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The effects of pairing students for work on a graphically oriented CAI simulation

by

James Sanders

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NAME OF AUTHOR James Sanders

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(Signed) ....

Permanent Address:
15222 - 81 Avenue
Edmonton, Alberta

Date:

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled

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submitted by James Sanders in partial fulfillment of the requirements for the degree of Master of Education in Vocational Education.

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Supervisor

....

....

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Dedication

For reasons she well knows, I dedicate this work to my wife.

Abstract

Fifty-six first year electrical apprentice students at the Northern Alberta Institute of Technology participated in a study designed to investigate the effects of pairing students while learning series/parallel circuit concepts by means of a computer-assisted instruction simulation program as opposed to having them work singly. The study was based on a pretest-posttest control group design with the treatment as the independent variable and the dependent variables being achievement scores, attitude scores, and time taken to complete the program. Stratified random sampling was used to place one half of the students into the experimental group (paired students) and the remaining half made up the control group (single students). Statistical analyses of the data resulted in failure to reject any of the three null hypotheses. Pairs and singles performed equally well on both subscales of the achievement measure, however post hoc tests indicated that a significant interaction on the total test data was the result of better performance by pairs on the retention test. The attitude of both treatment groups toward computer-based education in general was significantly influenced (in a positive

direction) by the experience on four of the 12 attitude items, but no differential effect was found between pairs and singles. There was no significant difference in time taken by either group. Subsidiary analyses determined that there was no significant difference between the control and experimental groups with respect to desire for more time, mean circuit connection time, attitude toward the program, and the desire to work alone. There appeared to be no detrimental effect on paired students, which suggests that a student pair could use computer hardware effectively and efficiently when using certain models of CAI.

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CHAPTER I

INTRODUCTION

The classroom educator is continually confronted with the challenge of providing a fulfilling educational experience to every student in a class. A major dilemma often encountered is that of attempting to provide an effective and efficient learning environment while accommodating students with varying educational levels, life experiences, and interests. The challenge can become more formidable when the class is made up of individuals, adult learners for example, whose circumstances have allowed them to accumulate diverse experiences which may impinge on classroom expectations and on general attitudes toward learning. Individual differences do exist among students, and more and more educators are becoming convinced that by providing programs that take this diversity into account, the learning process becomes more effective for each individual student, and often more efficient (Further Education Unit, 1983; Hagstrom, 1977; Heerman, 1984; Knowles, 1980; McWilliams, 1977; Romiszowski, 1984; Slavin & Karweit, 1985).

In the past, many educators who recognised the potential for individualized learning programs were intimidated or frustrated by the logistics of individually tracking and testing every student, manually (Cohen, 1983). However, technological advances over the last two decades have provided ready access to the microcomputer, a steadily evolving educational tool which has a unique potential to provide for individual differences (Cohen, 1983; Enochs, Handley, & Wollenberg, 1986; Lieber & Semmel, 1987).

Computers are being utilized in the classroom in a variety of ways, and are becoming increasingly capable of playing a significant role in the provision of learning environments that are able to meet the needs of the individual student. Computerized drill and practice programs, tutorials, games, and simulations, have all been shown to be capable of successfully providing lesson content (Becker, 1984; Bear, 1984; Brown, 1986; Erwin & Nelson, 1986; Kulik, 1985; Scandura, 1983; Vargas, 1986; Waldrop, 1984). Computers can provide tests, and track students' progress through course material. Once armed with effective methods of individual delivery, and freed from repetitive test construction, scoring and record keeping, it is possible for the teacher to spend more time responding to individual needs, thus providing a greater degree of one-to-one human contact and interaction than is feasible in a more traditional classroom environment.

The computer then, has the potential to be an effective tool in any classroom in which an attempt is being made to allow students to proceed through course materials at varying rates.

The Problem

Technological advances in recent years have allowed the dollars spent on computer hardware to buy increased computing power (Hofstetter, 1985; Levin & Meister, 1986; Roblyer, 1985). However, the equipment is still expensive, especially when compared to traditional chalk and chalkboard technology. Advocates of the use of computers in the classroom need to find ways to increase the effectiveness and efficiency of using computers for instruction (Bear, 1984; Roblyer, 1985; Vargas, 1986), thereby reducing the impact of the relatively high cost of hardware. The development of more effective software will assist in the attainment of the goal (Aster & Clark, 1985; Bear, 1984; Roblyer, 1985; Vargas, 1986; Waldrop, 1984), but the problem can be approached along other avenues as well. One such avenue is the traditional student/computer ratio.

Computer-Managed Learning (CML), by its nature, must deal with individual students, but since the time required for issuing and scoring exams is usually relatively brief, several students can make effective use of one terminal. Computer-Assisted Instruction (CAI) programs, on the other hand, have normally been envisioned and designed expressly to facilitate individual learning, and CAI delivery has traditionally been accomplished by means of students working alone at the terminal, whenever possible (Johnson, Johnson, & Stanne, 1985; Reid, Palmer, Whitlock & Jones, 1973). Cartwright (1973) claims that educators have a mind-set toward the one-to-one ratio which is a holdover from the days of teaching machines and programmed instruction, and suggests that group use of CAI should be considered. Reid, Palmer, Whitlock and Jones (1973) state that "there is little reason for arbitrarily limiting usage to the individual" (p. 65), and Johnson, Johnson, and Stanne (1985) make the claim that with the one-to-one ratio, CAI "may have a detrimental effect on educational practice" (p. 668) due to the lack of interpersonal interaction.

The question to be asked, therefore, is whether or not the ratio of one computer for each student is essential in order for effective and efficient learning to take place. Do some types of CAI program allow pairs or groups of students to work together efficiently--and still enjoy a meaningful learning experience--without losing the advantages of individualized instruction? Roblyer (1985) states the problem in practical terms:

> Although computer-assisted instruction is usually thought of as a way of making possible individualized instruction, school personnel often find that there are not enough computers to go around. Therefore, they have begun experimenting with pairing or grouping students for computer use. Studies are needed to indicate whether these approaches result in equal or fewer gains in achievement and accompanying student attitudes. (p. 42)

Purpose of the Study

Though considerable research has been undertaken to determine the differential effects of cooperative, competitive and individual goal strategies for group learning in non-computerized environments, few studies have been reported which attempt to determine the effects of pairing and grouping students for work on CAI (Lieber & Semmel, 1987; Roblyer, 1985; Johnson, Johnson, & Stanne, 1985; Webb, 1984). Studies which have been done--and are reviewed in more detail in Chapter II--include Carrier and Sales (1987), Cartwright (1973), Johnson, Johnson and Stanne (1985), Lieber & Semmel (1987), Reid, Palmer, Whitlock and Jones (1973), Sutter and Reid (1969) and Webb (1984).

Three of the seven studies did not test pairs or groups versus individuals, but rather, studied effects of various student characteristics within groups. Reid, Palmer, Whitlock and Jones (1973) studied college students paired on the basis of sex and test anxiety. Webb (1984) studied the cognitive abilities and styles of junior high students who worked together in groups of three. Johnson, Johnson, and Stanne (1985) tested grade eight students in cooperative, competitive, and individualistic groups of four. All three studies suggest that there are advantages to group use of CAI.

The remainder, (Carrier and Sales, 1987; Cartwright, 1973, Lieber & Semmel, 1987; and Sutter and Reid, 1969) contrasted the performance of individuals with that of pairs or groups, and generally suggest that paired or grouped students perform as well as individual students and have similar attitudes toward CAI instruction. In spite of these findings, most current CAI research and application is directed toward the individual at a work station. It is hoped that further investigation will encourage educators to consider the efficiency of a paired or grouped CAI learning environment.

The purpose of the present study is to investigate further the effects of having paired students (versus individuals) work on CAI; in particular, a CAI simulation program. It is recognized that the design of the CAI program itself could have a considerable effect on the outcome of any study in this area. It is possible, for example, that the learning processes involved in a simulation program may be enhanced by peer interaction. This type of CAI generally provides an answer to the question "What would happen if we were to try this?". The immediate feedback from the computer either corrects or reinforces a concept for the participants. The ensuing peer interaction may produce feedback which is more contextually appropriate than anything the program designer could build into the program.

If the results of the study imply that working in pairs produces no detrimental effect on attitude, achievement, or efficiency, procedures for encouraging students to work together on this type of CAI simulation program could be implemented with a degree of confidence. It would also suggest that further testing be done with other CAI programs, to determine if certain types of CAI are more appropriate than others for pair or group use. The benefits of working together would include not only a possible reduction in hardware requirements, but an increase in the degree of peer interaction among CAI users, thus countering reported negative effects (such as isolation and lack of interaction) of individual CAI use.

The Hypotheses

The null hypotheses for the study are as follows:

1. There will be no difference in achievement between students who work on the program singly and students who work on it in pairs.
2. There will be no difference in attitude toward the role of computers and CAI in education between students who work on the program singly and students who work on it in pairs.
3. There will be no difference in time taken by students who work on the program singly and students who work on it in pairs.

Limitations and delimitations

A limitation of this study concerns the degree to which the results can be generalized to a larger population. The experimental group was chosen at random from within the accessible population, but this larger group of students was formed (from the population of first year electrical apprentices from central and northern Alberta) according to the normal procedures utilized by the Apprenticeship and Trade Certification division of Alberta Career Development and Employment. Though it is difficult to envision any bias operating during this selection process which would influence the outcome of the study, this factor was not investigated, and remains a threat to the external validity of the experiment. However, with regard to sex, age, and education levels, the accessible population was deemed to be equivalent to the larger provincial population of first year electrical apprentices at the time of the study (refer to appendix A for a demographic summary).

The success of a CAI model for a given group of students will depend heavily on factors such as program design and content, and therefore a delimitation of the study is that the results are not intended to be generalized to any model of program other than the one tested.

The following chapter will investigate some of the literature which pertains to the hypotheses, in order to develop the background for the study.

CHAPTER II

LITERATURE REVIEW

This study examines the effects, on both achievement and attitude, of pairing students for work on a CAI lesson. The literature review includes the following topics which are relevant to the study: the impact of computers in the classroom; achievement; attitude and attitude change; learning in small groups; the effectiveness of small group work on CAI; and CAI program design.

Computers in the classroom

It appears that the use of computers in the classroom has changed from a phenomenon in the late sixties to a widely accepted mode of instructional delivery (Bear, 1984; Gray, 1987; Hofstetter, 1985; Johnson, Johnson & Stanne, 1985; Kulik, 1985; Loyd & Gressard, 1984). Supporters of Computer-Based Education (CBE) argue that the use of CBE is justified from many perspectives. Heerman (1984) states that "Computer-assisted learning can, in a highly confidential manner, provoke new awareness and illumination, thereby humanizing the learning process" (p. 86). Dalton and Hannafin (1984) cite several studies which provide "evidence to suggest that computer-assisted instruction is effective for improving achievement and learner attitudes" (p. 42). Kulik (1985), summarizing the findings of earlier studies, states that students in CBE programs have (1) learned more, (2) remembered what they learned longer, (3) learned their lessons in less time, (4) liked their classes more, and (5) developed more positive attitudes toward computers than their counterparts in non-CBE programs.

There is evidence, however, that computers have not always been applied appropriately in the educational process. Cartwright (1973) describes the interaction between a student and a terminal as rigid, since the student has little chance to discuss observations with fellow students. He states "In part, this restriction of the learning environment is due to the expectations teachers and researchers bring with them from the traditional classroom" (p. 10) and that the situation is aggravated by students having to work alone in carrels or booths. Some authors, such as Feldman and Sears (1970), have viewed computers as dehumanizing agents. Bear (1984), noting the rapid increase in the numbers of microcomputers in the schools, attributes much of the increase--not to demonstrations of educational effectiveness--but to a successful marketing strategy on the part of manufacturers and software developers. He states "we have few educators trained to use the technology, and little research supporting its cost-effective utility" (p. 11). Kulik (1985) points out that CBE has not had positive effects in every area in which it was studied, and Clark (1983) cautions against crediting computers or CBE with providing gains in achievement. Clark stresses that it is the content of the lesson which changes the learner, not the medium of delivery.

The continuing dialogue over the contribution of computers to advances in the field of education is evidence that computer technology is not always appropriately applied, and that not all CBE is effective. Conversely, that same dialogue suggests that the potential of CBE has been well demonstrated. However, since the success of any educational program depends on its design, content, and degree of applicability to a target group, it is evident that the effectiveness of any implementation of CBE, whether it's a new design of CML or a new model of CAI, can not be assured unless it has been tested by an appropriate group of students. New CBE programs should therefore be carefully reviewed and, if possible, tested by a representative sample of the target population before being utilized on a large scale (Gredler, 1986; Roblyer, 1985).

<u>Summary: Computers in the classroom</u>

This section of the literature review has outlined some of the factors in the ongoing discussion of the effectiveness of computers in the classroom, suggesting that while evidence exists that CBE can be effective and efficient, not all authors agree with the pro-CBE camp. Thus, individual applications of CBE (new models in particular) should be reviewed in light of the target population, and be tested if possible.

Achievement

Achievement, in the present sense, can be thought of as a measure of the attainment of learning. Learning is often rather broadly defined (Hill, 1985) and within the psychological definitions, can be conscious or unconscious, overt or covert, productive or nonproductive. Generally, theories of learning can be classified into one of two broad categories: the behaviorist or connectionist theories on one hand, and the cognitive approach on the other (Foster, 1986; Wittrock, 1974). Whereas the connectionist theories emphasize a relatively simple stimulus-response bond, the cognitive approach elevates cognitions (intervening variables such as perceptions, or attitudes or beliefs) to a role of greater prominence in the learning process (Hill, 1985). What Allport calls

"The 40 wilderness years of Radical Behaviourism" (1980, p. 26) have, to a large extent, given way to the cognitive or information processing approach to the study of human learning (Allport, 1980; Best, 1986; Foster, 1986; Wittrock, 1974). Whatever the process, the result is a change in level of achievement. Gagné defines learning as:

> a change in human disposition or capability that persists over a period of time and is not simply ascribable to processes of growth (1985, p. 2).

