taken to write the program in such a way as to minimize the number of possibilities that had to be checked for one answer. To accomplish this, all student input was accepted, checked (numeric or alphabetic characters), and then converted to uppercase before it appeared on the screen. For example, Figure 4 below required the student to enter the name of the angle.

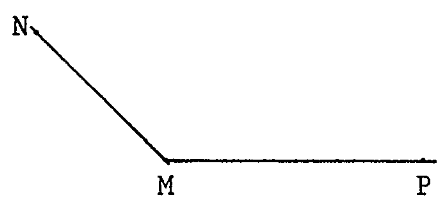


Figure 4

Name the Angle

When the student entered a response, the program rejected all non-alphabetic characters, converted the acceptable characters to upper-case then printed them to the screen. The answer was then evaluated as correct or incorrect. In this example, the expected answer was ∠NMP or ∠PMN.

Where an angle had to labelled with three letters, the program ensured that no two points of the angle had the same letter. This was an indirect means of indicating to the student that three distinct points were necessary and each had to have a unique letter.

Following the labelling of angles, the right angle was introduced. It was assumed that this angle, particularly if marked with corners, was the easiest type for the student to identify.

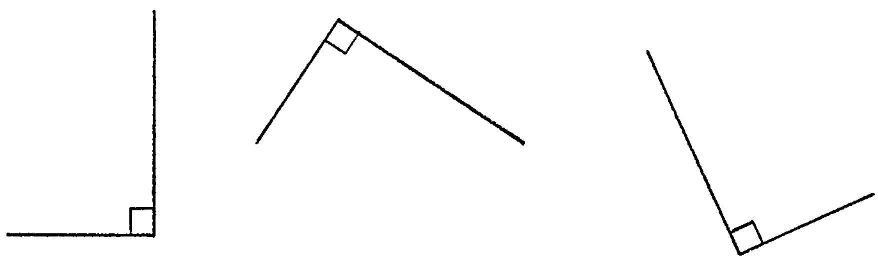


Figure 5

Right Angles

Hence it was used as the basis with which other angles could be compared. It is also an angle with which most students are familiar and which most are likely to confuse with the directions 'left and right'. Logically, to these students, if there is a right angle there ought to be a 'left angle', and a 'left angle' is usually a right angle facing left. Various diagrams of right angles such as those in Figure 5 were presented, making sure that they were turned in a variety of directions. The student was given an opportunity to label a right angle, identify its vertex, and its sides, and then the symbol used to identify a right angle was introduced. Finally, given a set of points, as in Figure 6, the student was required to define the shape of the right angle from a fixed point B. The expected input was Q and T for angle QBT or TBQ.

Q. .B

M.

.T

Figure 6

Define the Shape of a Right Angle

The acute angle was introduced next. The student first compared the acute angle with the right angle then moved into the definition of an acute angle. Exercises included identifying angles by measure. For example, given the three angles 28°, 94°, 45° the student identified which, if any were acute. Combining the measure with a diagram the student was again asked to identify an acute angle. Finally, diagrams without numbers were given and the student had to determine which, if any was acute. The student was also given an opportunity to complete diagrams which would create acute angles. For example, given the points as denoted in Figure 7, the student was required to select two which would complete an acute angle at point A. The expected input were points P and Q or Q and R.

P. .Q

A. .R

Figure 7

Complete an Acute Angle at Point A

By proceeding in this way, the student develops some familiarity with the basic shape of the acute angle.

Program one ended with a review section in the form of 'fill in the blanks'. All possible answers were printed and remained at the top of the screen until the review was completed. The objective of this technique was to reduce the incidences of the student entering incorrectly spelled words. There were six statements each with two blanks which were to be completed. If the answer was entered correctly, positive feedback was given, then the next statement was presented. However, if the answer was incorrect, the statement with the student's selections was printed on the screen and the student was given the option of making changes. If the student did not make any changes then the program displayed the correct selection.

At the end of the review section the student was given a score for the number correct on the first try only.

On completion of tutorial one, each student would be able to:

1. identify and define an angle
2. identify and name the vertex of a given angle
3. distinguish between an acute and a right angle
4. label an angle with one letter or with three letters
5. identify an acute angle, a right angle by sight/measure
6. define an acute angle; a right angle.

Lesson 3 - Tutorial 2

In the second lesson the obtuse, straight and reflex angles were introduced in that order. The obtuse angle was first compared with a right angle, then the definition was presented. Next, diagrams were drawn first with measures assigned, and the student was asked to identify each as obtuse, right or acute. These were followed by a further set of diagrams but without measures assigned and again the student was asked to identify each. Finally, the student was presented with a set of points on the screen. One point was identified as being fixed and the student was asked to select two points which would complete an obtuse angle with the vertex at the given fixed point.

The straight angle was presented as the sum of two right angles, as in figure 8, which,

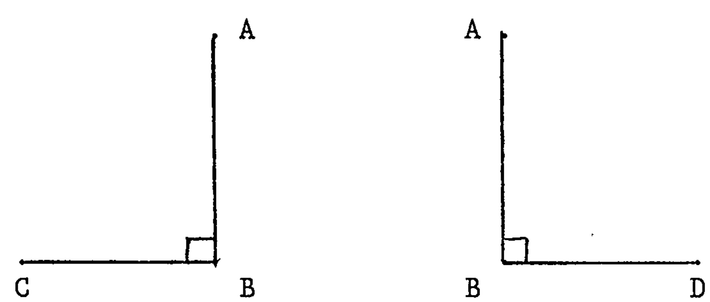


Figure 8

Right Angles

when combined, become a straight angle as follows:

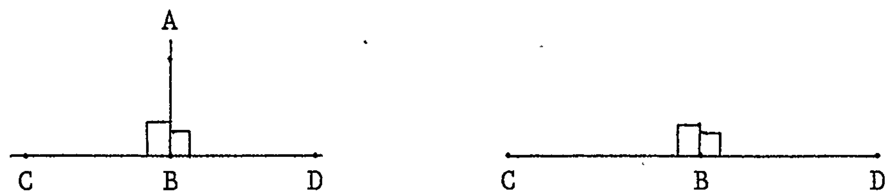


Figure 9

Straight Angle CBD

AB is eventually removed leaving angle CBD as a straight angle. At this point some animation was introduced and the student saw the angles moving together and finally one straight line. Since the straight angle is somewhat unusual, the student had to label a given straight angle then identify each side and the vertex. This helped the student to visualize the straight angle as an angle as opposed to a line and reinforced the fact that the straight angle has the same properties as other angles.

The third presentation was the reflex angle which was defined, and diagrammed with an accompanying degree measure. The diagram was shaded in order to differentiate between the acute angle and the reflex angle formed at the same point. This was also the first time any attempt was made to point out that two angles do in fact exist at the vertex, P.

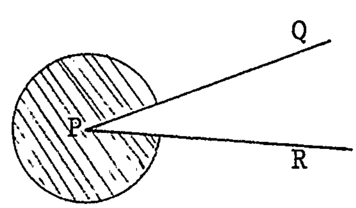


Figure 10

Reflex Angle RPQ or QPR

Little time was spent on this angle because it is not a commonly used angle and seems to have little meaning to most students at this level. However, the student was required to become familiar with the shape and measure and be able to identify and give example of reflex angles.

Finally, the review section covered topics from both lessons one and two. There were ten questions each of which allowed the student three chances to respond correctly. Again, a score was given at the end.

On completion of tutorial program two each student would be able to :

1. define obtuse, straight, and reflex angles
2. identify obtuse, straight and reflex angles by sight
3. identify obtuse, straight and reflex angles by measure
4. distinguish between obtuse, straight and reflex angles
5. know the five categories of angles: acute, obtuse right, straight and reflex.

<u>Lesson 5 - Tutorial 3</u>

Lesson five was concerned entirely with complementary and suplementary angles.

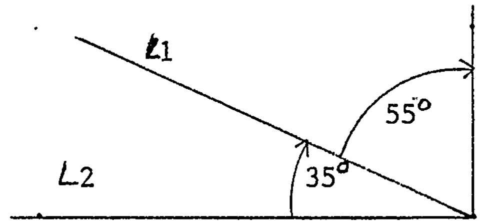


Figure 11

Complementary Angles

In diagrams such as the one in Figure 11, the student was required to identify each value and then find the sum. Since the students have difficulty with basic mathematical operations (addition and subtraction), the use of pencil and paper or a calculator was permitted. The program had a built-in branch which assisted in the addition of the two numbers and then returned the student to the question for completion. After the definition had been presented the student's attention was drawn to the fact that 55° is the complement of 35° and vice versa utilizing the appropriate language at each opportunity. A little game was introduced at this point. The student entered an angle value and the computer returned its complement. The student then indicated if the computer's response was correct or incorrect. The program was designed to give the correct answer each time but the student had to do the calculation (or guess) to determine this. At the top of the screen the score was maintained according to the student's responses. Figure 12 is an example of the display which was used for both halves of the game.

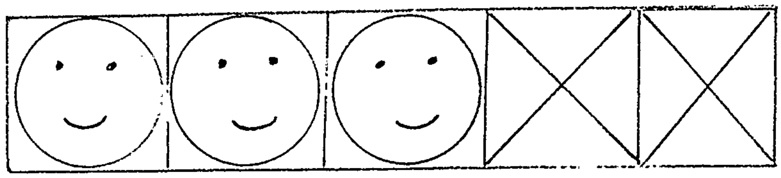


Figure 12

Score Board Used for the Game

Each face indicates a correct response by the student while an X represents an incorrect reply. At the end the student told the computer its total points scored. The program checked each time the student indicated an answer to be incorrect instead of correct and accumulated the total as errors. If the student did indeed miscalculate or entered the wrong score in error the computer's response was "did you cheat me a point or two, I think my score is ...". It was then the student's turn to answer the questions which were scored by the computer. At the end the student either received a congratulatory message such as "Excellent, your score is --- out of 5" for scores of four or five or "Sorry, hope you do better next time" for scores of less than four correct. The random generator was used when the computer posed questions and care was taken to ensure that no number was presented twice. Only five exercises were done by each player of the game.

A similar pattern ensued for supplementary angles.

The simple branch that was introduced in the program provided the student with help in addition. Figure 13 is an example of the steps which were presented to the student.

	1		
8 7	8 7	8 7	8 7
9 3	9 3	9 3	9 3
---	---	---	---
?	? 0	? 8 0	1 8 0

Figure 13

Addition Steps in Help Branch

The student had three attempts for entering a 0 (zero) at the question mark (prompt). If the correct entry was made then a 1 (one) was placed above the 8 and the prompt was moved to the next position below the 9. If no correct entry was made then the 0 (zero) was entered, the carry 1 was placed above the 8 and the prompt was placed below the 9. Again the student had three chances of entering the correct answer. Failure to answer correctly on the third try caused the computer to enter the correct digit and the prompt for the next.

Finally, the prompt was placed one place to the left of the 8 and the student input required was a 1. On completion of the addition exercise the student was then returned to complete the geometry question and continue. This branch was built into the courseware because the researcher was not concerned with basic skills. Hence, incorrect calculations would not necessarily be considered as a factor of poor performance.

The review section for tutorial program three was restricted to the concepts and skills covered in this lesson and consisted of only five questions. The student was asked to give the complement of a given angle and the supplement of a given angle. Also, given pairs of angles, the student had to determine if each pair was complementary, supplementary or neither. Like the other sections, a score was provided at the end. Again this was intended as a built-in form of reinforcement and motivation.

The objectives of tutorial program three were that on completion, each student would be able to :

1. define complementary and supplementary angles
2. identify complementary and supplementary angles
3. determine if given pairs of angles are complementary or supplementary
4. given one element of a pair, calculate the missing element.

Quizzes

Three quizzes were designed as part of the courseware. The first quiz comprized 11 questions, but was scored out of 16 since some questions had several parts. The material covered only the concepts introduced in lesson one. The second quiz also had 11 questions but was scored out of 25, again because questions had multiple parts. This quiz covered concepts from both tutorials one and two. The third quiz had eight questions but was scored out of 14 due to question format. Only concepts from tutorial three were tested in this quiz.

Each quiz was developed in an identical format. The question was presented and an answer entered by the student. Before the answer was evaluated, the student was given a chance to examine it and make changes if there was an obvious error, either typographical or an incorrect entry. If no changes were made, the answer was then evaluated and the next question presented. At the end of each quiz the student was informed of the number of questions that were correctly answered, the number incorrectly answered and the percentage score. Also presented was a message. If the score was 80% or better a congratulatory message was sent otherwise the message was simply "tomorrow you will do lesson ..." or "It was a pleasure working with you ...".

The Hardware

The programs were designed for and used on the International Business Machines' Personal Computer Junior (IBM PC Jnr). This machine was selected because of its graphics facility, the presence of colour, the ease with which the programmer/experimenter could combine text and graphics and the ability to activate colour at any time during the presentation of a lesson. The programs were stored on 6 x 5.25" floppy diskettes each with its own backup-copy.

The Language Used

The experimenter chose to use Advanced BASIC (BASICA) supplied on the DOS (Disk Operating system) cartridge of the IBM PC Junior. This language, although not formally structured, is designed for educational use and permits easy file handling, and easy combination of graphics and text.

Management Programs

A management system was designed and written by the experimenter in order to monitor each student's performance. Information stored in each student record included name and identification number, the time taken to complete each tutorial or quiz, the number of items correct on each quiz or review section, and a list of all user responses to the tutorial items only. For each quiz, a list of incorrect answers was stored. The questions were not stored in either the quiz or the tutorial.

CHAPTER IV

RESEARCH DESIGN

Introduction

In order to test the effectiveness of the courseware described in chapter three, it was necessary to design an experiment.

In this chapter, the objectives and the design of the investigation are described. Details of a small field test are given, and this is followed by a description of the sample selection, measures used to obtain data from the investigation and the administration of the treatment. Also included are the experimental hypotheses and the statistical methods used in the analysis of the data.

Objectives of the Investigation

The general purpose of the investigation was to make an evaluation of the effectiveness of computer assisted instruction in teaching a topic in introductory geometry to below average achievers (slow learners) first as the initial introduction to the topic, and secondly as remediation.

In this context, the effectiveness of the courseware was statistically assessed on the basis of student achievement and student attitude.

In order to complete this evaluation, the following four questions were considered:

1. Did the courseware teach the concepts for which it was designed ?
2. Was it effective as a tutorial program with students who had not previously covered the content material, and was it effective as remediation for students with some knowledge of geometry ?
3. With which levels of students was it more effective ?
4. Did exposure to the courseware effect any changes in students' attitude toward geometry ?

Field Test

Two gráde seven students assumed to be average achievers completed all sections of the courseware prior to the experiment. They worked with the experimenter outside of school time in the laboratory.

Based on errors made by these students and clarifications that they requested, some questions in the courseware were reworded and a few were deleted in order to reduce the time required to work through each program. The expected time for completion of each lesson was changed based on the time taken by these students.

Design of the Experiment

In order to meet the objectives and answer the above questions, it was necessary to include four experimenal groups of questions, it was necessary to include four experimenal groups of students in the experiment. It was further required that four corresponding control groups be established. This design was chosen in order to compare achievement between different experimental groups and between corresponding experimental and control groups.

The experiment was designed such that students in all four experimental groups received the same treatment, that is, they each completed the three tutorial programs and the three quizzes that made up the courseware. For each treatment group, achievement level in the subject was measured before and after the treatment, and attitude to the concepts of 'geometry' and 'computer' were also measured at the same times. While the control groups were not subjected to any special treatment, they completed the same tests at the same times as the experimental groups.

Each of the tutorial programs was designed to teach a specific number of skills and a data file recorded student responses to all questions. This file also contained answers to the quiz questions. At the end of each program the student was promoted to the next program in the series. This was done to ensure that each student received the same treatment, and was considered pedagodically sound as the content of each program was sequenced in very small steps and was also followed by a review section. Each student was exposed to the identical number of exercises and questions in each lesson as well as on each review section.

Measuring Instruments Used

Student achievement was measured by a test constructed by the experimenter since a standardized form which would measure the specific skills could not be found. This approach of designing and constructing achievement tests suited to the experimenter's needs has been used previously by other researchers (Wiens, 1975; Woetowich, 1980; Faulkner, 1982; Curda, 1985). To evaluate students' attitude toward the concepts of 'geometry' and 'computer', both semantic differential scales normed in Alberta and a sentence completion exercise were used. When these tests were completed, students were required to write their names on all tests. However, it was explained that this was only for the purpose of allowing the experimenter to identify and eliminate subjects who did not complete all tests that were required throughout the experiment.

Achievement Tests

The pre-test and post test for measuring achievement were identical. Each consisted of 39 items and was scored out of 41. To ensure face validity, the tests were submitted to instructors in the school as well as to experts in the field of mathematics. The tests were designed to be answered using the traditional pencil and paper method. Approximately 20 minutes were required for the writing of this test. The test is shown in Appendix A.

Attitude Scales

The School Subjects Attitude Scales (SSAS) (Nyberg & Clarke, 1973) which measure attitude towards school subjects uses the technique of the Semantic Differential developed by Osgood et al (1957). This test was selected because it has been normed for the Alberta student population. For each concept, the instrument consists of 24 descriptive word pairs, divided into three groups of 8. The first group defines the evaluation factor, the second group defines the usefulness factor and the last group defines the difficulty factor. There are five response positions for each adjective pair giving a maximum score of 40 and a minimum score of 8 on each section. Higher scores indicate a positive attitude toward the concept with a score of 24 being the median or neutral point. The concepts of 'geometry' and 'computer' were measured in this research. The traditional pencil and paper forms were used to obtain student responses. Each of the two parts of this test required approximately ten minutes. Appendix B gives details of this test.

Sentence Completion

The test consisted of three incomplete sentences about each of the two concepts 'geometry' and 'computer'. Each sentence was to be completed by students according to their feelings on the concepts. Each statement was then evaluated on a three point scale. A negative 1 was assigned if the statement indicated a negative feeling; a positive statement was scored as a one while a neutral statement was assigned a zero. Neutral statements included sentences not completed, and illegible statements. Scores obtained were summed in each category of neutral, negative and positive. This test appears in Appendix C.

The Sample

The sample for the experiment was selected from students at a secondary school. The school, designed to accommodate slow learners, is one of three vocationally oriented schools in the city of Calgary, Alberta. There are special entry requirements, and class sizes are smaller than in the other schools in the system. For entry into this special program a candidate must be 13 years old on September first of that year; must have failed at least two grades; must have scored below the 25th percentile on two or more sections in group testing; must be below average in individual testing; must have parental approval and must be referred from another school or by the Area office. In considering a student for the program, three of the above requirements are given priority, namely, parental approval, the student's age and performance on individual testing.

On entry at year one, students are placed in levels instead of the regular grade system. There are four levels in the school. Level one indicates first year in the program, level two suggests year two in the program, while level three suggests the third year in the program, and level four indicates that a student is in the final year of the program. It is also possible for a student to be registered in one level for academic subjects and a higher or lower level for technical subjects. By implementing this system, the student can avoid repeating any one year of the program.

When the students first enter the program they are tested in mathematics and language. Their skill levels vary widely but usually reading skills are between illiterate and grade seven and mathematics skills up to approximately grade five.

The sample consisted of students from levels one and two. Selection was completed as follows. All students in each of the 16 classes (eight at each level) were given the achievement pre-test, the Provincially standardized SSAS and the sentence completion exercise.

At each level, an experimental group of 22 students was selected from those whose score on the achievement pre-test was below 80 per cent. Students who demonstrated a lack of interest by refusing to attempt the pre-test were not considered suitable candidates.

Of these 22 students, 11 were chosen randomly from those classes where some geometry had been taught, and 11 from classes where no instruction in the topic had been given. The level two group of 22 students was also divided into two experimental groups each with 11 students similarly selected. The whole experimental group, therefore, consisted of 44 students.

For each of the four experimental groups a control group was defined. It consisted of all the students who completed the achievement test, attitude scales, and sentence completion exercise and who were in the same classes from which the students who formed the experimental group were drawn.

In summary, the sample consisted of the following:

level 1	no geometry	11 students
level 1	geometry	11 students
level 2	no geometry	11 students
level 2	geometry	11 students

For each of the above experimental groups there was one corresponding control group for a total of eight groups.

Administration

For the purpose of the experiment, six IBM PC Junior microcomputers were installed in a small study area in the Mathematics Department of the school. A seventh system was available as backup in case of equipment failure. Each computer was assigned a number for easy reference and each disk was assigned a corresponding number. This was necessary in order to aid the experimenter in collecting and processing data at the end of each session. It also helped the students who felt more at ease working with the same machine each day. All the required programs, tutorials and tests, and the student data files were stored on each diskette.

All four experimental groups were given the same treatment which normally took place between the hours of 8:45 a.m and 12:00 noon. These times were chosen because students were scheduled on the computer during their regular math classes and these were held at these times. An added convenience of these times was that those students who were late for school could be scheduled at the end of the period or after lunch. Students were reminded by the class teacher or the experimenter if they did not remember their assigned computer time.

The achievement pre-test, attitude scales and sentence completion exercise were administered over two days in the week prior to the treatment. Lessons one through four respectively were completed in the first four days of the week following that of the pre-test. The fifth day of the week was held in reserve to enable students who for some reason had fallen behind by missing a program on one of the previous four days to complete the requirements. The following week lesson five and lesson six were administered on the first and second days respectively. The third day of this week was retained as another day on which students could complete material missed. The post test, attitude scales, and sentence completion exercise were administered on the fourth day of the third week.

In order to have all students undergo as similar a treatment schedule as possible, all subjects who were not able to complete all the requirements as set out by the experimenter, were eliminated from the experiment. The treatment group was reduced from 44 to 34 by this means. Both the level one experimental groups had eight subjects each. The level two 'no geometry' group was reduced to nine subjects and the 'geometry' group to eight subjects. Among the ten eliminated subjects, two transferred to other schools and eight had been ill.

Hypotheses

In order to investigate the research questions posed, a number of formal hypotheses were considered. To answer the first question 'did the courseware teach the concepts for which it was designed?', the following hypothesis was formulated.

Hypothesis 1

There will be no significant difference between the mean post test score on the achievement test for the entire experimental group and mean post score of the entire control group.

Relating to the second question of whether the courseware was effective as a tutorial or as remediation, two hypotheses were drawn up.

Hypothesis 2a

There will be no significant difference between the mean pre-test score and the mean post test score on the achievement test of the two 'no geometry' groups.

Hypothesis 2b

There will be no significant difference between the mean pre-test score and the mean post test score on the achievement test of the two 'geometry' groups.

Question three investigated the level of students with which the courseware was more effective. For this question three hypotheses were formulated.

Hypothesis 3a

There will be no significant difference between the mean post test score on the achievement test of the two level one experimental groups and the mean post test score of the two level one control groups.

Hypothesis 3b

There will be no significant difference between the mean post test score on the achievement test of the two level two experimental groups and the mean post test score of the two level two control groups.