Whether or not intervening variables contribute to the process of learning (and whether or not the intervening variables are connectionist or cognitive) is not--for the purposes of this study--important. Of importance is the change in disposition or capability which is measured as learning. This change can be inferred by comparing behaviour before and after a learning event (Gagné, 1985), and measured with instruments designed to assess achievement.

The object of the CAI program employed in this study is to allow students to apply certain concepts of electrical theory within a simulated lab environment. The same goal has traditionally been achieved, or at least facilitated, by physical connection of actual circuit components on the lab bench. Often, due to time constraints, it is not possible for all students to connect a sufficient number of circuits so that concept mastery is attained. The computerized simulation permits the student to "connect" a greater number of circuits in a given time period and to have each circuit analyzed--as if by an instructor.

Previous experience--that which the learner brings to the learning situation--affects the learning which takes place (Wittrock, 1974). The student will have formed cognitive structures (schemata) which store conceptualizations (Rembold & Yussen, 1986) regarding series and parallel relationships. These conceptualizations may be accurate or inaccurate and, thus, the computer analysis of each circuit connected will either reinforce or weaken this structure. If the results of the analysis are not congruent with the student's perception of the relationships, then cognitive restructuring will take place. Claxton claims that this is a prime learning time: "When existing theories are inadequate, we learn. The most powerful stimulus for the development of a theory is its failure." (1987, p. 4).

Operational definition of achievement

This study has attempted to ascertain any measurable change in achievement which may have occurred during the period of the CAI treatment, and is less concerned with an absolute measurement of that variable. The attempt is being made to discern any differential effect upon the experimental and control groups, in order to determine if the treatment was no less effective, in terms of achievement, for the pairs than it was for the singles. Achievement, for this study, is operationally defined as the attainment of learning as measured by scores on an instrument designed to measure the ability of students to recognize relationships among certain circuit components and to complete certain types of circuit diagrams.

Summary: Achievement

Theories of learning can be broadly classified into one of two categories: connectionist or cognitive. The cognitive theories appear to be popular among learning theorists, due in part to the perceived importance of the cognitions of the learner. In other words, cognitive psychologists believe that learning occurs when new information is incongruent with existing schemata, and cognitive restructuring takes place.

Attitude and attitude change

The current study attempts to assess the 'attitude' of subjects in relation to CBE. The frequent and often casual utilization of the term both in CBE research literature and everyday language in no way reflects the degree of discussion and controversy which has surrounded the concept of attitude in the literature of social psychology, or its theoretical complexity. Attitude change, attitude measurement and the concept itself have all been a focus of debate for decades (Gagné, 1985; Lemon, 1973; Palmerino, Langer, & McGillis, 1984). Before operationalizing the term for this study, some of the discussion with respect to the concept of attitude, attitude change, and attitude measurement will be reviewed.

The concept of attitude

Early concepts of attitude were divided by De Fleur and Westie (1963) into two categories: (1) probabilistic conceptions and (2) latent process conceptions. Those in the first category produce behaviorally oriented definitions and require a behaviour to be observed before the existence of an attitude is recognised. This type of definition "anchors the attitude concept firmly to observable events" (De Fleur and Westie, 1963, p. 21).

The latent process definitions are more concerned with a mental process which plays a part in shaping or determining behaviour. The behavioral aspect is often present, but "the additional idea that the individual's behaviour is somehow 'shaped', 'guided', or 'mediated' by some underlying process" (De Fleur and Westie, 1963, p. 23) has been added. The latent process definitions describe a process which can not be observed directly, but only inferred, and in which attitude and behaviour are not parallel.

More recently, most attitude theorists appear to have related attitude more closely to a latent process. For example:

> Attitude is the predisposition of the individual to evaluate some symbol or object or aspect of his world in a favorable or unfavorable manner (Katz, 1967, p. 459)

Katz does not directly include behaviour in this definition, but goes on to say that attitudes include affective and cognitive elements and, further, that some attitudes do have an action component. Fishbein and Ajzen (1975) produced a description of attitude which suggests that behaviour is not always an indicator of attitude. According to them, attitude is:

> a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object (p. 6).

The phrase "predisposition to respond" recognises that a variety of social factors combine with attitude to influence resultant behaviour. Though they felt most investigators could probably agree with their description of attitude, Fishbein and Ajzen suggested that agreement on the description and its basic features would not prevent disagreement with respect to its interpretation. It would appear however, that the expected interpretation problems have not surfaced to any great extent, and that most investigators have been able to agree with Fishbein and Ajzen's description of attitude. According to Eiser (1984) and Palmerino, Langer, and McGillis (1984), the previously high level of activity regarding the study of attitude settled down considerably in the years following 1975. The writings of Palmerino, Langer, and McGillis (1984) and Kahle (1984) suggest that concepts of attitude have generally coalesced into some combination of the three basic components included in the Fishbein and Ajzen definition. These are (1) attitude is learned, (2) attitude predisposes action, and (3) attitude is consistently favorable or unfavorable.

Attitude change

Of the three components of attitude, one has rarely been debated. Lemon (1973) writes:

> One of the almost universally accepted assumptions about attitudinal behaviour is that it is learned. This is an integral part of almost all the well known definitions of the term, and has hardly ever been seriously questioned (p. 15).

The assumption gives rise to the hypothesis that attitudes can be modified or changed by further learning. This, in turn, has led to a high level of interest toward the study of attitude change, and a large number of theories of attitude change have been advanced.

One of the more widely respected of these, as evidenced by the wealth of research it has generated (Kahle, 1984; Kiesler, Collins, and Miller, 1969; McGuire, 1967), is the theory of cognitive dissonance, proposed by Festinger (1957, as cited in Kahle, 1984). According to this theory, cognitive dissonance occurs when a person becomes aware of two cognitive elements or cognitions that are the opposite of each other. The person will then strive for consonance by "changing cognitions or behaviors, changing the importance of cognitions, or adding new cognitions" (Kahle, 1984, p. 11), thus changing the attitude. For example, if an individual's attitude toward CBE has been less than positive due to previous personal experience or other influence, and the individual is then exposed to CBE which he or she perceives as rewarding, cognitive dissonance will occur. The cognitions will be evaluated as to their relative importance, and adjustments and modifications will be made in order to achieve consonance. The new, or adjusted cognitions will result in a different or changed attitude toward CBE. While this explanation is an oversimplification of the theory it will serve to explain a process of attitude change which the current study has attempted to measure.

<u>Measuring attitude</u>

The complex dimensions of the concept of attitude make it difficult to measure. Behaviour and opinions can be indicators of attitude (Katz, 1967), but both are affected, to varying degrees, by social factors. However, Thurstone (1928) argued that attitude measurement is both possible and desirable, in spite of the reality that "neither his opinions nor his overt acts constitute in any sense an infallible guide to the subjective inclinations and preferences" (p. 532) that make up an individual's attitude.

Techniques have been developed for the construction of attitude measurement instruments by, for example, Thurstone (1928), Likert (1932/1967), and Guttman (1944), and adequate methods to assess validity and reliability of the instruments have also evolved (Bohrnstedt, 1970). Several authors, for example Kahle (1984), Keisler, Collins, and Miller (1969), Lemon (1973) and Tittle and Hill (1967), suggest that one of the more useful scales in many respects--and the most popular--is the one designed by Likert. This scale attempts to determine attitude by summing the score of multiple items measuring the same concept. Many researchers have used this scale, more or less rigorously following Likert's original rather stringent guidelines for item analysis and selection. The Likert technique has been shown capable of producing scales having relatively high reliability coefficients even when using relatively few items and is noted for its ease of construction (Edwards & Kenney, 1946; Seiler & Hough, 1970; Tittle & Hill, 1967). Tittle and Hill examine an additional advantage for the scale, saying that it is weighted by an intensity factor, in addition to the evaluative one. Scale items need to be selected with care however. One of the characteristics of the Likert scale, according to Lemon (1973) is that it may include items that correlate satisfactorily with the final score, but correlate even more highly with a subset of items within the scale. The scale thus becomes multidimensional, and combining item scores into a single measure of attitude may be inappropriate.

Operational Definition of Attitude

In this study the general concern with attitude (as it is with achievement) is not its absolute measure, but in any measurable change in expressed likes or dislikes toward CBE which may have occurred during the period of the CAI treatment. In particular, the attempt is being made to discern any differential effect upon the experimental and control groups, in order to determine if the treatment, as perceived by the experimental group, was no less worthwhile and enjoyable than it was for the control group. Thus, attitude, for this study, can be operationally defined as opinions expressed on a Likert scale.

Summary: Attitude

Definitions of attitude generally include three components. These are (1) attitude is learned, (2) attitude predisposes action, and (3) attitude is consistently favorable or unfavorable. If attitude is learned, then it can be changed through experience or further learning. It has been widely accepted that attitudes can be measured by means of various scales, including the frequently used Likert scale.

Small group learning

The goal of accommodating varied rates of learning in the classroom is a worthy one, and, according to some, holds a promise of improving the educational process (Melmed, 1986; Knowles, 1980; National Task Force on Educational Technology, 1986; Slavin & Karweit, 1985).

Totally individualized programs have often been the result of attempts to meet this goal, but there have also been arguments put forward in favour of having students work together in small groups (Bennett, 1985; Deutsch, 1962; Durling and Shick, 1976; Johnson & Johnson, 1985; Sharon, 1980; Webb, 1982). While the formation of small learning groups has often been driven by expedience, additional benefits of working with peers have become evident.

For example, the efficacy of the small group arrangement is apparently complemented by the facilitation of peer interaction. Webb (1982) suggests that student/student interaction is the characteristic that distinguishes small group learning from other learning settings. In Webb's model, the interaction process is complex: input characteristics (such as the characteristics of the individual, characteristics of the group, and the reward structures which are operating) determine the amount and type of student/student interaction. The interaction (for example, giving or receiving help) is mediated by both the individual's cognitive processes and social-emotional variables. The result is a process of learning which is different than that experienced by a student learning individually. Johnson and Johnson (1985) have concluded that learning is better in groups where student/student interaction is facilitated. "The need to talk about information and ideas rather than just think about them is one of the variables contributing to higher achievement" (p. 23). The effects of verbal interaction on learning were also investigated by Durling and Shick (1976). They determined that vocalizing pairs had a higher rate of achievement than that of either non-vocalizing pairs or individuals vocalizing to the experimenter.

Within studies of small group learning, distinctions have been drawn among three types of motivation or reward structures: cooperative; competitive; and individualistic. Morton Deutsch, who is often credited with the early work in this area (Bennett, 1985; Johnson & Johnson, 1985; Sharan, 1980), describes benefits of cooperation, and argues that a cooperative condition will be initiated more successfully if the potential cooperants are interested in each other's welfare (Deutsch, 1962). This mutual interest will be fostered if the rewards of the participants are positively correlated, and hindered if the rewards are negatively correlated. The three reward structures are--in most examples--distinguished by the method of determining marks at the end of the learning session. Within a cooperatively structured setting, a student's mark is dependant on those of the other students in the group, and it is important for all that all in the group do well. In the competitively structured group higher marks are achieved at the expense of the other members of the group; a group hierarchy is established. In the individually structured group all work together, but one student's mark is not at all dependent on the marks of the others.

The extensive research of David and Roger Johnson and their colleagues has tended to support Deutsch's arguments, and reports increased educational effectiveness for the cooperative reward structure (Johnson & Ahlgren, 1976; Johnson & Johnson, 1985; Johnson, Johnson, Scott, & Ramolae, 1985). Some of these claims have been countered by Cotton and Cook (1982), and McGlynn (1982), who contend that the conclusions reached are not always supported by the findings, and by Slavin (1983), who argues that the studies of Johnson, Johnson and colleagues place too much emphasis on group achievement and fail to determine the achievements of the individuals within the group. Mcglynn claims that "most investigators have selected the values of the mediators that tend to favour cooperation" (p. 184). Bennett (1985) advises caution in interpreting all these arguments and suggests that "the conclusions reached occasionally appear to reflect the reviewers' own predilections as much as the findings themselves" (p. 106).

Summary: Small group learning

Small group learning can be a practical vehicle for achieving a degree of individualization within a classroom, and there are benefits to be derived. Student/student interaction appears to have positive effects on learning, but the effects of reward structures (cooperative, competitive, individualistic) have been the topic of considerable debate.

Studies involving group use of CAI

Group characteristics

This section reviews the literature which reports studies of small group learning within a CAI context. These studies have been undertaken in an attempt to examine the optimum characteristics of groups working together on CAI.

One such study was reported by Reid, Palmer, Whitlock and Jones (1973). Data were collected on students in an introductory college level algebra course with respect to attitude toward CAI, knowledge of the subject, test anxiety level, mathematical aptitude, independence, dominance, flexibility and sociability. The students were randomly grouped into pairs, which were then identified according to sex (MM, FF, MF) and levels of test anxiety (HH, LL, HL), thus forming nine subgroups. Each pair worked together (for a total of approximately 80 minutes of terminal time) to complete a section of a CAI program on pre-requisite college mathematical skills. An achievement post-test and an attitude post-test were then administered to the 81 pairs of students who had completed the other sections of the study.

The results indicated that in general, the measures of test anxiety level, change in attitude, posttest attitude, sex, achievement motivation, dominance, flexibility, and sociability had no significant relationship to achievement performance or on time required to complete the program. With regard to prior attitude toward CAI and achievement, significant positive correlations were found for female pairs and low anxiety male pairs, but for male-female pairs the correlation was significantly negative. Subjects with higher scores on the mathematical aptitude test scored significantly higher on the posttest, in significantly less time. The authors suggest that "more use of terminals by pairs or larger numbers of students should be encouraged and explored more thoroughly" (Reid, Palmer, Whitlock, & Jones, 1973,

p. 72).

A second study involving small group learning within a CAI context was reported by Webb (1984), who studied the effects of cognitive abilities, cognitive styles, and student demographic characteristics on the learning of computer programming in small groups. The subjects of this study were a self-selected sample of 35 students, aged 11 to 14, who were learning a programming language (LOGO). For five, three-hour sessions they worked together in groups of three. Within groups, the students were homogeneous with respect to previous computer experience, and heterogeneous with respect to age and sex. A set of cognitive pretests was administered to determine dimensions of cognitive ability and cognitive style, and a LOGO achievement test was administered on completion of the course. The study suggests that though there was considerable cognitive variation within groups, group composition did not significantly affect individual achievement results. "While these analyses do not entirely rule out group composition effects, they do suggest that group composition does not affect learning of computer programming in a straightforward way" (Webb, 1984, p. 1083). Student-student verbal interaction was recorded for a 30 minute interval during the course, and it appeared that verbal interaction did not relate significantly to learning, as measured by the ability to interpret or generate graphics programs. One reason suggested ~~for this was~~ the learning medium, since all group members could see what was occurring on the computer screen. A finding of this study which is of considerable interest in the context of the current study, was that "the number of turns and the amount of time at the keyboard had almost no relationship with computing outcomes" (Webb, 1984, p. 1086). Students not at the keyboard appeared to be equally involved with the material as those who were at the keyboard. There also appeared to be no relation between student characteristics and keyboard use. This finding, it was suggested, could help to alleviate fears of keyboard monopolization by high achievers, or males, or experienced students. The study concludes that the learning of computer programming can be successfully accomplished in a group setting.

A third study, which also reported beneficial results of group CAI, is that of Johnson, Johnson and Stanne (1985), who studied the effects of cooperative, competitive, and individualistic goal structures on CAI experiences. Their subjects were 71 grade eight students stratified for sex and ability into groups of four. The

CAI program was a computer simulation (presumably text-based) of a trip to the new world in an ancient sailing ship, and involved decisions regarding navigation and logistics. The results corroborate findings from earlier, non-CAI based research (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981) which found that the cooperative setting was beneficial to students along a variety of dimensions. In addition, the study determined that the cooperative groups engaged in more on-task oral interchange than the competitive or individualistic groups. The issue of attitude toward CAI and toward the subject being studied was addressed, and no significant differences were observed among the instructional groups, or between male and female students. Other differences surfaced between male and female students however. For example,

> Boys performed higher on the recognition and problem-solving questions on the final examination, were less individualistic and more competitive, perceived more support from teachers, and perceived the computer to be more of a male domain. In the cooperative condition, girls liked working with computers more than did boys, whereas the opposite was true in the competitive condition (p. 676).

The conclusion was reached that structuring group CAI lessons cooperatively maximizes achievement.

<u>Summary: Group use of CAI</u>

The three studies reviewed in this section, though not comparing groups to singles, conclude that group work on CAI is appropriate, and warrants further investigation.

Pairs versus singles

This section will review studies in which the performance of individuals working in pairs on CAI was contrasted to the performance of individuals working alone.

Sutter and Reid (1969). In a study designed to determine the affects of having students work in pairs on CAI as compared to working singly, Sutter and Reid (1969) looked at three personality variables, (test anxiety, dominance and sociability) of 100 male undergraduates. The CAI tutorial dealt with an heuristic approach to problem solving and was described as "an attempt to simulate tutorial interaction" (p. 154). One experimental group of 40 worked through the CAI lesson alone, a second group of 42 worked in pairs, and a control group of 18 did not work at the lesson at all. Pretest and posttest measures were administered to assess achievement and attitude change. Overall, there was no significant difference in attitude or achievement change between singles and pairs, but when personality variables were taken into account, some significant relationships emerged. High test anxiety was associated with negative attitudes in both groups. In terms of achievement, those with high test anxiety worked better alone, while those with low test anxiety worked better in pairs ($p = .025$). The measure of sociability had no significant relationship on attitude toward CAI, but a trend toward higher achievement was identified in the group characterized by a higher measure of sociability ($p = .06$). Dominance had no significant relationship with achievement, but a significant correlation (-.36) was found between dominance and attitude change in the paired group. The study concludes that "the effectiveness of CAI in teaching a course in problem solving is the same for the student working alone with the machine as for the student working with a partner at the machine, except when conditional upon certain personality traits" (p. 156).

Cartwright (1973). The subjects of Cartwright's study were 282 university summer school students ranging in age from 20 to 59. The subjects were randomly assigned to treatment groups and worked either individually, in pairs, in groups of three or in groups of four. The students worked on three computer lesson sessions, one week apart, for a total of approximately 140 minutes. The CAI program was a tutorial which included branching and remediation in the 2nd and 3rd lessons.

The criterion learning test, (paper and pencil format), consisted of thirty multiple choice items based on the material in the CAI lessons, and was administered one week after the completion of the course. The attitude instrument was designed to determine students' attitude toward various teaching methods, including CAI, and was applied both as a pretest and posttest. Personality dimensions of anxiety, introversion-extroversion and neuroticism-stability were measured, as was locus of control.

This study found no significant difference among the four treatment groups for achievement or for change of attitude toward the five teaching methods. As well, no significant differences appeared when the personality variables were taken into account. The findings suggest that "the personality composition of the group does not significantly affect the learning of individuals in the group" (p. 96). The time differences among the groups were not significant, but a trend was indicated: "In all three lessons, it appears that students working in groups tend to move through each lesson slightly faster than those students working alone" (p. 101). Cartwright noted that the number of correct responses were similar for all groups, but that individuals working alone made significantly more responses, and therefore a greater number of errors, than did groups.

Cartwright advances the following arguments for the use of group CAI:

1. students can and should learn from one another as well as from the computer.
2. the group use of the computer represents a more "human" use of the technology.
3. group CAI may win more rapid acceptance in educational communities than individual CAI.
4. students learn equally well with group CAI.
5. group CAI can effect a significant cost reduction in terms of equipment and operating costs per student.

Carrier and Sales (1987). The performance of pairs and individuals on a single session CAI lesson which dealt with coordinate concepts was compared in a study of 36 undergraduate volunteers (13 female and 23 male) by Carrier and Sales (1987). The program combined tutorial and drill-and-practice elements and allowed students to choose between four levels of feedback. The following options were available: (1) no feedback, (2) knowledge of results, (3) knowledge of correct response, and (4) elaborate feedback. The study investigated posttest performance, reading times for lesson components, the level of feedback chosen by each treatment group, and the verbal exchanges between pairs.

Statistical results indicated that there was no significant difference between treatment groups with regard to posttest or retention test performance. Pairs spent significantly greater amounts of time reading two types of display: screens which presented practice items, and screens which presented feedback menus. They did not however, differ in time spent reading definitions, expository items, or feedback. Students in the Pairs treatment selected a significantly greater number of elaborate feedback items while individuals chose a greater number of feedback items which provided a knowledge of results.

The verbal interactions between members of a pair were analyzed and divided into five categories. The catagories, with their frequency in percent, were: task specific (34%), help seeking (9%), help giving (16%), transition/directions (18%), and off task (23%).

<u>Lieber and Semmel, (1987)</u>. Lieber and Semmel investigated the relationship between group size and performance on problem solving microcomputer CAI. Their subjects were 20 learning handicapped boys (LH) and 20

nonhandicapped boys (NLH) from grades four, five, and six. The CAI program involved arithmetic exercises, and each subject participated in a total of 12, ten minute sessions under each of three group configuration conditions: individual, homogeneous dyad, heterogeneous dyad. Group size had no significant effect on achievement for either LH or NLH subjects, although LH subjects tended to perform better in a heterogeneous dyad, particularly on the more difficult levels of the CAI program. Of particular interest to the current study is that Lieber and Semmel found no detrimental effect on the performance of the NLH subjects when they worked with a LH partner.

<u>Summary: Pairs vs singles on CAI</u>

The results of the studies reviewed in this section suggest that pairs and singles achieve equally well, and that their attitude is equally affected, when learning from a CAI program. One study, (Cartwright) found that pairs worked through sections of the program faster than singles, while another (Carrier and Sales) found that pairs took longer to read certain screen displays. The subjects in the three studies were post-secondary students who worked on a CAI lesson individually or in pairs. The goal structures could be defined as individualistic, as opposed to cooperative or competitive, since the performance results were determined on an individual basis, and were not affected by the marks of other students.

CAI program design

One of the parameters which distinguishes the current study from those just reviewed is the CAI program itself, and it is presumed that the choice of a program could have a significant effect on the outcome of studies of this nature. Factors involved may include the type of program used, (such as simulation, drill and practice, or tutorial), the degree of learner control, the feedback provided, and the ability of the program to reduce anxiety.

Type of program

The program utilized for this study is a narrowly focused, graphically oriented simulation, specifically designed for the subjects of the experiment. Simulation CAI programs come in many guises (Gredler, 1986) but since this program closely simulates the reality of a lab bench, the descriptor is not inappropriate. A graphically oriented simulation may be more effective for paired work than non-simulation, or non-graphic simulation programs, since graphic screen displays may be more readily interpreted by both partners. The "What if?" question implicitly asked by the simulation may tend to stimulate proactive participation by allowing the members of a pair to determine together the condition or situation to be judged by the computer.

Learner control

The degree of learner control versus program control is an aspect of CAI design which has received attention from researchers. Waldrop (1984) suggests that total learner control does not always provide positive results, and suggests the use of a modified program control where the student can elect to take a lesson or not, but has to complete the lesson, once begun. Gray (1987) reports that comprehension was positively affected by learner control of the sequencing of a CAI lesson, while retention was not. Roblyer (1985) also reports mixed research findings and suggests that there is an interaction between learner control and locus of control, such that an individual with an internal locus of control may benefit more from increased learner control.

Within the context of a simulation, a certain degree of learner control is implicit. The simulation provides an opportunity for learning, and it is the participant who will determine the extent to which the opportunity is capitalized. As stated by Vargas (1986):

> A simulation should require the student to make decisions similar to those required in a real situation, and the consequences of a simulation should be similar as well (p. 741).

Pairs may have the advantage when working on a simulation since chances are that one of the two will have a more inwardly oriented locus of control and will exercise control of the program in a manner beneficial to both members of the pair. At the very least, decisions forced on the members of a pair will elicit increased interaction.

<u>Feedback</u>

According to Roblyer (1985) immediate feedback is one of the unique capabilities of the computer and CAI can be designed to take advantage of this element. Roblyer states however, that "little is known about what form this feedback should take" (p. 42), and suggests that corrective feedback for incorrect answers may be most useful. Vargas (1986) stresses that to be effective, feedback must be immediate, to the point that the consequences of one response are known before another is made. Cohen (1983) urges that CAI feedback be non-threatening, immediate, and relevant, and also provide appropriate remediation. Non-judgmental and non-threatening feedback will have a tendency to reduce the consequences of failure, and thus reduce anxiety (Aster &

Clark, 1985). Non-judgmental immediate feedback will be interpreted as either corrective or reinforcing, but--in a paired situation--any effects of built-in feedback may pale beside that of feedback spontaneously generated by a peer, which will probably be more contextually appropriate than anything the program designer could envision.

Reducing anxiety

Freeman and Clark (1985) report that a CAI user's anxiety (which, they suggest, can be caused either by nervousness about computer use or by skill deficits or both) can reduce the effectiveness of a CAI program. CAI can be designed to ease anxiety and to improve learner self-esteem by design features such as simplicity of use and by thoughtful presentation of feedback (Dalton & Hannafin, 1984). Stress can also be reduced by reducing the consequences of failure (Apter & Clark, 1985). The effects on anxiety of having students work in pairs on a program may be modified by the personality variables within the dyad. Some may be able to reduce anxiety by working with an empathetic peer, whereas others may find it more stressful to work under the watchful eye of another.

Summary: CAI program design

It is presumed that the design of a program would have an important affect on a study of this nature. Factors such as the type of program used, the degree of learner control, the feedback provided, and the ability of the program to reduce anxiety, may all influence the performance of pairs as opposed to singles.

Chapter summary

In this chapter an attempt was made to establish a framework for the current study by discussing topics which are relevant to it. These have included the effectiveness of computers in the classroom, achievement, attitude and attitude change, learning in small groups, the effectiveness of small group work on CAI, and CAI program design. The following chapter outlines the procedures followed to obtain data for the study.

CHAPTER III

METHOD

Subjects

The designated sample for the study was 56 first year electrical apprenticeship students enrolled in two regular classes at the Northern Alberta Institute of Technology (NAIT) in March of 1987. The students were drawn from central and northern Alberta according to the normal procedures utilized by the Apprenticeship and Trade Certification division of Alberta Career Development and Employment. With regard to sex, age, and education levels, this group was deemed to be equivalent to the larger Provincial population of first year electrical apprentices at the time of the study. (Refer to appendix A for details.) The students had no previous knowledge that CAI would be utilized in the course. All students from both classes participated in the study. One student, a single, was absent from the pretest, and one student, also a single, was absent from the retention test. The data related to these two students were not included in the statistical analyses.