Hypothesis 3c

There will be no significant difference between the mean time taken by the level one experimental groups and the mean time taken by the level two experimental groups to complete the courseware.

For the fourth question of investigating the changes in attitude effected by the courseware the following hypotheses were considered.

Hypothesis 4a

There will be no significant difference between the mean post test score on attitude to 'geometry' of the total experimental group and the mean post test score of the total control group.

Hypothesis 4b

There will be no significant difference in the mean post test score on attitude to 'computer' of the total experimental group and the mean post test score of the total control group.

Statistical Technique

In order to identify the significant differences, if any, resulting from the treatment and to test the above hypotheses, t-tests were employed using a 0.05 level of significance. In addition, measures of central tendency were also used.

CHAPTER V

ANALYSIS OF RESULTS

Introduction

This chapter details the results obtained from the statistical analysis of data established in relation to each of the formal hypotheses. In addition, a brief discussion of subjective observations is included.

Results

Data for the experiment was collected and analysed statistically with the aid of the Statistical Package STAGGAR written in compiled BASIC for the IBM/PC in the Computer Applications Unit, Faculty of Education at the University of Calgary.

Testing of the Hypotheses

Data from the pre-tests and post tests for all the groups identified in the hypotheses were examined to determine whether scores were normally distributed. An examination of the measures of skewness and kurtosis indicated deviations from the normal distribution small enough to permit the use of parametric statistics.

Both correlated and uncorrelated t-tests, and measures of central tendency were used to examine the hypotheses stated in chapter 4.

Achievement

Hypothesis 1 stated that there is no significant difference between the mean post test score of the total experimental group and the mean post test score of the total control group.

The mean post test score ($\bar{X}$ = 28.86) of the experimental group was 12 points greater than the mean pre-test score. The control group, on the other hand, demonstrated little change. When t-tests were used to compare the two groups, the increase of the experimental group over the control group was found to be significant (t = 5.85; df = 65; p = 0.001).

The null hypothesis was therefore rejected and it was concluded that the courseware was effective in teaching the content of introductory geometry.

Measures of central tendency and t-values for the experimental group and the control group are reported in Tables 1 and 2 and a graphical representation of the data is shown in Figure 14.

Table 1

Means and Standard Deviations on Achievement for Experimental and Control Groups

	Pre-test			Post test		
Group	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	Gain
Exp.	16.86	9.13	34	28.86	11.16	12
Control	16.16	8.75	33	15.39	8.25	- 0.77

Table 2

Comparison of Mean Scores on Post Tests for Experimental and Control Groups

Post-test	Observed t-value	N1	N2	DF	Significance
Experimental/ control	5.85	34	33	65	0.001

The second hypothesis, which relates to the two experimental sub-groups, those who had previously received some instruction in geometry and those who had not, was divided into two parts.

Hypothesis 2a stated that there would be no significant difference between the means of the pre-test and post test scores of the combined 'no geometry' group. When the scores were compared, the experimental group showed an increase of 12.6 points over their pre-test score. When analysed this increase was found to be a significant improvement for the 'no geometry' group ($t = -7.24$; $df = 35$; $p = 0.001$).

The null hypothesis was therefore rejected. It was concluded that the significant improvement in achievement resulted from the effectiveness of the courseware for this group which had had no previous exposure to the topic. Results for this group are summarised in Table 3, Table 4 and Figure 15.

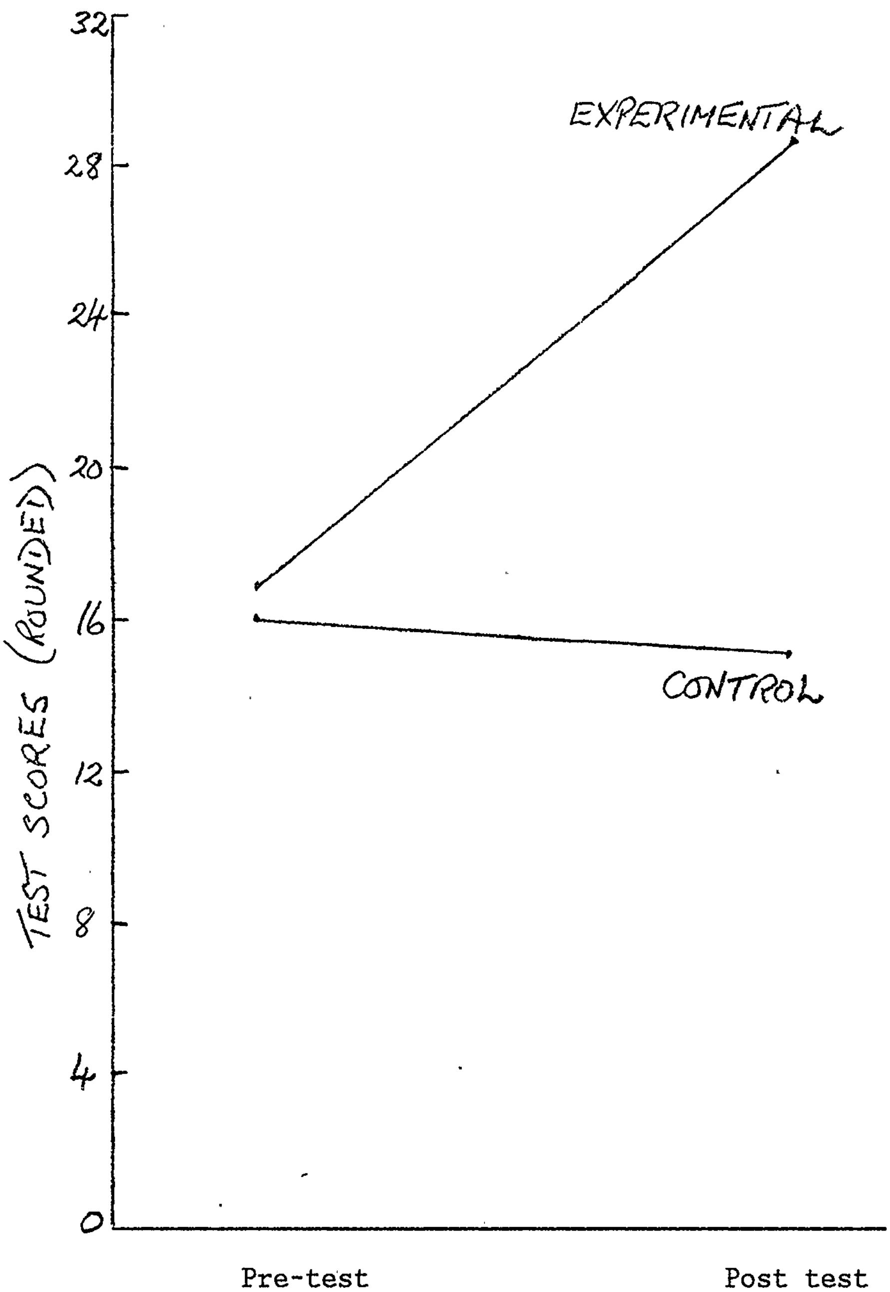


Figure 14

Mean Pre-test and Post Test Achievement Scores for Combined Groups

Table 3

Means and Standard Deviations on Achievement Measures for the 'No Geometry' Groups

	Pre-test			Post test		
Group	$\bar{X}$	S.D.	N	$\bar{X}$	S.D	Gain
'No Geometry'	10.74	8.47	18	23.35	14.58	12.61

Table 4

Comparison of Mean Scores on Pre-test and Post Test for the 'No Geometry' Groups

Pre-test/Post test	Observed t-value	N1	Df	Significance
'No Geometry'	-7.24	18	35	0.001

Hypothesis 2b stated that there would be no significant difference between the means of the pre-test scores and the post test scores of the combined 'geometry' groups. This group showed a 7.7 points increase over the pre-test score. When analysed, this increase was found to be significant (t = -5.05; df = 31; p = 0.001).

The null hypothesis was therefore rejected and it was concluded that there was a significant increase in the achievement scores of the group who had already taken some

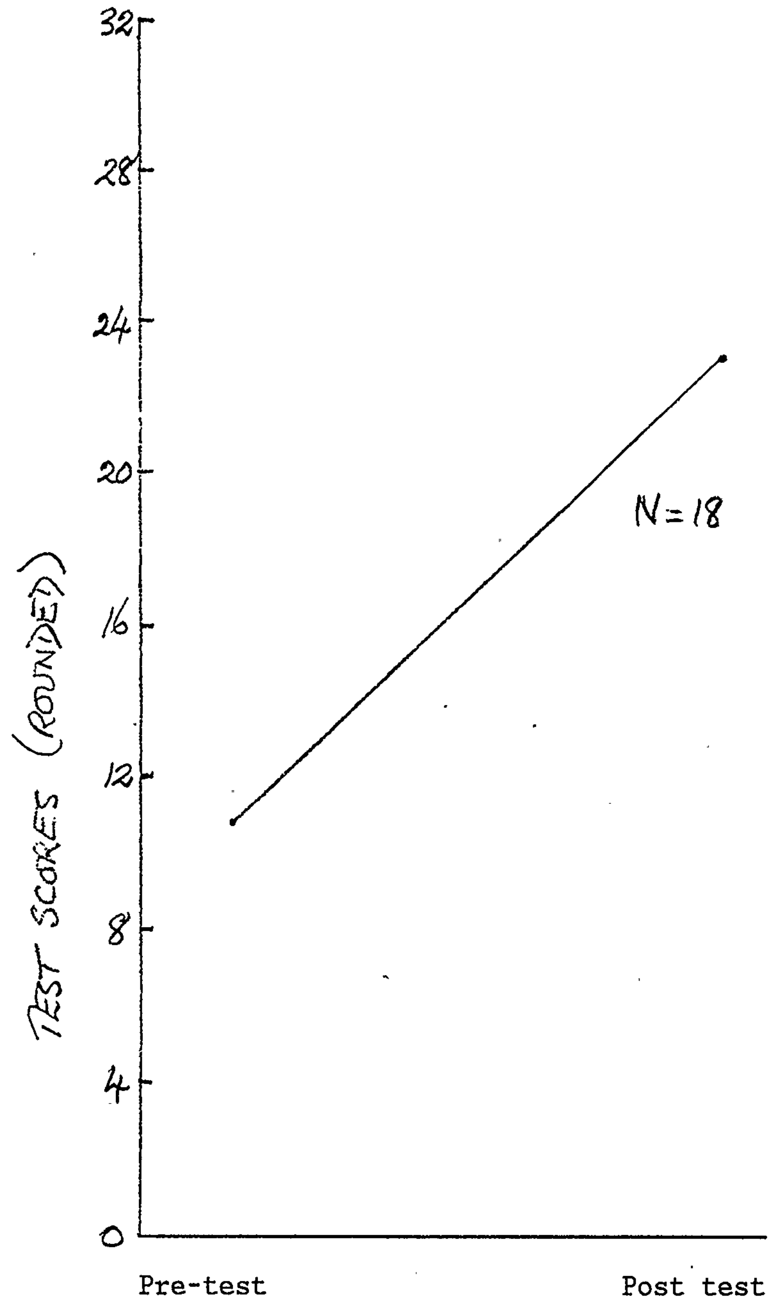


Figure 15

Mean Pre-test and Post Test Achievement Scores for the Experimental 'No geometry' Group geometry classes. Tables 5 and 6 and Figure 16 refer to results relating to this hypothesis.