Design of the study

The study was based on a pretest-posttest control group design (Campbell and Stanley, 1963). The independent variable was the treatment: working in pairs versus working singly. The dependent variables were achievement scores, attitude scores, and time taken to complete the program.

As is customary for first year electrical apprentices at NAIT, each class had been alphabetically divided into two sections for work in the labs. Each lab section was taught by a different instructor, so the sample was stratified according to section in order to ensure balanced representation in the experimental group. As a result, four pairs of students were chosen at random from each of two lab sections and three pairs from each of the remaining two. These 14 pairs of students formed the experimental group, with the balance (28 students) as the control.

The fact that all students participated in the study is worthy of note. In some studies, the use of volunteers is mandated from an ethical standpoint and authors such as Erwin and Nelson (1986) and Kahle (1984) have suggested that in such studies, the element of "pre-selection" could have influenced the results. The contention is that if students with negative attitudes toward some element of the study (computers in this case) are given the choice to participate in a study, they will decline, and the sample is then biased. For the present study, as the CAI program to be used in the experiment had been designed expressly to complement the first year curriculum, and had been successfully piloted, permission was obtained from NAIT and Apprenticeship Branch officials to integrate the CAI program into the regular course of studies. The students participated en masse, as they would any other lab project which was assigned to them.

Materials

Instruments

Achievement Instruments

The achievement instruments were designed to evaluate the students' ability to apply the concepts learned and exercised in the CAI program, and focus "on the broad ability represented by the phrase construct and interpret" (Bloom, Hastings & Madaus, 1971, p. 63). The first draft of the achievement pretest consisted of five multiple choice questions which asked the student to interpret wiring diagrams and five items which required the student to construct a wiring diagram by drawing in the correct wires. The paper and pencil instrument replicated, with a high degree of fidelity, the tasks portrayed on the computer screen. The test was validated by content experts and administered in January, 1987, to 29 first year students in the fourth week of their program. The test mean was 50.3% with a standard deviation of 20.4. The test had a reliability of 0.56 using the Kuder-Richardson (kr-20) formula, and the correlation coefficient between the pretest results and the results of a lab exam which tested some of the same objectives was 0.58. The low mean was somewhat surprising at this point in the course, as the concepts had by this time been presented in theory class and practiced in lab, but it can be noted that it was this apparent lack of understanding of series and parallel circuit concepts which resulted in the CAI program being written.

Subsequent to the preliminary test, the diagrams were redrawn to improve clarity, and two more multiple choice items were added. An achievement posttest, which used exactly the same wording as the pretest in all but the lamp designations, was administered to five volunteer students in the seventh week of their program. The five, who had written the pretest earlier, but who had not worked through the CAI program, had a mean pretest-posttest gain score of 15.5%. The instrument was discussed with the students who stated that they found the test fair, and that it tested objectives which they should have known.

The achievement posttest was also used as the one week retention test.

A copy of each achievement instrument can be found in appendix B.

Attitude Instruments

Instruments for the purpose of determining attitudes toward computers and computer-based learning have been developed and validated (Bannon, Marshall, & Fluegal, 1985; Loyd & Loyd, 1985; Dambrot, Watkins-Malek, Silling, Marshall, & Garver, 1985; Bear, Richards, & Lancaster, 1987). Most share a common design: statements are presented and the respondent is asked to rate the statement on a "5-point Likert-type scale from 5 (strongly agree) to 1 (strongly disagree)" (Dambrot et al, 1985, p. 74). It was found, however, that several of the statements from the validated instruments would not apply to the population of this study. The pre-treatment/post-treatment attitude instruments were therefore designed specifically for this test by combining relevant items from two validated scales; the Computer Attitude Scale (CATT) (Dambrot et al. 1985), and the Computer Attitude Scale (CAS) (Loyd & Loyd, 1985).

The resulting instruments contain 12 items designed to measure the students' attitude toward the use of computers in education. In addition, the post-treatment instrument included an item designed to determine preference for single or paired learning, plus five items designed to assess attitude toward the program itself. These five were taken from a student attitudinal instrument used to assess the program in November, 1986. Both surveys used a Likert type scale to measure the students' reactions, and the instruments were validated by a panel of content experts.

A copy of each attitudinal instrument can be found in Appendix B.

The CAI Model

The CAI program used in the experiment focuses on bridging the gap between circuit theory and the actual connection of series, parallel, and series/parallel combination circuits in the laboratory. The subject content of the program is applicable to any student of basic electricity. It employs a model of CAI which allows the student to use his/her own penchant for exploration to manipulate any of 15 wires in the connection of three lamps in a simulated circuit.

Classifying the Model

The purpose of the CAI program is to allow students to reinforce theoretical concepts of series and parallel circuits before attempting to actually connect the circuits on a lab bench. By simulating conditions on a lab bench, the program will allow for a learning experience that will be safer, easier on equipment, and is expected to be more thorough than spending equal time on the lab bench, since the students can connect circuits faster in the simulation and are provided with immediate feedback as to the type of circuit they have connected. The model most closely matches the simulation mode of CAI, in which "programs imitate a real situation and/or model the underlying characteristics of a real situation." (Manion, 1985, p. 27).

Preliminary Testing

A major benchmark of a CAI program must be its value as perceived by the students who use it. It must provide the appropriate course content, but should also allow students to enjoy the learning process. With factors such as these in mind, the program used in the study had been designed to be simple to use, to allow for student controlled practice, to provide for non-threatening formative testing and to dispense non-judgmental corrective feedback. A version of the program used in the study had been tested in November, 1986, by 14 volunteers from the first year electrical apprentice students at

NAIT, plus seven instructors, the senior instructor and the department chairman. Two attitudinal survey instruments were used, one for the students and one for staff. Reaction to the program from both levels was positive in terms of observed reactions, written comments, and survey results. The comments of the two groups were noted, and constructive suggestions were incorporated in the final version of the program. The students did appear to enjoy using the program, and it was judged by both groups to be a valid and worthwhile learning experience.

<u>Design of the Program</u>

The program has four menu-driven sections. The first is a tutorial which introduces the graphic representation of the circuit components and then presents a review of circuit definitions and a short, formative quiz. Students using the program are expected to have been introduced to the theory of series and parallel circuits, but this section allows them to review the concepts and will, if required, upgrade their knowledge to the prerequisite level.

The second is a short section which explains how to "draw" and "erase" wires on the screen and allows the student to become comfortable connecting circuits.

A third section allows the student to practice connecting circuits. Any combination of fifteen wires can be connected between either two or three lamps, then erased and redrawn, until the student is ready to have the circuit checked. The program then analyzes the circuit to determine which of the 18 possible circuits has been connected. A switch closes, the lamps glow with an appropriate brilliance, or a fuse blows, and feedback is provided to the student as to the type of circuit connected. The student can choose to connect as many circuits as he/she wishes.

The final section "challenges" the student to connect specific circuits at each of the three levels of difficulty; series, parallel and series/parallel. If the attempt is incorrect, the student has the option of rewiring the circuit or seeing the correct circuit displayed on the screen.

Under standard classroom conditions the student would have full control over the order in which he/she worked through the four sections of the program. However, for the purposes of the experiment, it was decided to alter the program to force the student to enter each section sequentially. This ensured that all subjects were exposed to all facets of the program.

Refer to appendix C for sample screen printouts from the program.

<u>The Facility</u>

The experiment took place in a 24 station micro-computer lab located close to the students' usual classrooms. The stations were set up two to a row, with six rows arranged diagonally on either side of a centre aisle. The micro-computers used were MSDOS machines complete with 14 inch, high resolution, monochrome monitors. Each station was provided with caster equipped "steno" chairs and the stations were of sufficient size as to avoid crowding when used by two persons. The student pairs were able to change places at the keyboard with ease.

Procedure

On the afternoon of March 18, 1987 the subjects were informed that a CAI program would make up a part of their regular instruction and that they, as a group, would be participating in a study. At this time they were not advised as to the nature of the experiment (pairs versus singles). All subjects completed a pre-treatment attitudinal survey and an achievement pretest.

The following morning students from one lab section at a time were escorted to the computer facility. The students were seated according to a pre-arranged plan which ensured that the paired subjects were located toward the front of the facility, with the singles more widely distributed toward the rear. The subjects (pairs and singles together) were provided with a verbal overview of the program along with step-by-step instructions for signing on and then allowed to proceed at their own pace through the program. No special instructions were given with regard to peer interaction or keyboard use.

As a result of an earlier pilot test, it had been estimated that 35 minutes would be a reasonable time for students to spend on the program, but a full class period of 55 minutes was provided for each lab section, with the extra time expected to be used by those students with special interest in the program. The experimenter was available to answer both procedural and content questions. Two observers were also present and able to help with procedural problems. The program was designed to store information about student-computer interaction and automatically wrote this information to a computer disk file at the end of each session. When all sessions were complete these files were merged for later analysis.

During the afternoon of the same day both classes were asked to complete a post-treatment attitude survey and an achievement post-test. One week later, on March

26th, the subjects completed an achievement retention test.

Chapter summary

Fifty-six first year electrical apprentice students at the Northern Alberta Institute of Technology participated in a study designed to investigate the affects of pairing students to learn series/parallel circuit concepts by means of a CAI simulation program as opposed to having them work singly. The study was based on a pretest-posttest control group design with the treatment as the independent variable and the dependent variables being achievement scores, attitude scores, and time taken to complete the program. Stratified random sampling was used to place one half of the subjects into the experimental group (paired students) and the remainder made up the control (single students).

The following chapter will present results of statistical analyses of the data collected in the experiment.

CHAPTER IV

RESULTS

This section consists of summaries of the experimental data, the results of statistical tests, conclusions regarding the three hypotheses which were introduced in chapter one, and the results of subsidiary analyses.

Hypothesis 1: Achievement

There will be no difference in achievement between those who work on the program singly and those who work on it in pairs.

Each of the 12 item achievement instruments was analyzed both as a single scale and as two subscales divided on the basis of question type. Subscale one was made up of seven multiple choice questions, and subscale two of five circuit completion questions which required students to draw wires to complete a specified circuit. Figure 1 reveals that, although the pairs pretest mean (on each subscale and the complete test) was lower than the singles pretest mean, the pairs posttest and retention test means were higher.

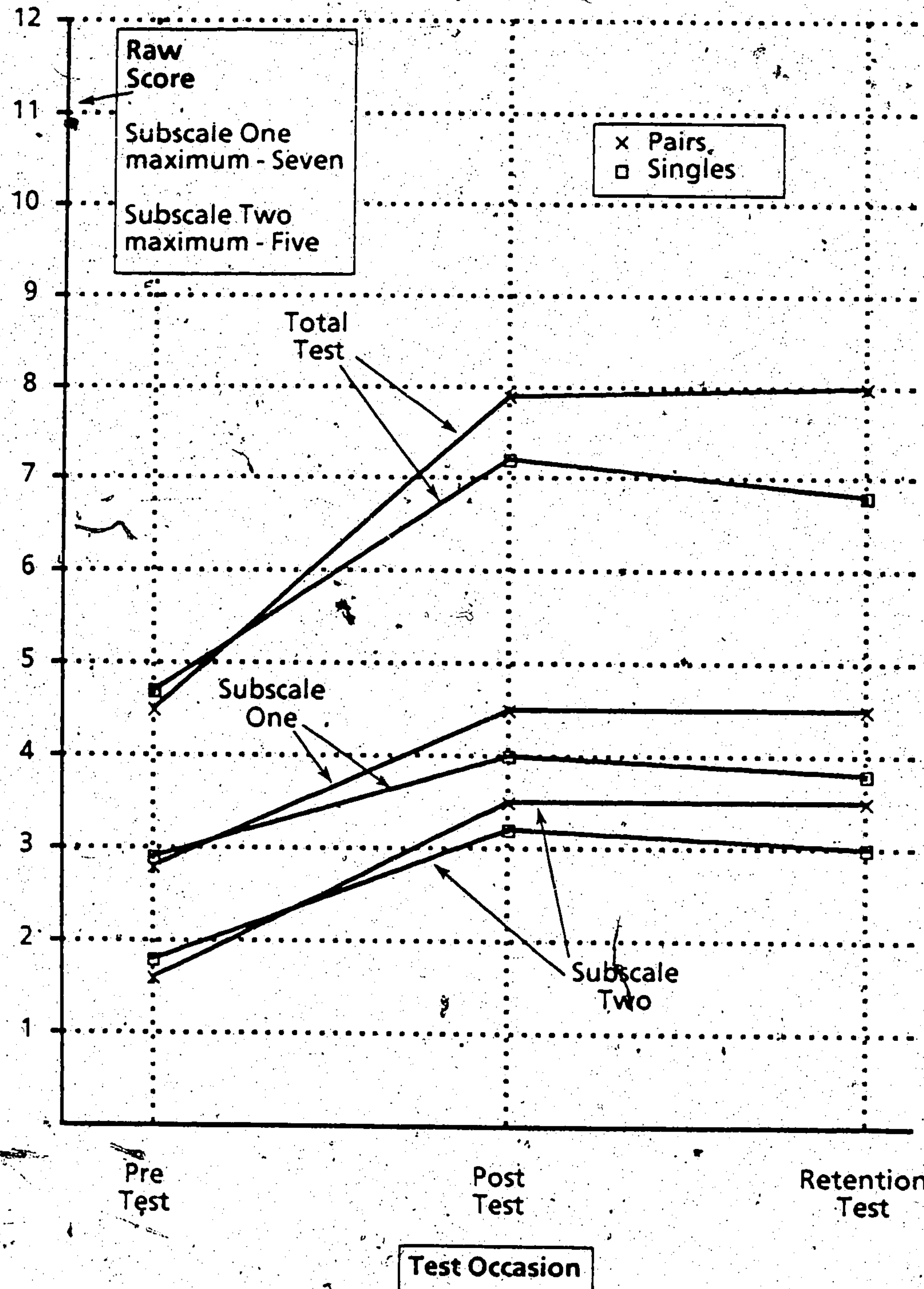

Figure 1 Achievement means

Table 1 summarizes the achievement data over the three measures of pretest, posttest, and retention test, on each of the two subscales and the complete test.

Table 1 Achievement data

	Pretest Mean(SD)	Posttest Mean(SD)	Retention Mean(SD)
Subscale 1 (Multiple choice)			
Singles	2.92(1.5)	4.03(1.2)	3.77(1.4)
Pairs	2.82(1.3)	4.46(1.4)	4.46(1.4)
Subscale 2 (Diagram completion)			
Singles	1.77(1.6)	3.15(1.3)	3.00(1.4)
Pairs	1.64(1.8)	3.46(1.2)	3.54(1.4)
Complete test			
Singles	4.69(2.8)	7.19(2.1)	6.77(2.2)
Pairs	4.46(2.7)	7.93(1.9)	8.00(2.0)

A two x three analysis of variance (ANOVA) with repeated measures was used to determine if the differences were significant, for each of the subscales and for the complete test. The results are summarized in Tables 2, 3 and 4.

Table 2 Two x three analysis of variance with repeated measures. Subscale one of the achievement tests (Pre, Post, and Retention)

Source of variation	Sum of squares	d.f.	Mean squares	F ratio	p
Between subjects	202.1	53			
Treatment(A)	4.670	1	4.670	1.230	0.273
Error between	197.5	52	3.797		
Within subjects	180.0	108			
Measures(B)	62.36	2	31.178	28.950	0.000
AB	4.425	2	2.213	2.055	0.133
Error within	112.0	104	1.077		

On each of the subscales and for the complete test, the first of the main effects (pairs vs singles) was not significant. The second, (repeated measures) was significant, and a Scheffé multiple comparison test was applied for each ANOVA. These follow-up tests determined that on each of the subscales and for the complete test, significant gains occurred between the pretest and posttest scores ($p < .001$), and between pretest and retention test scores ($p < .001$).

Table 3 Two x three analysis of variance with repeated measures. Subscale two of the achievement tests (Pre, Post, and Retention)

Source of variation	Sum of squares	d.f.	Mean squares	F ratio	p
Between subjects	200.4	53			
Treatment (A)	2.331	1	2.331	0.612	0.438
Error between	198.1	52	3.809		
Within subjects	228.7	108			
Measures (B)	90.07	2	45.035	34.883	0.000
AB	3.052	2	1.526	1.182	0.311
Error within	134.3	104	1.291		

The difference between scores on the posttest and scores on the retention tests was not significant. However, a significant interaction (p = .049) was revealed, as indicated in Table 4.

Table 4 Two x three analysis of variance with repeated measures. Complete Achievement test (Pre, Post, and Retention)

Source of variation	Sum of squares	d.f.	Mean squares	F ratio	p
Between subjects	583.8	53			
Treatment(A)	13.59	1	13.589	1.239	0.271
Error between	570.2	52	10.965		
Within subjects	570.7	108			
Measures(B)	302.0	2	150.987	63.106	0.000
AB	14.84	2	7.421	3.102	0.049
Error within	248.8	104	2.393		

Tables 5 and 6 summarize the results of follow-up one way ANOVAs on the posttest and retention test data.

Table 5 One way analysis of variance - complete achievement test. (Posttest)

Source of variation	Sum of squares	d.f.	Mean squares	F ratio
Error between	7.31	1	7.31	1.87
Error within	203.90	52	3.92	
Total	211.20	53		

Table 6 One way analysis of variance - complete achievement test. (Retention test)

Source of variation	Sum of squares	d.f.	Mean squares	F ratio
Error between	20.42	1	20.42	4.57*
Error within	232.61	52	4.47	
Total	253.04	53		

*p < .05

This study failed to reject the first null hypothesis, as it appears that overall, students working in pairs and students working alone achieved equally well. However, as indicated in Table 5, the pairs scored higher on the retention test.

Hypothesis 2: Attitude

There will be no difference in attitude between those who work on the program singly and those who work on it in pairs.

Figure 2 reveals that the attitude scale means increased from pretest to posttest, for both control and experimental groups.

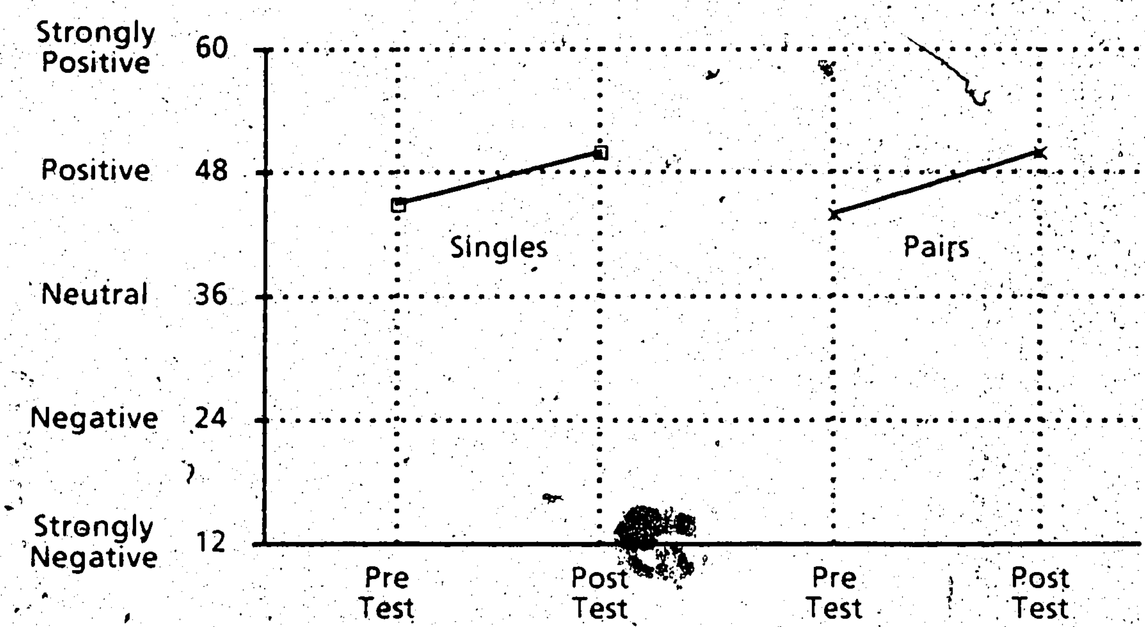

Figure 2 Attitude scale - pretest and posttest means

Table 7 summarizes the results of the attitude pretest and posttest, for the singles, the pairs, and the total group. A one sample Hotelling T^2 test on the total group means indicated that the pretest to posttest increase was significant ($T^2 = 101.44$, $F = 6.699$, $DF = 12/42$, $p < .001$). Follow-up individual tests indicated that four items contributed to the significant difference (Table 8).

Table 7 Attitude Scale - Pretest and Posttest

	n.	Mean	SD	Range	KR(20)	SEM
Pretest						
Singles	26	45.08	7.03	31-60	0.91	2.04
Pairs	28	43.79	5.97	30-57	0.89	1.90
Total	54	44.41	6.47	30-60	0.90	1.98
Posttest						
Singles	26	49.62	4.83	41-60	0.84	1.82
Pairs	28	49.79	7.06	35-60	0.94	1.64
Total	54	49.70	6.03	35-60	0.91	1.74

Table 8 Attitude scale scores for individual items, (pretest and posttest)

Item	Pretest		Posttest	
	mean	sd	mean	sd
1	3.593	0.836	4.222	0.793*
2	4.111	0.538	4.444	0.538
3	3.981	0.629	4.389	0.596
4	3.815	0.702	4.370	0.525*
5	3.222	1.058	4.000	0.777*
6	4.019	0.789	4.167	0.720
7	3.333	0.932	3.796	0.898
8	3.593	0.836	4.111	0.538*
9	4.019	0.598	4.278	0.529
10	3.685	0.797	4.000	0.777
11	3.296	0.768	3.796	0.959
12	3.741	0.805	4.130	0.702

* $p < .05$

In order to test the difference between the two levels of treatment, a multivariate analysis of covariance

(MANCOVA) was applied, using the 12 pretest item scores as covariates. No significant difference was found between the means of the control and the experimental group (F = 1.3237, DF = 12/29, p < .2585).

This study failed to reject the second null hypothesis, as it appears that students working in pairs and students working alone experienced a similar change in attitude.

Hypothesis 3: Time

There will be no difference in time taken by those who work on the program singly and those who work on it in pairs.

Table 9 summarizes the data regarding total time taken by the control and experimental groups, and presents the result of a t-test on the means. The difference between the two groups with respect to time spent on the program was found to be non-significant.

Table 9 **Total time spent on the program**

Treatment	Mean	Range	SD	t
Single	42.52	33.3-50.0	4.17	0.39
Pair	42.08	35.4-49.6	4.12	

On the basis of this t-test, the study failed to reject the third null hypothesis, as it appears that pairs and singles required similar periods of time to complete the program. The subsidiary analysis section includes the results of two t-tests which are of interest in a discussion of the third hypothesis.

Subsidiary analysis

Program Attitude

The attitude posttest instrument (refer to appendix B) included five items designed to determine the attitude of the students toward the program itself. The scale allowed for a range of scores from five (strongly negative) to 25 (strongly positive). These results are summarized in Table 10.

Table 10 Program Attitude Scale

	n	Mean	SD	Range	KR(20)	SEM
Singles	26	21.77	1.90	19-25	0.69	0.95
Pairs	28	21.43	2.46	17-25	0.85	0.84
Total	54	21.59	2.19	17-25	0.79	0.90

Inspection reveals that the program attitude scale means were positive for both control and experimental groups. A two sample Hotelling T^2 test on the group means determined that the difference between the means of the control and experimental groups with respect to attitude toward the program was not significant ($T^2 = 4.587$, $F = 0.8469$, $DF = 5/48$, $p < .524$).

<u>Desire for more time</u>

The attitude posttest instrument (refer to appendix B) included an item which asked the students whether they would have preferred more time on the program, and if so, how much more time. The item was scaled from zero, (no more time desired), to six (would like more than 30 minutes). A response of four represented a desire for an additional 20 minutes. A t-test was utilized to compare the means of the two groups, and the results are displayed in Table 11. No significant difference was determined between the groups with respect to desire for more time.

Table 11 <u>Desire for more time</u>

Treatment	Mean	Range	SD	t	p
Single	3.96	0-6	2.50	-0.22	0.83
Pair	4.11	0-6	2.41		

The scores of the pairs were analyzed to determine the degree of discrepancy between the responses of members of a pair. The mean discrepancy was 0.93 and ranged from 0 to 3.

Circuit Connection Time

To further investigate the effects of the treatment on time requirements, the total number of circuits connected by each student in the two major sections of the program was divided by the total time each student spent on the same two sections, to determine a mean circuit connection time. A t-test was utilized to compare the means of the two groups, and the results are displayed in Table 12. No significant difference was determined between the group means for circuit connection time.

Table 12 Circuit connection time

Treatment	Mean	Range	SD	t	p
Single	1.70	1.09-2.52	0.43	0.92	0.36
Pair	1.57	0.67-3.36	0.60		

Desire to work alone

An item on the attitude posttest (refer to appendix B) polled students to determine their preference for working alone or working in pairs. The item was scaled from one (strongly prefer not to work alone) to five (strongly prefer to work alone). A t-test was utilized to compare the means of the two groups, and the results are displayed in Table 13. No significant difference was determined between the group means for desire to work alone.

Table 13 Desire to work alone

Treatment	Mean	Range	SD	t	p
Single	3.654	2-5	0.892	1.28	0.21
Pair	3.288	1-5	1.182		

Was partner known

A question on the attitude posttest asked members of a pair how well they knew their partners, if they knew them at all. The item was scaled from one, (did not know partner at all), to five, (knew partner very well). The mean score was 1.43 and ranged from 1 to 3. The mean discrepancy between responses of members of a pair was 0.5 and ranged from 0 to 1.

Observations

Two observers were present in the computer lab at the time of the experiment. They were issued an instrument on which they were to record observations made during each of the four sessions. No previous attempt had been made to establish interrater reliability, and there was some difficulty in implementation of the instrument. As a result, this is a summary of anecdotal observations only.

The observers periodically attempted to assess students' reactions to the program in terms of verbalization and body language. Verbalization was grouped into two classifications: on topic and off topic. Singles spoke to one another on occasion, but pairs naturally had more opportunity for verbalization and their frequent discussions were often quite animated. Comments by both groups were overwhelmingly on topic. Body language was periodically interpreted by the observers and recorded by checkoffs in columns labelled interest, boredom, excitement, frustration, and concentration. The checkoffs were predominantly in the areas of interest and concentration for both pairs and singles, with occasional evidence of excitement among the pairs and occasional indications of frustration and boredom among the singles. The observers reported comparatively little emotional expression by the single students, and that the learning process appeared to be more enjoyable when working in pairs. Comments overheard and recorded by the observers are included in appendix E.

Chapter summary

This chapter presented the results of statistical analysis of the attitude measures, the achievement measures, the time taken by each group of students, and of subsidiary analyses of certain aspects of the experiment.

There appears to be no difference between the experiences of the two groups of students with regard to attitude, achievement, or time required, except for performance on the achievement retention test, where it was determined that the pairs scored higher. The following chapter contains a more detailed discussion of these results.