Table 5

Means and Standard Deviations on Achievement Measures for the 'Geometry' Groups

	Pre-test			Post test		
Group	$\bar{X}$	S.D.	N	$\bar{X}$	S.D	Gain
'Geometry'	19.05	10.36	16	26.75	14.13	7.70

Table 6

Comparison of Mean Scores on Pre-test and Post Test for 'Geometry' Groups

Pre-test/Post test	Observed t-value	N1	Df	Significance
'Geometry'	-5.05	16	31	0.001

The third hypothesis concerned with the groups at the two levels was divided into three parts. Hypothesis 3a stated that there is no significant difference in the mean post test score between the combined level one experimental group and that of the combined level one control group. An examination of the results of these two groups illustrates a mean post test score of 30.28 for the experimental group. This is an increase of 15.34 points over their mean pre-test score. On the other hand, the scores of the control group showed little change.

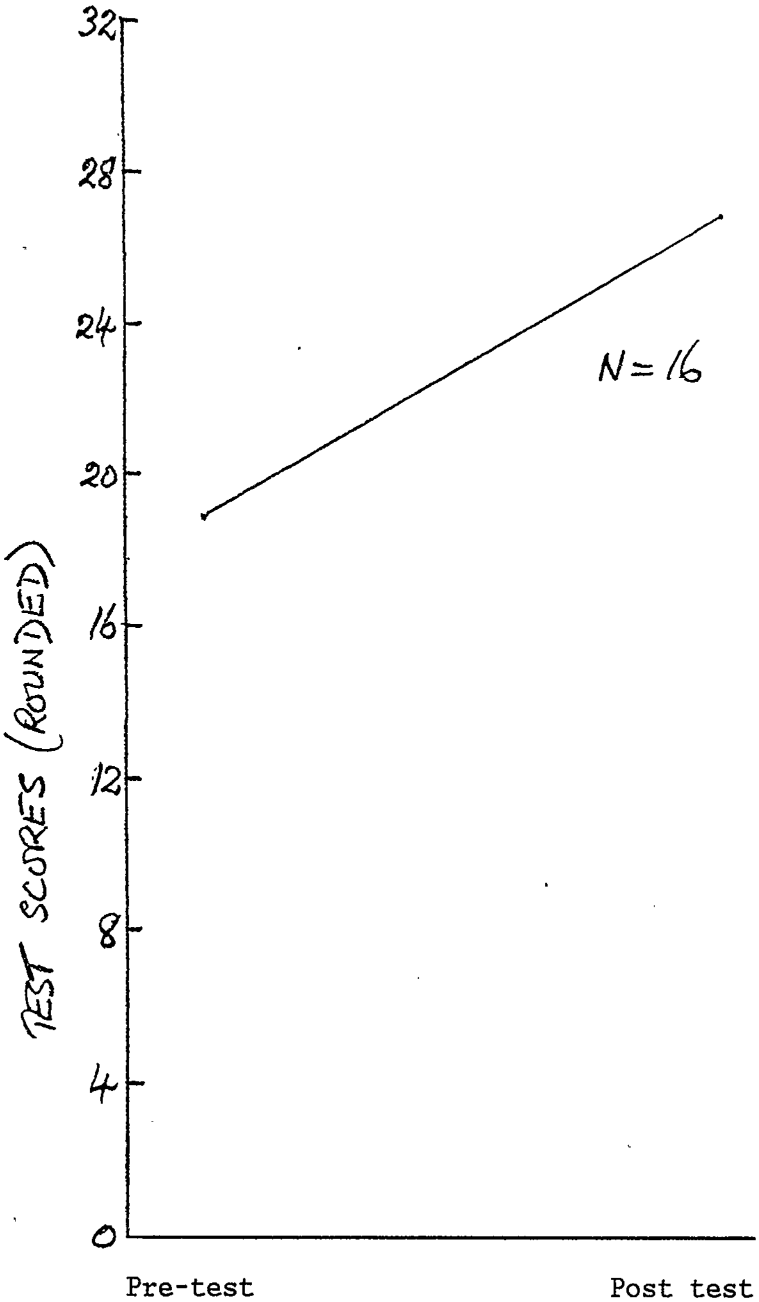


Figure 16

Mean Pre-test and Post Test Achievement Scores for the Experimental 'Geometry' Group

Uncorrelated t-tests were used to compare the scores. The increase was found to be significant ($t = 4.79$; $df = 32$; $p = 0.001$).

The decision was to reject the null hypothesis as a result of the significant increase in achievement scores demonstrated by level one, and conclude that the courseware used was effective in teaching introductory geometry to this group. Tables 7 and 8, and Figure 17 give summarized results.

Table 7

Means and Standard Deviations on Achievement Measures for Level One Experimental and Control Groups

	Pre-test			Post test		
Group	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	Gain
Level One						
Experimental	14.94	8.78	18	30.28	9.30	15.34
Control	16.25	9.64	16	15.88	8.10	-0.35

Table 8

Comparison of Post Test Achievement Scores between the Level One Experimental and Control Groups

Level One	Observed t-value	N1	N2	Df	Significance
Experimental/ Control	4.79	18	16	32	0.001

Hypothesis 3b stated that there is no significant difference in the mean post test scores of the combined level two experimental group and the combined level two control group.

The mean post test achievement score of the level two experimental group at 32.68 indicated an increase of 10.49 points over that of the pre-test. The control group did not show an increase, instead it showed a slight decrease of 1.13 points. When the mean scores were compared the t-value ($t = 8.27$; $df = 31$; $p = 0.001$) indicated a significant difference. Since the observed t-value was found to be greater than the critical t-value, the null hypothesis was rejected. It was concluded that there was a significant difference between the mean post test score of the experimental group and that of the control group. It was further concluded that this difference could be attributed to the effectiveness of the courseware used in the treatment. Summaries of the results are found in Table 9, Table 10, and Figure 18.

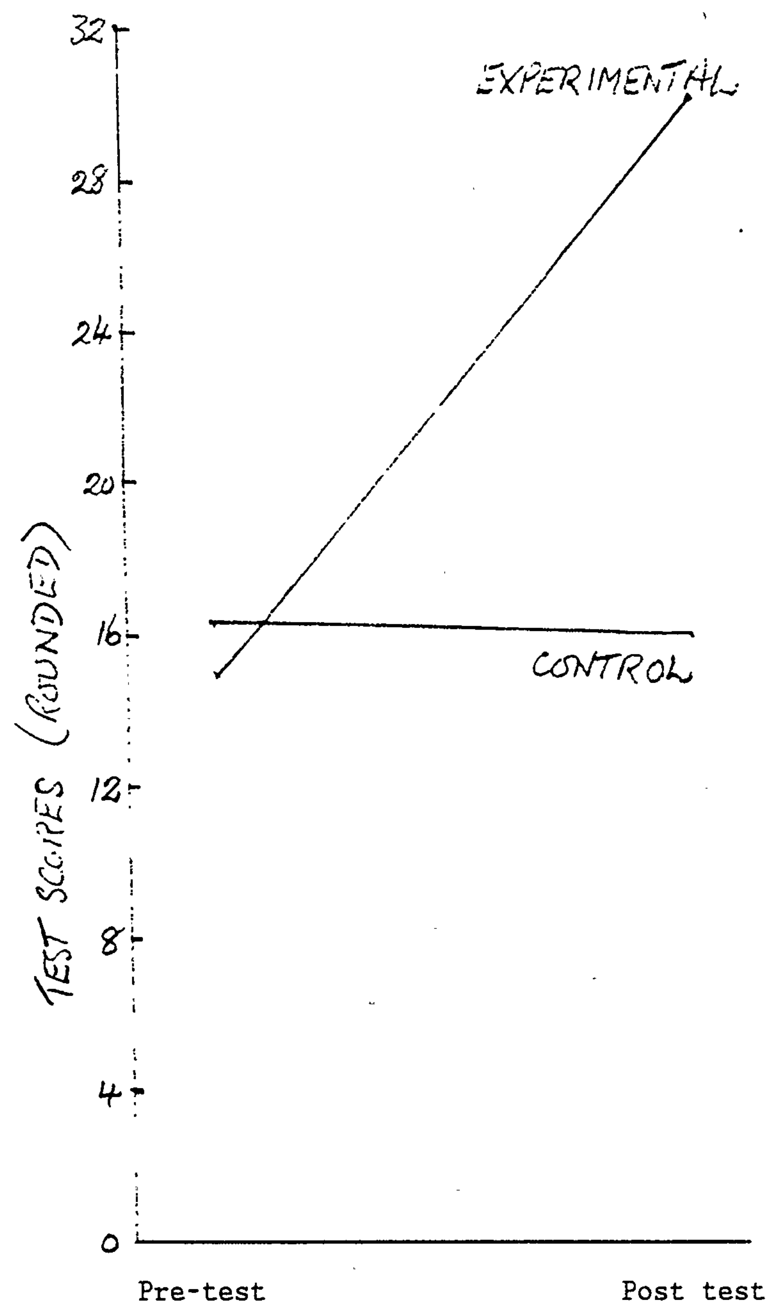


Figure 17

Rounded Mean Achievement Scores for
Level 1 Experimental and Control Groups

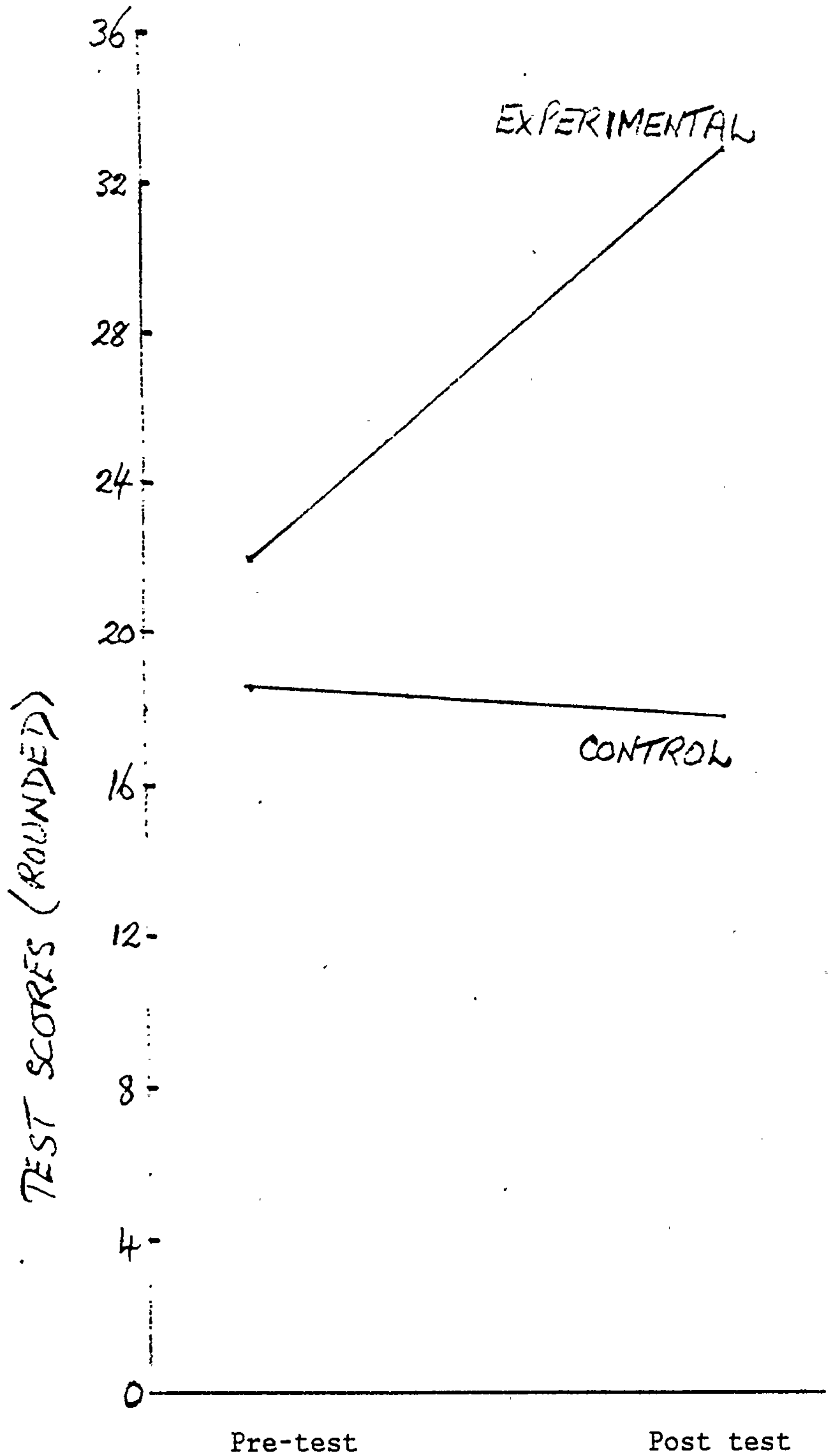


Figure 18

Rounded Mean Achievement Scores for
Level 2 Experimental and Control Groups

Time

Hypothesis 3c stated that there would be no significant difference in the mean task completion time taken between the level one experimental group and the level two experimental group.

Level one completed the treatment in the mean time of 64 minutes while level two needed 58.4 minutes. These times suggest a difference of 5.6 minutes.

In comparing the mean time taken for task completion by the above two groups, uncorrelated t-tests were used. The observed t-value (t = 1.43) indicated no significant difference in mean time taken to complete the treatment. Hypothesis 3c was, therefore, accepted. It was concluded that since there was no significant difference in time taken for task completion, then the courseware difficulty must have been similar at both levels. Mean time scores and t-value are displayed in Table 11.

Table 9

Means and Standard Deviations on Achievement Measures for Level Two Experimental and Control Groups

	Pre-test			Post test		
Group	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	Gain
Level Two						
Experimental	22.19	4.58	16	32.68	4.05	10.49
Control	18.78	5.20	16	17.65	6.12	- 1.13

Table 10

Comparison of Post Test Achievement Scores between the Level Two Experimental and Control Groups

Level Two	Observed t-value	N1	N2	Df	Significance
Experimental/ Control	8.27	16	17	31	0.001

Table 11

Mean Time in Minutes by Level

Group	N	$\bar{X}$	S.D
Combined Experimental Groups			
Level One	18	64	11.3
Level Two	16	58.4	10.1

($t = 1.43$; p = NS)

Attitude

The Concept 'Geometry'

Hypothesis 4 which relates to attitude was divided into two parts. Hypothesis 4a stated that there would be no significant difference in the mean post test scores on attitude to the concept 'geometry' between the combined experimental groups and the combined control groups.

Uncorrelated t-tests were performed on the evaluative factor scores of the attitude scale for the two groups. The observed t-value was significant at the 0.01 level ($t = 3.08$; $df = 65$; $p = 0.01$).

Hypothesis 4a was therefore rejected and it was concluded that after exposure to the CAI material, attitude toward the concept 'geometry' was more positive. Results relating to this attitude scale are displayed in Tables 12, 13 and in Figure 19.

For the sentence completion exercise on attitude toward the concept 'geometry' the scores were compared by the use of chi-square. For the experimental group, the observed value of chi was 17.22 with 2 degrees of freedom. This indicates a significant difference at the 0.05 level. The observed chi for the control group was 5.70. This value indicates no significant difference.

This result further indicates that the treatment had a positive effect on the students' attitude toward 'geometry' and supports the rejection of the null Hypothesis 4a. Table 14 gives observed chi-values of the sentence completion exercise.

Table 12

Means and Standard Deviations on Attitude (SSAS Scales)
Measures for the Experimental Group
Concept: 'Geometry'

	Pre-test			Post test	
Group	$\bar{X}$	S.D.	N	$\bar{X}$	S.D
Evaluation					
Exp	23.50	11.48	34	28.34	12.02
Control	22.32	11.32	33	20.22	10.80
Usefulness					
Exp	27.89	10.64	34	30.38	10.41
Control	25.24	11.65	33	23.24	10.69
Difficulty					
Exp	22.76	9.88	34	26.08	10.83
Control	20.62	9.82	33	21.35	8.90

Table 13

Comparison of Mean Scores on Attitude Post Tests for
Experimental and Control Groups
Concept: 'Geometry'

Experimental /Control	Observed t-value	N1	N2	DF	Significance
Evaluation	3.08	34	33	65	0.01

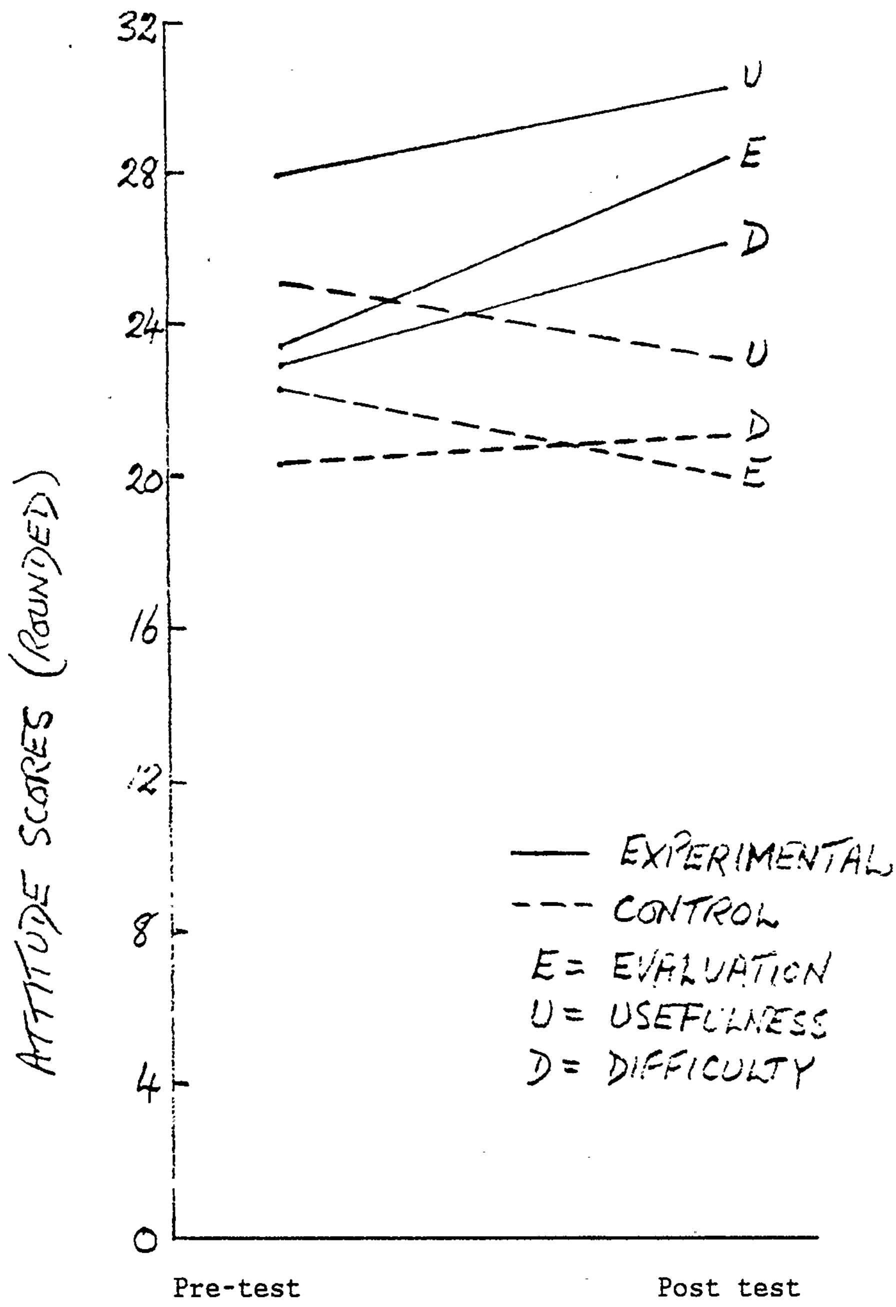


Figure 19

Mean Pre-test and Post Test Scores for Attitude to the Concept 'Geometry'

Table 14

Sentence Completion Exercise
Concept: Geometry

Group	Chi Value	DF	Significance
Experimental	17.22	2	0.05
Control	5.70	2	NS

<u>The Concept 'Computer'</u>

The second part of hypothesis 4, namely hypothesis 4b, stated that there is no significant difference in the mean post test scores on attitude toward the concept 'computer' between the combined experimental group and the combined control group.

T-tests were performed on the scores of the evaluative factor of the attitude scale. The observed t-value of 2.07 was not significant ($t = 2.07$; $df = 65$; $p > 0.05$).

Hypothesis 4b was accepted and it was concluded that after exposure to the CAI courseware, the attitude of the subjects to the concept 'computer' did not indicate any significant change. Summarized results are displayed in Tables 15 and 16 and illustrated in Figure 20.

Chi square tests were applied to the scores of the sentence completion exercise on attitude toward the concept 'computer'. The chi value of 1.06 indicated no significant change in the attitude of the experimental group toward the concept "computer'. This result supports the acceptance of Hypothesis 4b. A summary of chi-values for the sentence completion exercise regarding the concept 'computer' is displayed in Table 17.

Table 15

Means and Standard Deviations on Attitude (SSAS Scales)
Measures for the Experimental Group
Concept: 'Computer'

	Pre-test			Post test	
Group	$\overline{X}$	S.D.	N	$\overline{X}$	S.D
Evaluation					
Exp.	32.16	11.13	34	34.14	12.17
Control	31.14	12.09	33	28.73	12.58
Usefulness					
Exp.	32.24	10.49	34	33.68	10.88
Control	29.78	11.63	33	28.35	12.56
Difficulty					
Exp	23.84	9.76	34	27.62	9.92
Control	23.70	10.11	33	23.68	10.62

Table 16

Comparison of Mean Scores on Attitude Post Tests for
Experimental and Control Groups
Concept: 'Computer'

Experimental/ Control	Observed t-value	N1	N2	DF	Significance
Evaluation	2.07	34	33	65	NS