CHAPTER V

DISCUSSION

In this chapter, the results of the study are summarized and analyzed with respect to theoretical and practical implications. Suggestions for further research are also presented.

Summary of results

Statistical analyses of the data resulted in failure to reject any of the three null hypotheses. Pairs and singles performed equally well on both subscales of the achievement measure, however post hoc tests indicated that a significant interaction on the total test data was the result of a better performance by pairs on the retention test. The attitude of both treatment groups toward CBE was significantly influenced (in a positive direction) by the experience on four of the 12 attitude items, but no differential effect was found between pairs and singles. There was no significant difference in time taken by either group.

Subsidiary analyses determined that there was no significant difference between the control and experimental groups with respect to desire for more time, mean circuit connection time, attitude toward the program, or the desire to work alone.

Theoretical implications of results

Achievement

The studies of Carrier & Sales, (1987), Cartwright, (1973), Leiber & Semmel, (1987), and Sutter & Reid, (1969) all conclude that pairs achieve as well as singles when working on a CAI lesson. This study lends support to these findings but determined further that with this program, pairs outperformed singles on the retention instrument.

The results of the achievement measures indicate that while the pairs pretest scores were slightly lower than those of the singles, their posttest scores were higher. Of greater significance, their retention scores increased, while those of the singles dropped. During the seven day period between the posttest and the retention test, all four lab sections (each containing a random mix of pairs and singles), connected series and parallel circuits on the lab bench, and this hands-on learning experience could account for an increased retention score. It appears, however, that since the pairs' retention scores were significantly higher than the singles, the hands-on experience differentially affected the two groups. It may be that the pairs' treatment had left the paired subjects with more sturdy cognitive structures on which they had stored their conceptualizations of series and parallel circuit theory. This group would then be more prepared to profit from further instruction, and the higher retention scores could be the result.

Decreased time on the keyboard and increased peer interaction are the obvious factors which distinguish the experience of a paired subject from that of a single. Webb (1984) reported that the amount of time each member of a pair spent on the keyboard was not related to performance outcomes, and suggested that students not at the keyboard and students at the keyboard were equally involved with the material. Though time on the keyboard was not measured in this study, observation and results suggest that Webb's findings were corroborated by this study. Student interaction may well be the major difference between this and the four earlier studies comparing pairs and singles on CAI (Carrier & Sales, 1987; Cartwright, 1973; Leiber & Semmel, 1987; Sutter & Reid, 1969) as a result of the type of program utilized for the experiment. Pair interaction was facilitated by the program, as the graphically oriented simulation provides a ready focus for interaction between two partners. The interaction allows for the formulation and testing of "minitheories" or constructs (Claxton, 1987). The constructs themselves may change, or the situations to which the constructs apply will be changed. The effects of verbal interaction on learning were investigated by Durling and Shick (1976). They determined that vocalizing pairs had a higher rate of achievement than that of either non-vocalizing pairs or individuals vocalizing to the experimenter. Interaction causes the learner to be an active processor of information, not a passive receiver, and this, according to Wittrock (1974), could affect retention: "it seems that instruction which causes the learner to generate distinctive associations between stimuli and memory facilitates long-term recall and understanding" (p. 94). Active participation (Webb, 1980) and spontaneous verbalization of the concepts involved (Lewis, 1986), tends to reinforce the concepts being learned. "Given the proper setting, students can--and will--argue and debate with one another. Student talk is useful and provides a stimulus for learning as well as an impetus for further exploration of topics" (Christenbury & Kelly, 1983, p. 2).

It appears that there is some theoretical justification for the finding that the pairs retained information better than the singles--for programs which stimulate or facilitate peer interaction. In contrast, interaction between members of a pair working with a more heavily text based program may be adversely affected by disparate reading and comprehension levels.

<u>Attitude</u>

With the attitude instruments an attempt was made to determine (1) whether or not the experience, as perceived by the subjects, was both a pleasurable and worthwhile learning experience and (2) if the perception of the experience was different--better or worse--for the experimental group. The attitude of both treatment groups toward CBE was significantly (and positively) influenced by the experience on four of the 12 items, and no differential effect was found between pairs and singles.

Any measure of attitude by a verbal or written instrument must be a measure only of what the respondent wishes to convey to the experimenter. Overt responses may or may not accurately reflect a respondent's inner feelings, and may or may not be corroborated by subsequent behaviour. However, in spite of the obstacles it is important to attempt to determine attitudes toward the developing field of CBE (Bear, Richards, & Lancaster, 1987) as a form of feedback from a most appropriate source. Written responses, requested with an assurance of confidentiality, may be minimally influenced by social factors and may provide a reasonably accurate assessment of the subject's "predisposition to respond in a consistently favorable or unfavorable manner" (Fishbein & Ajzen, 1975, p. 6) at any given time.

Attitudes do change. "The experienced value of any event depends upon comparisons with other events" (Parducci, 1984, p. 1), and a new event can cause the experienced values to be altered. The changing nature of attitude is also described by Kahle (1984):

> Attitudes and cognitions are not static and fixed but rather are often growing and being adjusted. When we measure an attitude, we are not capturing the exact external position of the attitude as a picture of a statue might. Rather, the measured attitude is better conceived as a single frame from a motion picture of an active object (p. 41).

The attitude pretest captured one frame, the posttest another, and the two pictures are--in some respects--different. Between the administration of the two instruments, the CAI experience significantly changed the subjects' attitude toward the following aspects of the use of computers in education:

Item 1: A computer could make learning more fun for me.

Item 4: Computers are so complicated I would rather not use one for learning.

Item 5: Even though computers are valuable and necessary, I still have a fear of them.

Item 8: Working with a computer would make me very nervous.

The scores on the remaining eight items changed in a positive direction as well, though the change was not significant at the predetermined level of probability. It may be interpreted that for both groups the experience was enjoyable and tended to reduce anxiety with respect to computer use.

A factor to consider when reviewing these attitudinal results is that the study was completed with an all-male group of students. Since females constitute only one percent of the first year electricians in the province of Alberta, the group was representative with regard to sex, but it may be found that a population with a higher percentage of females would produce different results. In a study which focused on sex differences with respect to attitudes toward and involvement with computers, Dambrot et al (1985) found that attitudes of females were more negative toward computers than were those of males, which suggests that a class with equal representation of both sexes would not have scored as high on the initial attitude instrument. However, Johnson, Johnson and Stanne (1985) and Loyd and Gressard (1984) found no difference between male and female attitude toward CBE.

Dambrot et al (1985) also discussed the attitude of people in general toward computers. They cite studies (completed between 1979 and 1983) which concluded that the prevalent attitude was a negative one. Three major reasons were offered: (1) many computer users had experienced functional problems with computers, such as access difficulties, frequent interruptions in service, poor documentation, and inconsistencies between and compatibility problems with systems and languages, (2) inadequate training prior to initial use of computers, resulting in a less than satisfactory experience, and (3) a general resistance to change and a fear of the unknown represented by the new technology. The 1985 report concluded that people's attitudes in general to computers was negative, yet the present study, two years later, found a positive reaction to the use of computers in education, even at the pretest stage. It may be that as hardware and software designers become more sophisticated, a greater percentage of the general population have had positive experiences with computers and the positive results of this study are a result of a general attitude shift.

Time taken

On the basis of a pilot test of the program, it had been estimated that 35 minutes would be a reasonable time for students to spend on the program, and that by providing a full class period (55 minutes) the time allowed would be more than adequate. Settling the students into their stations, providing an overview of the program, and explaining the sign-on procedures reduced the total time available. This time varied somewhat between groups so that while the maximum time recorded for a student session was 50.0 minutes, some of the lab sections had less time available to them. For this reason, and due to the difficulty of knowing when one has "completed" this type of program, the total time data may require some degree of caution in its interpretation. Within each lab section however, both groups experienced the same time limitations and it may be assumed that the failure to reject the third null hypothesis (equal time requirements for both treatment groups) does represent an equal time requirement for both groups, especially in light of the subsidiary analyses which investigated differences in the time required to complete a circuit and the desire for more time.

Though some students, from both groups, expressed dissatisfaction due to the simplicity of the program and ended their session early, others, from both groups, appeared totally engrossed and had to be requested to leave their terminals at the end of the period. (Refer to appendix D for comments collected from the attitude instruments, and to appendix E for comments overheard during the sessions and recorded by the observers.)

<u>Desire for more time</u>

When responding to the attitude posttest item regarding additional time desired, 22% of the subjects expressed no desire to spend more time on the program while 48% wanted to spend an additional 30 minutes or more. No difference was determined between the responses of the two treatment groups, which may suggest that the members of a pair were not particularly frustrated by an experience which limited their access to the keyboard. The fact that most subjects wanted to spend more time on the program indicates that the learning opportunities were not exhausted, and that posttest scores may well have been higher had more time been allowed. However, since both pairs and singles operated under the same time constraint, the validity of the experiment remains unaffected.

<u>Mean circuit connection time</u>

Further evidence that pairs and singles are alike with respect to time requirements was revealed when the mean time taken to connect a circuit was determined for each group, and it was found that, on average, pairs connected circuits slightly faster than singles. The difference was determined to be non-significant, but it is important to consider that pairs must have remained equally on task and that peer interaction must generally have focused on program content.

Attitude toward the program

The attitude of pairs and singles toward the program itself was determined to be equally positive. This suggests again that both groups perceived the experience to be enjoyable and educationally rewarding.

Desire to work alone

On the question of whether they would prefer to work singly or in pairs, the opinions of the two groups did not differ significantly. While neither group, as a whole, expressed a strong desire to work alone, the responses suggest that if given a choice most members of both groups would chose to work alone. While, for members of a pair, this statement may appear incongruent beside the previous results (which have suggested that the pairs' experience has been positive), it should perhaps come as no surprise. A single positive cooperative learning experience by a member of a pair may not be sufficiently strong to alter what has perhaps been seen as a more socially acceptable attitude toward learning. These results suggest that the learning environment must be intentionally structured to facilitate and encourage paired work in order for the potential gains in efficiency to be reaped.

Practical implications

It appears that pairing students for work on a graphically oriented CAI simulation has no detrimental effects on learning, attitude or time required, and the treatment has shown positive results with respect to retention. The use of this model of CAI with a 2-to-1 student-computer ratio could result in more efficient use of existing computer hardware, and perhaps ultimately, in a relative reduction of terminals required. Consideration should be given to the design of computer work stations, so that sufficient room is allowed for two students to work together. In addition, the apparent success of this model of CAI, for both pairs and singles, suggests that the model could be used for future programs, and other models could be specifically designed for two or more users.

One further practical implication is that the negative effects of social isolation often attributed to

CAI can be overcome to some extent through paired or group CAI use, thus overcoming the reluctance of some educators to utilize this instructional method. An increased number of educators adding CAI to their complement of educational tools will result in an increased demand for good CAI, and better CAI will be the result.

Suggestions for further research

To test the degree to which the findings of this study can be generalized, further investigations should be carried o[illegible]mine (1) if these findings apply to groups [illegible] students using CAI, (2) a range of CAI [illegible]fficiently used by pairs or small gro[illegible] findings are limited to a certain seg[illegible]on.

[illegible] research could also be conducted to investigate whether or not the apparent success of the CAI model produces a subsequent reduction in hands-on lab time.

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APPENDIX A

SUBJECT SEX, EDUCATION LEVEL AND AGE

Sex

Of the 476 first year electrical apprentices in Alberta in January 1987, five (slightly over 1%) were female. Therefore an a[illegible]e group of 56 subjects can be considered representative in terms of sex.

Level of formal education

The modal education level of the subjects was grade 12, but ranged from grade nine (two students) to two years of post secondary education (one student). The education level distribution was representative of the provincial population as indicated in Table 14.

Table 14 Education level

	<11	11	>11
Provincial population	10%	11%	81%
Subjects	11%	9%	79%

Age

The subjects ranged in age from 19 to 39 years with a mean age of 24.25. Provincially, first year apprentices range in age from 18 to 55 years, with a mean age of 24.5.

The age distribution was representative of the provincial population as indicated in Table 15.

Table 15 Age*

	18-23	24-29	>29
Provincial population	54%	28%	18%
Subjects	59%	22%	20%

*The data on age and education level of the provincial population of first year electrical apprentices as of January, 1987, was supplied courtesy Wayne Nixon, Director, Registration and Certification, Apprenticeship and Trade Certification, Alberta Career Development and Employment. The same data for the subject group were provided courtesy of Rod Meuller, Apprenticeship and Trade Certification Liaison Officer at the Northern Alberta Institute of Technology. In order to safeguard individual rights, neither set of data included names.

APPENDIX B

INSTRUMENTS

Achievement instruments

Pretest

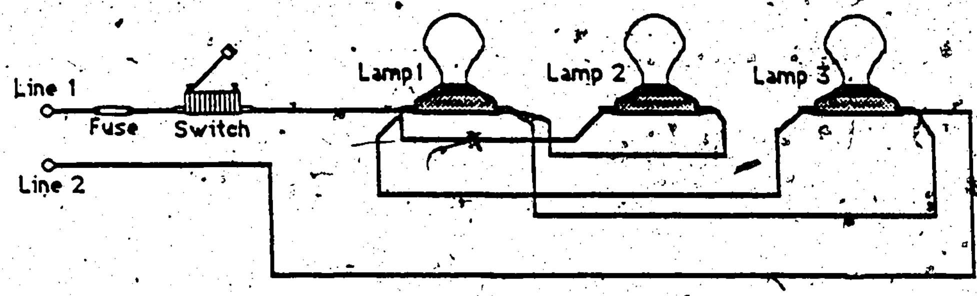
The following pages contain the achievement pretest, administered to the subjects on the afternoon of March 18, 1987.