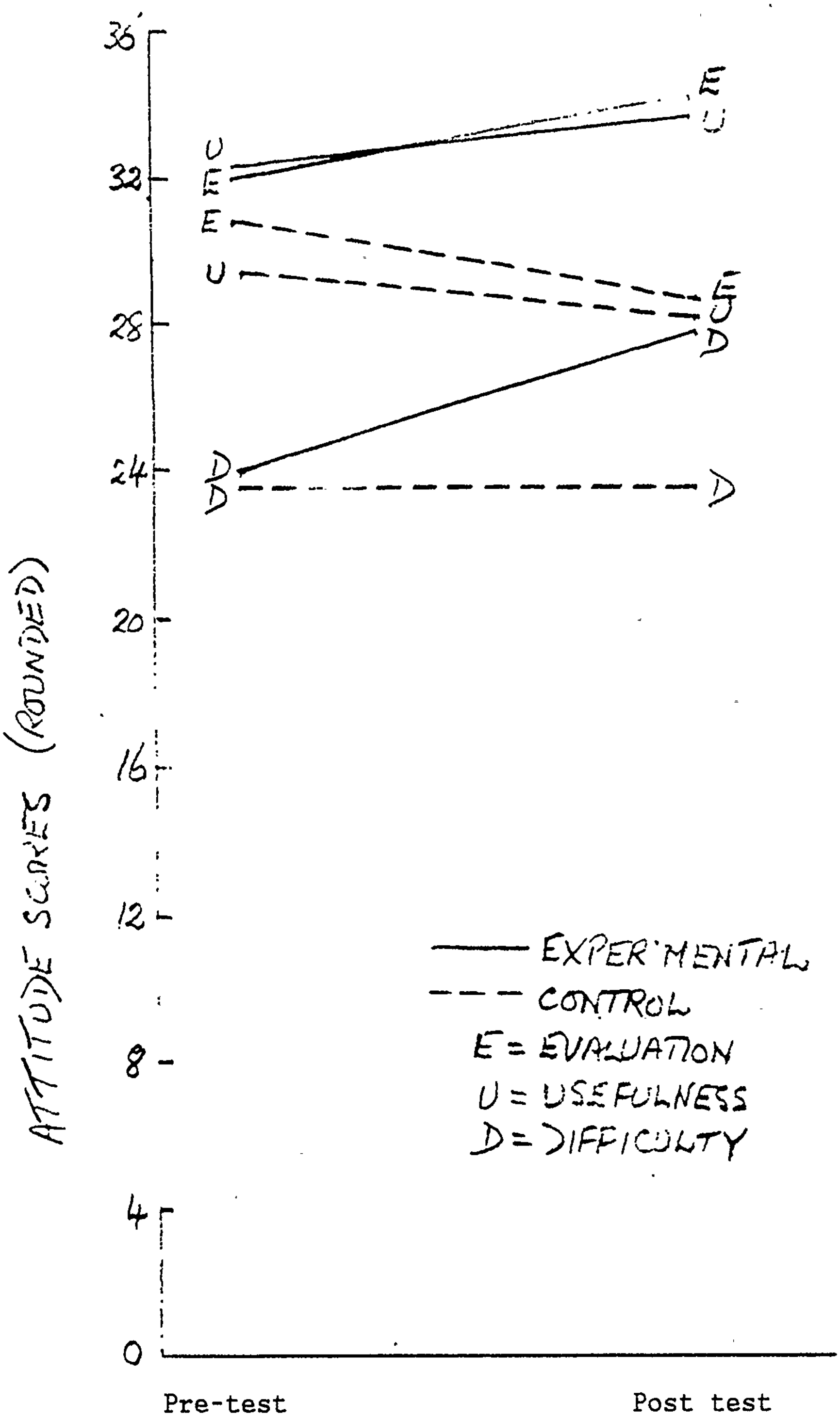


Figure 20

Mean Pre-test and Post Test Scores for Attitude to the Concept 'Computer'

Table 17

Sentence Completion Exercise
Concept: Computer

Group	Chi Value	DF	Significance
Experimental	1.06	2	NS
Control	4.55	2	NS

Subjective Observations

Students

The experimenter received considerable feedback from the subjects involved in the experiment as well as from the Mathematics' teachers of these students. Since student reaction to any instructional program contributes to improving the effectiveness of the program, the comments and observations made were considered valuable information although they cannot be subjected to any formal analysis.

Many students commented on their enjoyment of the CAI programs and expressed a wish that they would be given the opportunity to do other subjects on the computer. They especially liked the fact that they were allowed more than one attempt to answer the questions, and that they could go "at our own pace". Students were elated and 'felt special'. Their discussions with students not involved in the experiment led to some of these students requesting a chance 'to play on the computer'. Further, students who were not able to complete the project expressed disappointment, and all expressed further disappointment at the completion of the investigation.

The teachers indicated that all the subjects were usually enthusiastic about their participation in the project. The experimenter found that many students would repeatedly arrive before their scheduled time and had to be constantly reminded about the limits on their allotted time on the computer.

Microcomputer Hardware

Further observations include a few disadvantages of working with microcomputers at their present stage of development. Firstly, the experimenter found that it was very difficult to maintain student records in a file system. Students were assigned to a specific numbered microcomputer with the corresponding diskette in order to reduce the work of the experimenter in compiling data. Invariably however, this did not work as planned because students were sometimes late or absent. Data from each disk had to be compiled on a master disk at the end of each session.

On the other hand, the experimenter found that by working with microcomputers, there was very little time lost in systems being 'down', and students were ready to start as soon as they were seated at their stations. Also noticable was that no time was lost in 'downloading' from a multi-user system and students did not have to learn to 'login' or 'logout'. Because most of the students had been previously exposed to microcomputers, orientation time was also minimized. These factors were considered advantageous in the use of microcomputers for the experiment.

Courseware

The experimenter found some limiting factors which may have indirectly affected the outcome of the experiment. Many students had difficulty following instructions because of their low reading level. As a result, some of the instructions in the programs were not interpreted as expected. For example where a student was asked to 'name an angle' it was frequently confused with 'type of angle'. There were a few who asked for the meaning of 'sum' and the meaning of 'difference' and while others understood the symbol for 'is equal to', they had difficulty putting the verbal expression into context unless the statement was read to them. These students had difficulty with word recognition and interpretation. When the instructions were read to them, they had less difficulty with execution.

Many had poor basic mathematics skills, hence they had difficulty with such simple operations as 180 - 98, or 90 - 64.

Others had low self-esteem and poor self-confidence. At first, some students made such comments as 'I can't do it', or 'I'll get it wrong'. For many, however, this gradually changed to 'Can I come two times ?', or 'This is fun'.

CHAPTER VI

DISCUSSION AND CONCLUSIONS

Introduction

The purpose of this study was to investigate the effectiveness of CAI in the first instance as a tutorial and in the second instance as remediation of the same material for slow learners. This chapter begins by addressing the issue in relation to the results of the hypotheses tested. Limitations of the study and suggestions for further research are also discussed.

Discussion of the Results

Achievement

The effectiveness of the courseware was statistically assessed on the basis of student achievement, student attitude and task completion time. The four main questions of the research required the formulation of four hypotheses, three of which were sub-divided to address the corresponding question. The first question sought to investigate whether the the courseware had successfully taught the concepts for which it was designed.

To answer this first research question hypothesis one was tested. Data from the post test scores of all the experimental groups was compared with that of the entire control group. The results of the t-tests performed on these data indicated that significant gains were made by the students who received the CAI treatment.

Since there were no significant pre-experimental differences in the achievement scores of the groups, it was assumed that any difference found could be attributed to the treatment.

The second question related to whether the same courseware was effective as tutorial material to those students who had not previously studied introductory geometry and, as remediation for those who had previously received some instruction.

Hypothesis two, therefore, also dealt with achievement. It was examined in two parts. First, the data from pre-test and post test of the 'no geometry' groups were compared, then the data from the pre-test and post test of the 'geometry' groups were compared. In both instances significant increases in achievement were found.

Since, when pre-experimental data was compared there was no significant difference found, it can be assumed then, that any difference found on the post test data could be attributed the CAI treatment. In the first case, it was concluded that the courseware was effective as a tutorial, and, in the second instance, that it was effective as remediation for the group of students with whom it was used.

Hypothesis three was examined in three parts. In the first instance post test scores of the level one experimental group were compared with post test scores of the control group. Again significant differences in scores were found. Similarly, when post test scores of the level two experimental group was compared with the post test scores of the control group, significant differences in achievement scores were found. It was concluded that these results could be attributed to the effectiveness of the courseware.

Each experimental group demonstrated significant improvement from pre-test to post test. The control group in both instances did not show any improvement from pre-test to post test.

These results indicate that the CAI instruction was successful in meeting the educational objectives of this particular investigation with this particular content at both level one and level two. Since there was no significant difference in the time taken to complete the courseware at the different levels, and since there was little difference in the post test scores of the two groups, it was not possible to draw any conclusions regarding the relative effectiveness at the two levels. The time comparison excluded lesson one which was interrupted by a fire drill.

Attitude

Hypothesis four was formulated to determine if there was any change in attitude due to the treatment. This hypothesis was also examined in two parts, the first part concerning the concept 'geometry' and the second, the concept 'computer'.

Although the length of time over which the treatment was administered was not very long, the difference observed between the pre-test and post test scores for the experimental group on the evaluative scale of the SSAS for the concept 'geometry' was found to be significant. This indicated a positive change in attitude. The control groups either remained the same or showed decreases in their pre-test to post test scores. These did not however, indicate any significance when t-tests were performed.

The decrease in attitude of the control group can be attributed to the fact that they were not exposed to the courseware.

Analysis of the sentence completion exercise also indicated a significant increase in positive attitude toward the concept 'geometry'. There were 22 students who made 37 positive statements about 'geometry' on the pre-test while 29 students made 78 positive statements on the post test. It was concluded that the change was a direct result of their using the courseware since prior to the treatment their attitude bordered on neutral to negative.

Using the same measures, no significant improvement in attitude toward the concept of 'computer' was observed for the experimental group. When post test scores were compared, no significant difference was found between the experimental and the control group. The control group however, demonstrated a slight negative trend. This may have resulted from the fact that they were not exposed to the treatment. Although the experimental group demonstrated slight increases in scores, it was not found to be significant when t-tests were applied. There are perhaps two explanations. The first is that the treatment was administered over a short period of time and hence not long enough to effect a significant, positive change. The second is that all students began with a very positive attitude toward computers because they had had previous experience working with computers. They retained their positive attitude at the end of the treatment. If perhaps the treatment was extended over a longer period of time a greater improvement in attitude might have occured.

The post test scores on the sentence completion exercise on attitude to computers showed slight changes when compared to those on the pre-test. There were no negative statements on the post test as opposed to four on the pre-test. On the pre-test, 32 students made 72 postive statements about computer. On the post test, 32 students made 78 positive statements indicating an increase of 6 points. When analysed, however, no significance was found.

Time

The experimental groups successfully completed the courseware in an average time of one hour. When the same material is taught using the conventional classroom method it usually requires more class time. There was no substantial difference between level one and level two in the amount of time required to complete the courseware.

Students who failed to perform well on tests were those who spent the least amount of time on the courseware and guessed the answers to the questions.

Limitations of the Investigation

For the purpose of this experiment, it was necessary to impose limits on the test period in order to measure performance. Exposure to the courseware was restricted to one trial per program and each subject had to complete each section. These limitations resulted in a loss of 10 students who were not able to meet these requirements. Another limitation related to the sample size. A sample size larger than 34 would likely have provided a more reliable set of data for comparison. On the other hand a sample of 34 is a statistically managable size. The duration of the experiment provided another limitation. It is not known if the subjects would have continued to improve or would have performed significantly better if the experiment lasted for a longer period of time.

It could be argued that the Hawthorne effect influenced the magnitude of the pre-test to post test gains for the experimental groups. The effect might have been controlled by providing work on the computer for the control group but in a different subject area. Since this control was not possible at the time of the investigation, it may be considered as a limiting factor.

A desirable feature of courseware designed for this population would be to have some branching based on student choice as well as program choice. In preparing the program for the purpose of this investigation, this feature had to be omitted. This therefore was considered a limitation.

Conclusions

Although some major conclusions can be drawn from this experiment, findings cannot be generalized beyond the group which formed the experimental population. These findings, however, may well be used as a basis for further research.

These results suggest that CAI can successfully be used as an effective teaching tool for slow learners at the vocational secondary school in Calgary where the experiment was carried out. Since there are two other schools with similar populations, these results may indicate possible directions for further research and practice into the teaching of mathematics to these populations.