Wiring Diagram Pretest

Part 1.

Choose the letter of the answer which best describes the way in which these circuits are connected.

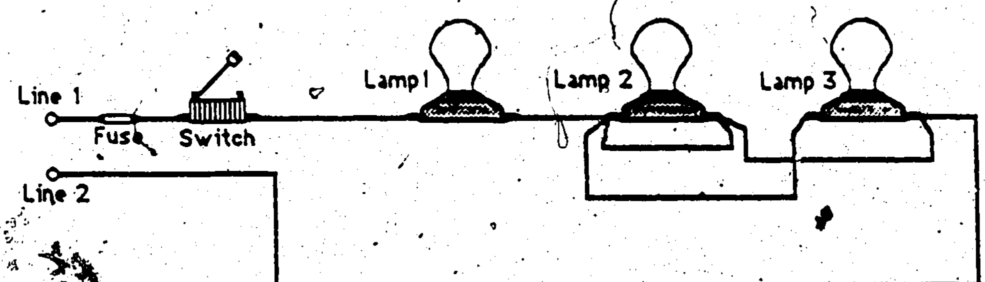
Circuit 1.



a. Lamps 1, 2 and 3 are connected in series.
b. Lamps 1, 2 and 3 are connected in parallel.
c. Lamps 1 and 3 are connected in parallel, with lamp 2 in series with them.
d. Lamps 1 and 3 are connected in series, with lamp 2 in parallel with them.
e. This connection is a short circuit.

Circuit 1 answer: ______

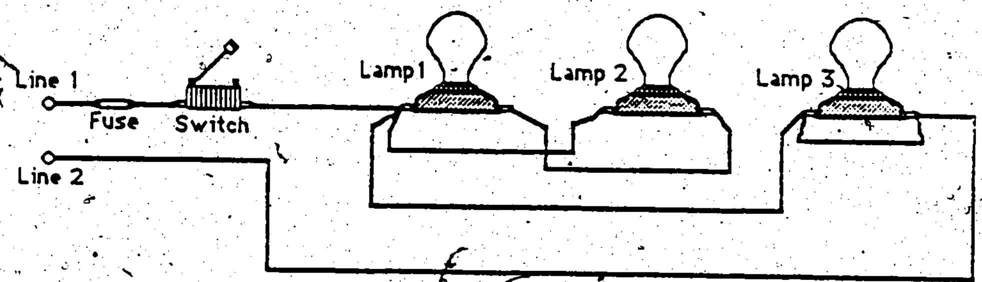
Circuit 2.



a. Lamps 2 and 3 are connected in parallel, with lamp 1 in series with them.
b. When the switch is closed, only lamp 1 will be lit.
c. When the switch is closed, only lamps 1 and 3 will be lit.
d. Lamps 2 and 3 are connected in series, with lamp 1 in parallel with them.
e. This connection is a short circuit.

Circuit 2 answer: ______

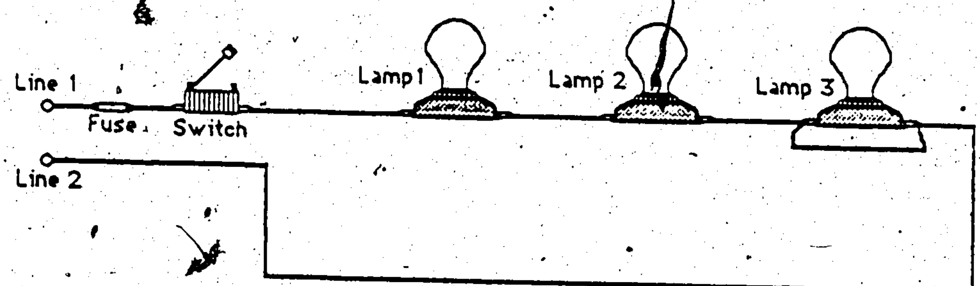
Circuit 3.



a. Lamps 1 and 2 are connected in parallel, with lamp 3 in series with them.
b. Lamps 1 and 2 are connected in series.
c. When the switch is closed, only lamps 1 and 2 will be lit.
d. Lamps 1, 2 and 3 are connected in parallel.
e. This connection is a short circuit.

Circuit 3 answer: ________

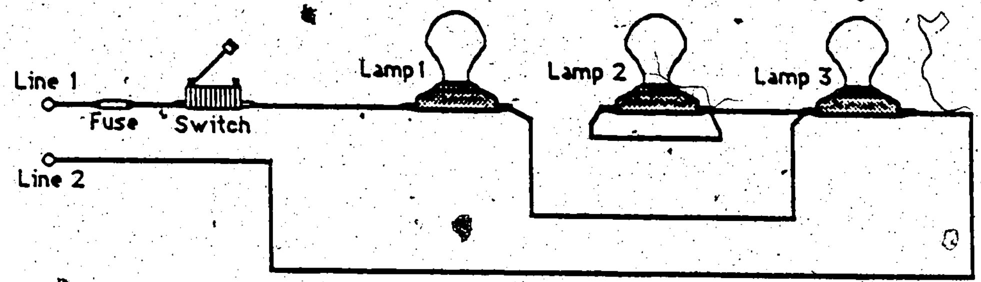
Circuit 4.



a. Lamps 1 and 2 are connected in parallel, with lamp 3 in series with them.
b. When the switch is closed, only lamp 3 will be lit.
c. When the switch is closed, only lamps 1 and 2 will be lit.
d. Lamps 1, 2 and 3 are connected in series.
e. This connection is a short circuit.

Circuit 4 answer: ________

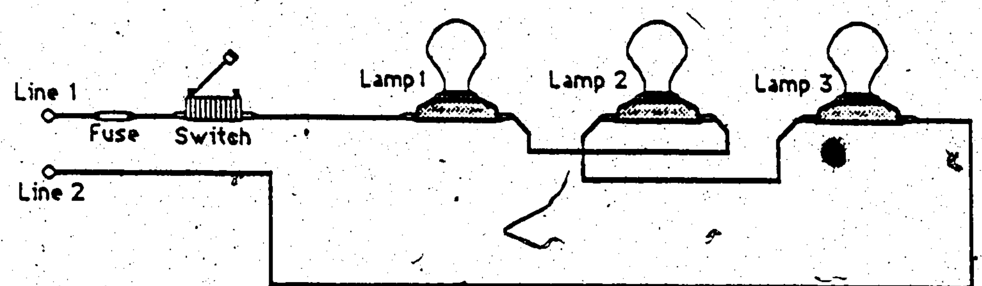
Circuit 5.



a. Lamps 1 and 3 are connected in parallel, with lamp 2 in series with them.
b. Lamps 1, 2 and 3 are in series.
c. When the switch is closed, only lamps 1 and 3 will be lit.
d. Lamps 1 and 3 are connected in series, with lamp 2 in parallel with them.
e. This connection is a short circuit.

Circuit 5 answer: ______

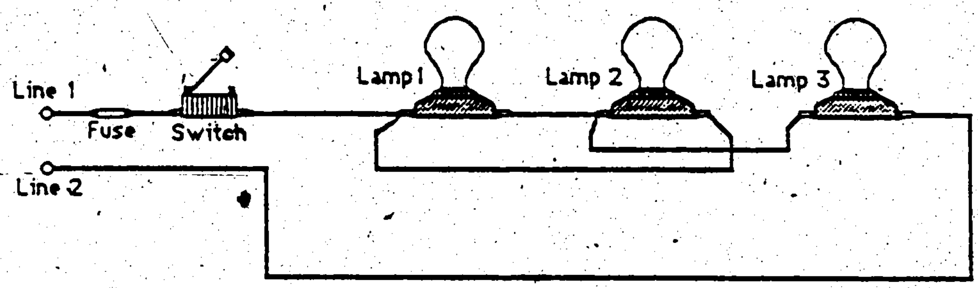
Circuit 6.



a. Lamps 1 and 3 are in series.
b. Lamps 1, 2 and 3 are in series.
c. Lamps 1 and 3 are in series, and lamp 2 is in parallel with them.
d. Lamps 1 and 2 are in parallel.
e. Lamps 1, 2 and 3 are in parallel.

Circuit 6 answer: ______

Circuit 7.



a. When the switch is closed, only lamp 3 will be lit.
b. Lamps 2 and 3 are in series, and lamp 1 is in parallel with them.
c. Lamps 1 and 3 are in series.
d. Lamps 1 and 2 are in parallel, and lamp 3 is in series with them.
e. This connection is a short circuit.

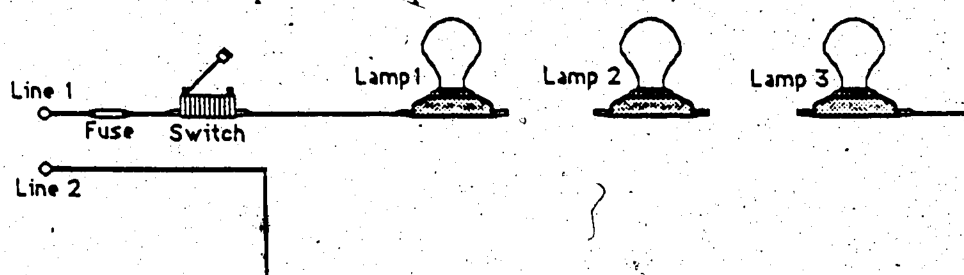
Circuit 7 answer: ________

****

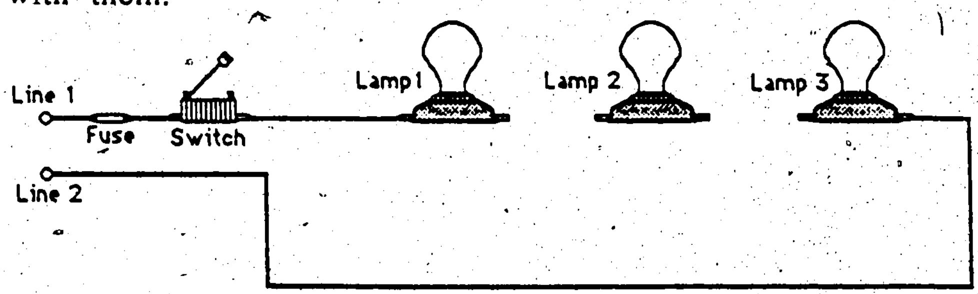
Part 2

Complete the following wiring diagrams.

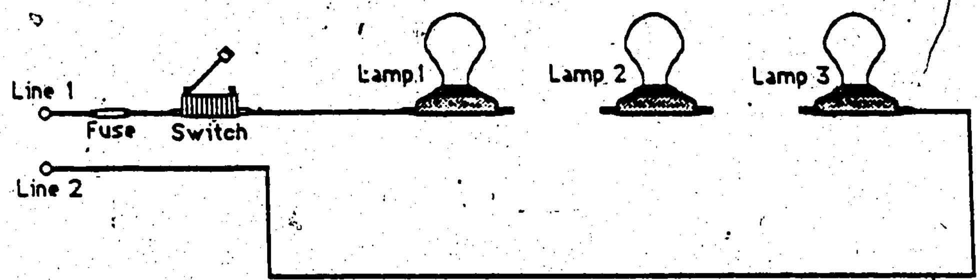
Circuit 8.
Complete a circuit where lamp 1 is in parallel with lamp 3.



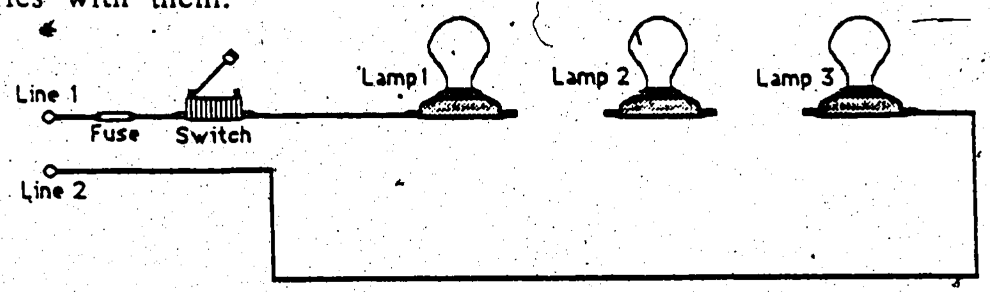
Circuit 9.
Complete a circuit where lamps 1 and 3 are in series, and lamp 2 is in parallel with them.



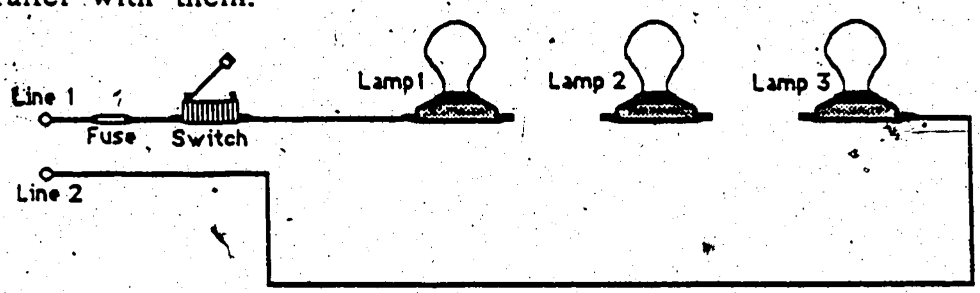
Circuit 10.
Complete a circuit where lamps 1 and 2 are in series, and lamp 3 is in parallel with them.



Circuit 11.
Complete a circuit where lamps 1 and 2 are in parallel, and lamp 3 is in series with them.