The results further show that CAI can be used successfully both as a tutorial with those students who were learning new concepts, and as a means of remediation with those who had previously been introduced to introductory geometry. The literature found has suggested that CAI is successful with slow learners partly because they are usually in control of the pace, and because of the immediacy of the feedback.

Another conclusion is that the courseware used was generally effective with students at both levels. This finding indicates that similar courseware would likely be as effective at other levels as well and further that CAI would be a likely means of providing instruction in mathematics at all levels with a similar student population.

Although, further study would be needed to determine the implication to other areas in mathematics and posibly other levels of students, these results are positive enough to indicate a need for further investigation.

While it can be argued that some of the high achievement scores were due to chance, it must also be noted that the post test scores of all thirty-four participants increased over their pre-test scores. If, therefore, scores were affected by chance then post test scores should have shown some decrease and this did not occur. The results can therefore be interpreted as a direct outcome of the interaction with the courseware.

Finally, the significant change in attitude to the geometry, shown by the experimental group may well be attributed to the interaction with the courseware. This result suggests that the use of CAI with these slow learners had positive effect on their attitude toward geometry. This would further imply a need for more studies in this area over a longer period of time.

The attitude of the experimental group to the computer remained positive over the duration of the treatment. Although increases in scores were noted, these were not significant. Since the treatment period was very short, this result was expected. On the other hand, attitude of the control groups which had no exposure to the courseware remained mostly the same but showed slight decreases. It maybe suggested that there was no detrimental effects on the attitude of the students as a result of the treatment.

The level of success of this investigation further suggests that CAI may be used successfully with these students in other areas of mathematics.

Suggestions for Further Research

In the discussion of the subjective observations, it was noted that many students had difficulty with some of the instructions. The difficulty which they experienced, however, was not considered when the data was analysed. Further research should be done to determine if students who are experiencing severe reading and comprehension difficulties can successfully learn when CAI is used.

One of the limitations of this study was cited as the length of time over which the experiment was run. It is necessary, therefore, that future studies be extended over a longer period of time, allowing for the introduction of more content and providing extra drill and practice for students who demonstrate less than average performance on any section.

Most of the literature which was reviewed were studies which investigated CAI as remediation, or one CAI method of presentation compared with another. Ma (1980) compared the use of CAI with conventional classroom instruction in teaching 'average achievers'. Of interest, would be a similar investigation involving a population of slow learners.

Another area which needs further investigation is that of the slow learner's retention and transfer of learning. Research is needed to compare student achievement two weeks or two months or a year after the investigation.

While research has been done on the use of multi-media approaches to delivering instruction to handicapped individuals, none has been found with the slow learner population. This is another area which requires further investigation.

There are several observational reports concerning the 'novelty effect' of the computer and how it affects attention span and motivation of the learner. Although it could be difficult to design such a project, the idea does warrant formal investigation.

Finally, an investigation which measured the effect of using a combination of graphics and text as a means of reinforcement compared with that of using reinforcement presented by text format only would provide useful data for the design of teaching materials for this population.

Although this study was limited to a small sample, the results are positive enough to indicate further investigation over a longer period of time. As well, as the development of microcomputer technology continues it will necessitate ongoing research into developing courseware that is in keeping with the capability of the hardware. In particular, well designed courseware that will strongly reflect the needs of the slow learner has the potential of providing effective instruction for that particular student group.

REFERENCES

Aiken, L. R. Two scales of Attitude toward Mathematics. Journal for Research in Mathematics Education, 1974, 67-71.

Atkinson Richard C. et al. Futures: Where will Computer-Assisted Instruction be in 1990? Educational Technology, April 1978, 60-63.

Alderman, Donald L. et al. PLATO and TICCIT: An Evaluation of CAI in the Community College. Educational Technology, April 1978, 40-45.

Bell, F. H. Can Computers Really Improve School Mathematics? Mathematics Teacher, May 1978, 428-433.

Benedict, Richard R. The Kotter Key to Educating Disadvantaged Students. Educational Leadership, 37(7), April 1980, 594-595.

Brebner, Ann, Clark, L.M. & Johnson, Ken. Vocational Training for Developmentally Handicapped Adults Using CAI. Computer Education, 8(4), 1984, 445-448.

Brebner, Ann & Hallworth, H.J. Computer Managed Instruction in Elementary School Reading and Mathematics in the County of Wheatland. Edmonton: Alberta Education, March 1985.

Brebner, Ann, Hallworth, H.J., & McKinnon G. A. A Multi-Media Computer Based Instruction System with an Interactive Author Support Environment. NATO, Brussells, 1985.

Bunderson, C. V. The TICCIT Project: Design Strategy for Educational Innovation. Provo, Utah: Brigham Young University, Sept. 1973. (ERIC file #096 996).

Camp, John S. Computer Enhanced Mathematics. Viewpoints in Teaching and Learning, Spring 1981, 1-12.

Campanini, Susan. Learning Characteristics of the Disadvantaged: Implications for CAI Lesson Design. Studies in Languages Learning, 1981. (ERIC file #218 947).

Copple, Christine. Computers in the Secondary Mathematics Curriculum. June 1981. (ERIC file #204 144).

Crawford, A. N. A Pilot Study of Computer-Assisted Instruction Drill and Practice in Seventh Grade Remedial Mathematics. California Journal of Educational Research, 21(4), 1970, 170-181.

Curda, John B. A Study of Computer Assisted Instruction for Teaching some Skills required for Estimation of Products at the Grade Six Level. Unpublished Master's Thesis, University of Calgary, 1985.

Dence, Marie. Toward Defining the Role of Computer-Assisted Instruction: A Review. Educational Technology, November 1980, 50-54.

Dent, David. 1984: A Look at Education in the Future. Today's Generation, Oct. 1974, 24.

Donhardt, Gary L. Microcomputers in Education: Elements of a Computer Based Curriculum. Educational Technology, April 1984, 30-32.

Dunn, Rita S. Learning - A Matter of Style. Educational Leadership, 36(6), March 1979, 430-432.

Eisele, James E. Classroom Use of Microcomputers. Educational Technology, XIX(10), Oct. 1979, 13-15.

England, G.D. A Study of Computer Assisted Budgeting Among the Developmentally Handicapped. Unpublished Doctorial Dissertation, University of Calgary, 1979.

Fleenor, C., Eicholz, R.E., & O'Daffer, P.G. School Mathematics 1. Don Mills, Ontario: Addison-Wesley (Canada) Ltd., 1975.

Faulkner, Martha C. A Study of the Effectiveness of CAI for Teaching Time-Telling Skills and Time Related Concepts to Developmentally Handicapped Adults. Unpublished Master's Thesis, University of Calgary, 1982.

Gershman, Janis & Sakamoto, Evannah. Computer Assisted Remediation and Evaluation: A CAI Project for Ontario Secondary Schools. Educational Technology, March 1981, 40-43.

Gerzanick, Rita et al. Microcomputer Remedial Instruction. The Computing Teacher, Oct. 1982, 50-52.

Gibson, Joella. Use of Computer Assisted Instruction in Math for Disadvantaged Seventh Grade Youth, 1971. (ERIC file #049 057).

Grant, W. The Effectiveness of Two Computer Assisted Instruction Presentations in Mathematics for Slow Learners. Unpublished Master's Thesis, University of Calgary, 1977.

Hallworth, H. J. & Brebner, Ann. Computer assisted Instruction in Schools: Achievements, Present Developments, and Projections for the Future. Edmonton: Alberta Department of Education, Planning and Research, June 1980.

Hill, Shirley A. The Microcomputer in the Instructional Program. The Arithmetic Teacher, Feb. 1983, 30(6), 14-15 & 54-55.

Hill, Sylvia et al. An Agenda for Action, Recommendations for School Mathematics in the 1980's. Reston, Virginia: National Council of Teachers of Mathematics, 1980.

Hilles, Robert. Computer Assisted Instruction and Written English. Unpublished Master's Thesis, University of Calgary, 1984.

Holz, E. A. Study of the Use of Computer Assisted Instruction for Teaching a Social Sight Vocabulary to Mentally Handicapped Adolescents. Unpublished Master's Thesis, University of Calgary, 1976.

Karlin, M. S., & Berger, R. Successful Methods for Teaching the Slow Learner. West Nyack, N.Y.: Parker Publishing Co. Inc., 1969.

Kephart, N. C. The Slow Learner in the Classroom. 2nd Ed. Columbus, Ohio: Charles E. Merrill Publishing Co., 1971.

Kraus, William. Golf Classic/Compubar. St. Louis, Missouri: Milliken Publishing Co., 1982.

Krueger, R. D. Integration of CAI into Students' Learning. Unpublished Master's Thesis, University of Calgary, 1986.

Krysak, W., Bye, M., Elliot, H. A. Math Probe 1. Toronto: Holt, Rinehart and Winston of Canada, Ltd., 1975.

Lucas, V. Classroom Activities for Helping Slow Learning Children. New York, NY: The Centre for Applied Research in Education, Inc. (Ed.) W.B. Barbe, 1974.

Leavitt, Gerald A. Computer-Assisted Instruction in Introductory Algebra. Unpublished Master's Thesis, University of Calgary, 1975.

Ma, S. N. A Study of Students Learning Logarithmic Functions using an Adaptive CAI System. Unpublished Doctoral Dissertation, University of Calgary, 1980.

Macken, E., & Suppes, P. Evaluation Studies of CCC Elementary School Curriculum. 1971-1975. Palo Alto, California: Computer Curriculum Corporation, 1976.

Moursund, David. Introduction to Computers in Education for Elementary and Middle School Teachers. Eugene, Oregon: University of Oregon, October 1982.

Nyberg, V. R., & Clarke S. C. T. School Subjects Attitude Scales Administrator's Manual: A Manual for Administration, Scoring, and Interpretation. Edmonton: Alberta Education, Planning Services, 1973.

Olivier, W. P. Computer-Assisted Mathematics for Upgrading Student Skills. Proceedings of the Canadian Symposium on Instructional Technology, Ottawa: National Research Council, 1972, 206-220.

Overton, Victoria. Research in Instructional Computing and Mathematics. Viewpoints in Teaching and Learning, Spring 1981, 23-36.

Pagliaro, Louis A. The History and development of CAI: 1926-1981: An Overview. The Alberta Journal of Educational Research, March 1983, XXIX(1), 75-84.

Paschal, B. J. Geometry for the Disadvantaged. The Arithmetic Teacher, Jan. 1967, 4-6.

Pikaart, L., & Wilson, J. W. The Research Literature. In W.C. Lowry (Ed.), The Slow Learner in Mathematics. The National Council of Teachers of Mathematics, Thirty-fifth Yearbook, 1972.

Rogler, Paul V. Classroom and School Administration. In W. C. Lowry (Ed.), The Slow Learner in Mathematics. The National Council of Teachers of Mathematics. Thirty-Fifth Yearbook, 1972.

Sandals, L. H. Computer Assisted Learning with the Developmentally Handicapped. Unpublished Doctorial Dissertation, University of Calgary, 1973.

Sandals, L. H. et al. An Overview of a Six Year Computer Assisted Learning Project for Special Needs Children and Adolescents. Proceedings of the Third Canadian Symposium on Instructional Technology, Ottawa: National Research Council, 1980, 201-209.

Schloss, Lisa & Ball, Leslie D. Computerized Education: Should We or Shouldn't We. Monitor, August 1981, 18-21.

Schulz, Richard W. Characteristics and needs of the Slow Learner. In W. C. Lowry (Ed.), The Slow Learner in Mathematics, The National Council of Teachers of Mathematics, Thirty-fifth Yearbook, 1972.

Skinner, Steven J., & Grimm, Jim L. CAI Case Study: The Introductory Marketing Course. Educational Technology, July 1979, 34-36.

Smith, I. D. Impact of Computer Assisted Instruction on Student Attitudes. Journal of Educational Psychology, March 1973, 366-372.

Splittgerber, Fred L. Computer-Based Instruction: A Revolution in the Making. Educatational Technology, January 1979, 20-25.

Strain, A. Computer Assisted Instruction in Social Arithmetic for the Retarded. Unpublished Master's Thesis, University of Calgary, 1974.

Strain, A. Coin Computation: A Task Analysis and a Computer Assisted Instruction Program for the Retarded. Unpublished Doctorial Dissertation, University of Calgary, 1980.

Suppes, P. Computers for Individualized Instruction. Intellect, January 1974, 219.

Suppes, P., & Macken, E. Historical Path from Research and Development to Operational Use of CAI. Educational Technology, XVIII(4), April 1978, 9-11.

Suppes, P., & Morningstar, M. Computer-Assisted Instruction. Science. 166(3903), Oct. 1969, 343-350.

Suppes, P., & Morningstar, M. Computer Assisted Instruction at Stanford 1966-1968. New York: Academic Press, 1972.

Taylor, Sandra. The Effectiveness of CAI. A paper presented at the Annual Convention of the Association for Educational Data Systems, New York, May 1974. (ERIC file # 092 074).

White, Mary Alice. Synthesis of Research on Electronic Learning. Educational Leadership, May 1983, 13-15.

Wiens, I. Walter. Computer Assisted Remediation in Secondary School Mathematics. Unpublished Master's Thesis, University of Calgary, 1975.

Wigle, R., Dowling, P., Jennings, P., Mathematical Pursuits One. Toronto: MacMillan Company of Canada, 1975, S.I. Edition.

Woetowich, Herman M. A Study of CAI for Integer Arithmetic and the Effect of some Adaptive Instructional Strategies. Unpublished Master's Thesis, University of Calgary, 1980.

______ Evaluator's Guide for Microcomputer Based Courseware. Edmonton, Alberta: Program Development Division of Alberta Education, 1983, 22-23.

______ Individualized Instruction. Research Action Brief #14. Washington, D.C.: National Institute of Education (DHEW). Dec. 1980. (ERIC #198 621).

APPENDIX A

ACHIEVEMENT TEST

GEOMETRY TEST Level_______________

Name___________________________________ Room # ____________

Match each definition in Column A with the best fitting phrase from Column B.

A	B
-----1. Two angles whose sum is equal to 180°.	a) acute angle
-----2. An angle greater than 90° but less than 180°.	b) complementary angle
-----3. An angle of exactly 90°	c) obtuse angle
-----4. An angle less than 90°.	d) right angle
-----5. Two angles whose sum is 90°.	e) reflex angle
-----6. An angle of exactly 180°.	f) vertex
-----7. Angle greater than 180° but less than 360°.	g) straight angle
-----8. The point at which two lines meet.	h) supplementary angle

9. When two lines meet at a point, an angle is formed. Draw an angle in the space below. <u>Label</u> the angle with one letter.

Fill in the blanks in each of the following:

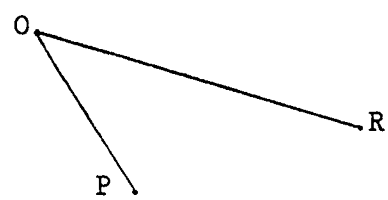
10. The complement of 40° is __________________.

11. The complement of 14° is __________________.

12. The supplement of 40° is __________________.

13. The supplement of 14° is __________________.

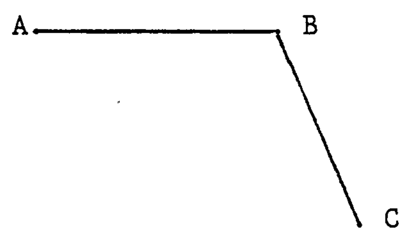
14. The vertex of this angle is __________________.



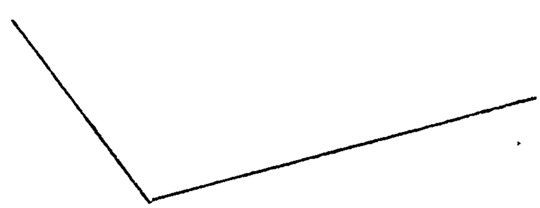
15. Name the sides of this angle.

side 1___________

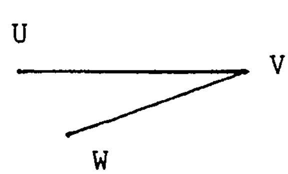
side 2___________



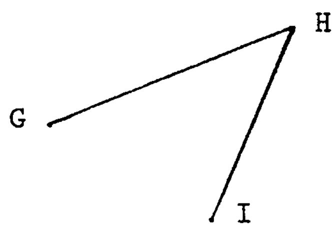
16. Label the following angle as DEF.



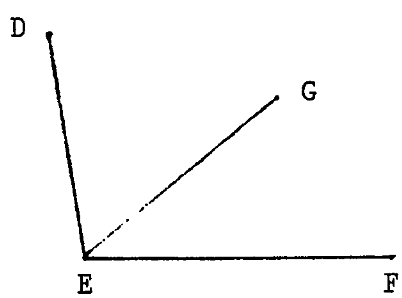
17. Using only one letter, identify this angle _________ .



19. To identify this angle using three letters, we must write the letter _______ in the middle since it is the vertex of the angle.



20. Name any <u>two</u> of the angles from the diagram below.



Angle 1 _________

Angle 2 _________

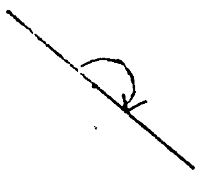
21. If angles are equal and complementary, what is the measure of each ?_____________________________.

22. If angles are equal and supplementary, what is the measure of each ? ___________________________.

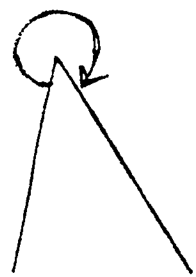
23. Is an angle of 67° smaller or greater than a right angle ?__________

24. Is an angle of 120° smaller or greater than a right angle ? _________

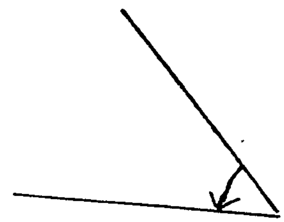
Identify each angle below as obtuse, acute, right, reflex or straight.



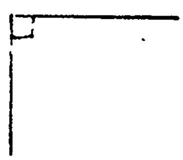
25.__________



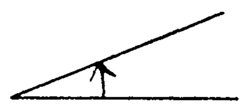
26.__________



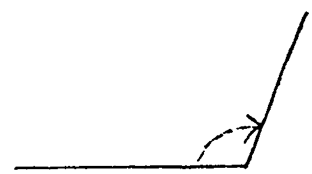
27.__________



28.__________



29.__________



30.__________

Identify each of the following as obtuse, acute, right, reflex, or straight :

31. An angle of 80° . ________________
32. An angle of 90° . ________________
33. An angle of 99° . ________________
34. An angle of 180° . ________________
35. An angle of 218° . ________________

Identify each pair of angles below as complementary (C), supplementary (S), or neither (N).

36. 99°, 81° ______________.

37. 38°, 57° ______________.

38. 44°, 46° ______________.

39. 22°, 158° ______________.

APPENDIX B

SCHOOL SUBJECTS ATTITUDE SCALES

Attitude Scales

Name________________________ Room #____________________________

Fill in ONE of the following circles between each pair of words to indicate how you feel towards the concept of Geometry. Complete ALL pairs.

Example:-

If you were rating a "Big Mac" on the scale

good ( ) ( ) ( ) ( ) ( ) bad

you would fill in the first circle if you thought it was very good,

but you would fill in the second circle if you thought it was good.

If it did not matter either way, you would fill in the middle circle.

If you thought it was bad, you would fill in the the fourth circle,

and if you thought it was very bad you would fill in the last circle.

Please Complete ALL word pairs.

nice	()	()	()	()	()	awful
boring	()	()	()	()	()	interesting
unpleasant	()	()	()	()	()	pleasant
dislike	()	()	()	()	()	like
bright	()	()	()	()	()	dull
dead	()	()	()	()	()	alive
lively	()	()	()	()	()	listless (inactive, lazy)
exciting	()	()	()	()	()	tiresome (makes a person feel tired)
useless	()	()	()	()	()	useful
important	()	()	()	()	()	unimportant
impractical	()	()	()	()	()	practical (useful or workable)
worthless	()	()	()	()	()	valuable
helpful	()	()	()	()	()	unhelpful
unnecessary	()	()	()	()	()	necessary
harmful	()	()	()	()	()	advantageous (brings good or gain)
meaningful	()	()	()	()	()	meaningless
hard	()	()	()	()	()	easy
light	()	()	()	()	()	heavy(a lot of work)
clear	()	()	()	()	()	confusing(mixes a person up)
complicated	()	()	()	()	()	simple
elementary	()	()	()	()	()	advanced (beyond the beginning level)
strange	()	()	()	()	()	familiar
understandable	()	()	()	()	()	puzzling(hard to understand)
undemanding	()	()	()	()	()	rigorous(has to be exactly right)

Name________________________ Room #____________________________

Fill in ONE of the following circles between each pair of words to indicate how you feel towards the concept of Computer. Complete ALL pairs.

Example:-

If you were rating a "Big Mac" on the scale

good () () () () () bad

you would fill in the first circle if you thought it was very good,

but you would fill in the second circle if you thought it was good.

If it did not matter either way, you would fill in the middle circle.

If you thought it was bad, you would fill in the the fourth circle,

and if you thought it was very bad you would fill in the last circle.

Please Complete ALL word pairs.

nice	( )	( )	( )	( )	( )	awful
boring	( )	( )	( )	( )	( )	interesting
unpleasant	( )	( )	( )	( )	( )	pleasant
dislike	( )	( )	( )	( )	( )	like
bright	( )	( )	( )	( )	( )	dull
dead	( )	( )	( )	( )	( )	alive
lively	( )	( )	( )	( )	( )	listless (inactive, lazy)
exciting	( )	( )	( )	( )	( )	tiresome (makes a person feel tired)
useless	( )	( )	( )	( )	( )	useful
important	( )	( )	( )	( )	( )	unimportant
impractical	( )	( )	( )	( )	( )	practical (useful or workable)
worthless	( )	( )	( )	( )	( )	valuable
helpful	( )	( )	( )	( )	( )	unhelpful
unnecessary	( )	( )	( )	( )	( )	necessary
harmful	( )	( )	( )	( )	( )	advantageous (brings good or gain)
meaningful	( )	( )	( )	( )	( )	meaningless
hard	( )	( )	( )	( )	( )	easy
light	( )	( )	( )	( )	( )	heavy(a lot of work)
clear	( )	( )	( )	( )	( )	confusing(mixes a person up)
complicated	( )	( )	( )	( )	( )	simple
elementary	( )	( )	( )	( )	( )	advanced (beyond the beginning level)
strange	( )	( )	( )	( )	( )	familiar
understandable	( )	( )	( )	( )	( )	puzzling(hard to understand)
undemanding	( )	( )	( )	( )	( )	rigorous(has to be exactly right)

APPENDIX C

SENTENCE COMPLETION EXERCISE

NAME______________________________ ROOM #_________________________

SENTENCE COMPLETION

Please complete each of the following sentences.

1. Geometry classes are

2. I think geometry is

3. When I have a geometry lesson I

4. My classes in computing are

5. I think computers are

6. When we have a lesson in computing I