Circuit 12.
Complete a circuit where lamps 2 and 3 are in series, and lamp 1 is in parallel with them.



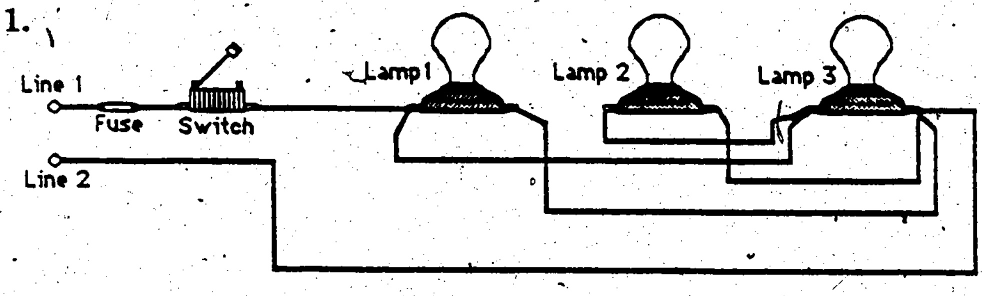
Posttest/Retention test

The following pages contain the achievement posttest, administered to the subjects on the afternoon of March 19, 1987, and again on March 26, as a retention test.

Part 1.

Choose the letter of the answer which best describes the way in which these circuits are connected.

Circuit 1.



a. Lamps 1, 2 and 3 are connected in series.

b. Lamps 1, 2 and 3 are connected in parallel.

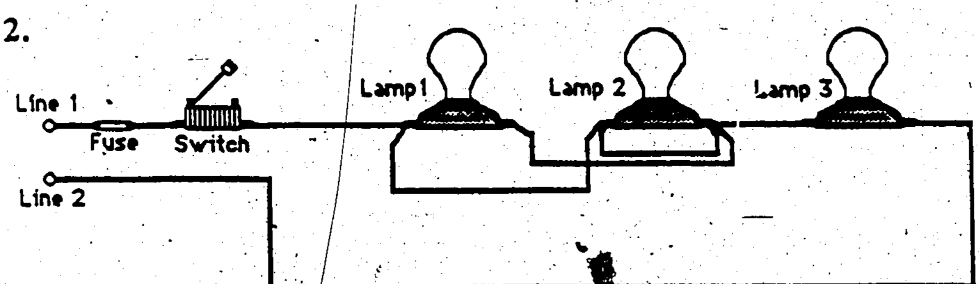
c. Lamps 1 and 3 are connected in parallel, with lamp 2 in series with them.

d. Lamps 1 and 3 are connected in series, with lamp 2 in parallel with them.

e. This connection is a short circuit.

Circuit 1 answer: ________

Circuit 2.



a. Lamps 1 and 2 are connected in parallel, with lamp 3 in series with them.

b. When the switch is closed, only lamp 3 will be lit.

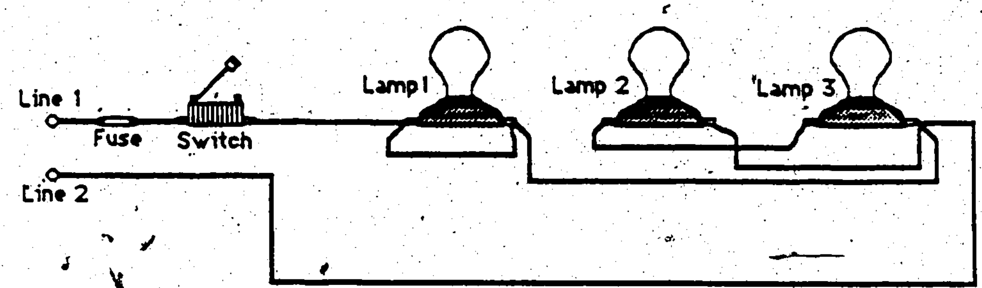
c. When the switch is closed, only lamps 1 and 3 will be lit.

d. Lamps 1 and 3 are connected in series, with lamp 3 in parallel with them.

e. This connection is a short circuit.

Circuit 2 answer: ________

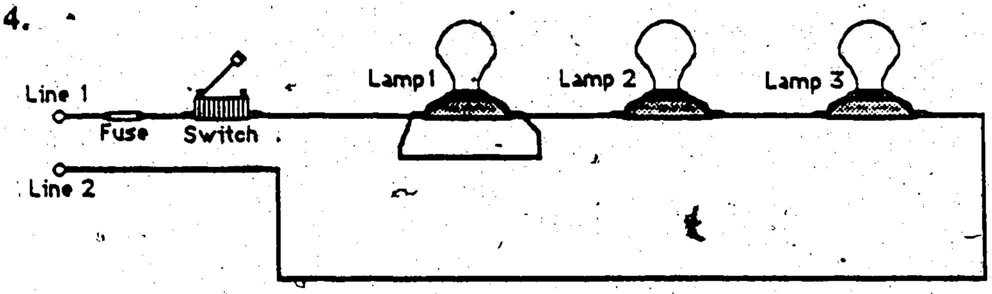
Circuit 3.



a. Lamps 2 and 3 are connected in parallel, with lamp 1 in series with them.
b. Lamps 2 and 3 are connected in series.
c. When the switch is closed, only lamps 2 and 3 will be lit.
d. Lamps 1, 2 and 3 are connected in parallel.
e. This connection is a short circuit.

Circuit 3 answer: ________

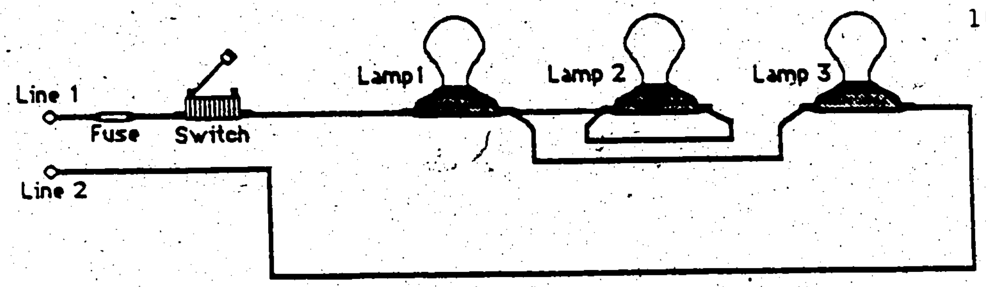
Circuit 4.



a. Lamps 2 and 3 are connected in parallel, with lamp 1 in series with them.
b. When the switch is closed, only lamp 1 will be lit.
c. When the switch is closed, only lamps 2 and 3 will be lit.
d. Lamps 1, 2 and 3 are connected in series.
e. This connection is a short circuit.

Circuit 4. answer: ________

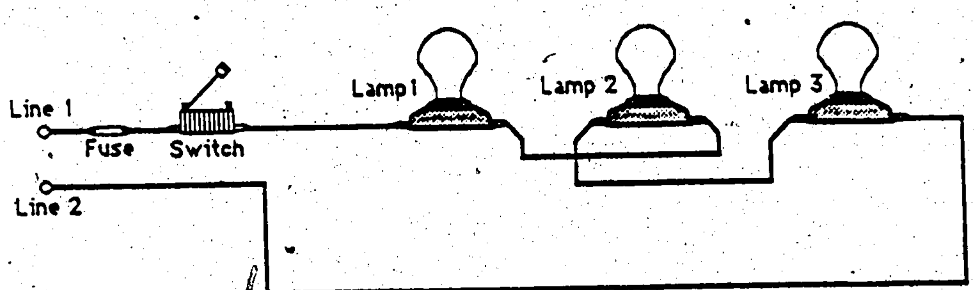
Circuit 5.



a. Lamps 1 and 3 are connected in parallel, with lamp 2 in series with them.
b. Lamps 1, 2 and 3 are in series.
c. When the switch is closed, only lamps 1 and 3 will be lit.
d. Lamps 1 and 3 are connected in series, with lamp 2 in parallel with them.
e. This connection is a short circuit.

Circuit 5 answer: ________

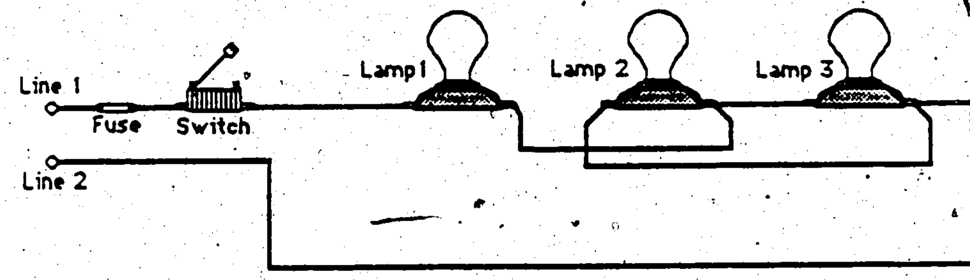
Circuit 6.



a. Lamps 1 and 3 are in series.
b. Lamps 1, 2 and 3 are in series.
c. Lamps 1 and 3 are in series, and lamp 2 is in parallel with them.
d. Lamps 1 and 2 are in parallel.
e. Lamps 1, 2 and 3 are in parallel.

Circuit 6 answer: _______

Circuit 7.



a. When the switch is closed, only lamp 1 will be lit.
b. Lamps 2 and 3 are in series, and lamp 1 is in parallel with them.
c. Lamps 1 and 3 are in series.
d. Lamps 2 and 3 are in parallel, and lamp 1 is in series with them.
e. This connection is a short circuit.

Circuit 7 answer: ______

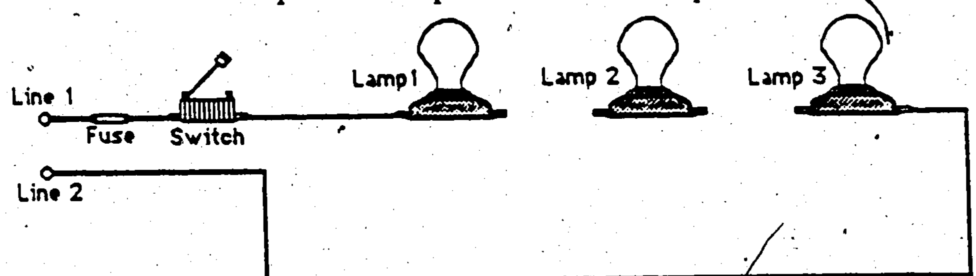
****

Part 2

Complete the following wiring diagrams.

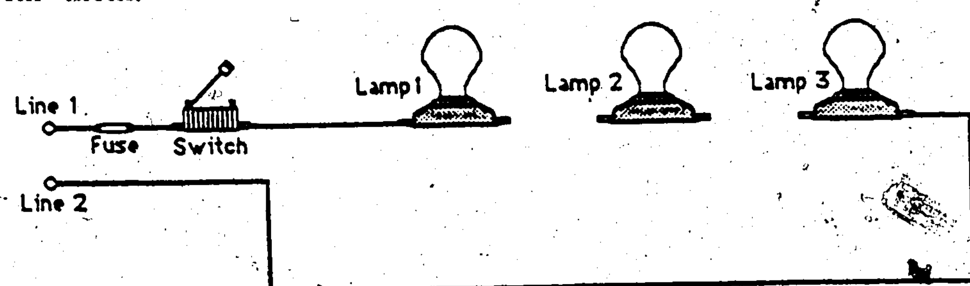
Circuit 8.

Complete a circuit where lamp 1 is in parallel with lamp 3.



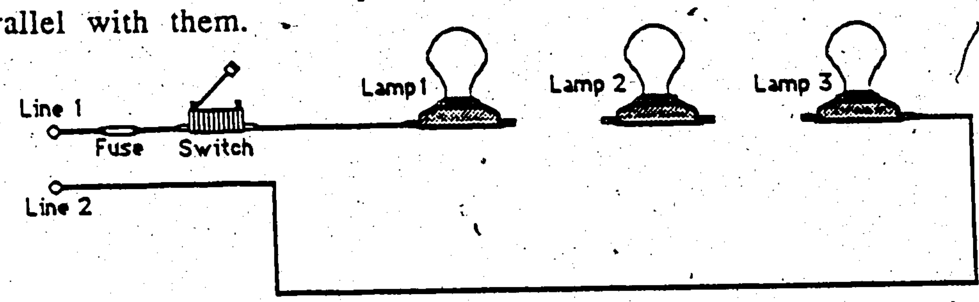
Circuit 9.

Complete a circuit where lamps 1 and 3 are in series, and lamp 2 is in parallel with them.



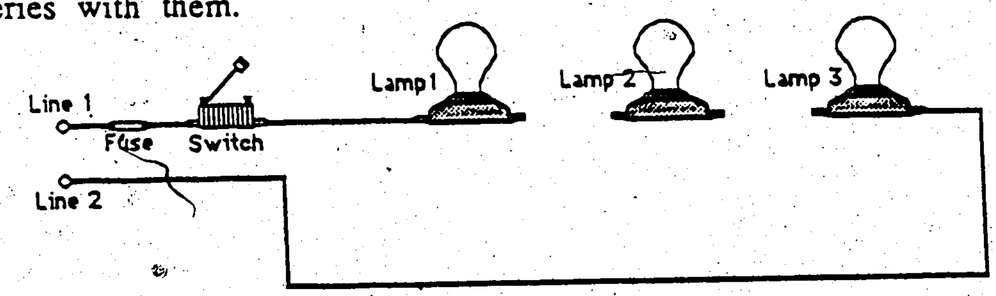
Circuit 10.

Complete a circuit where lamps 1 and 2 are in series, and lamp 3 is in parallel with them.



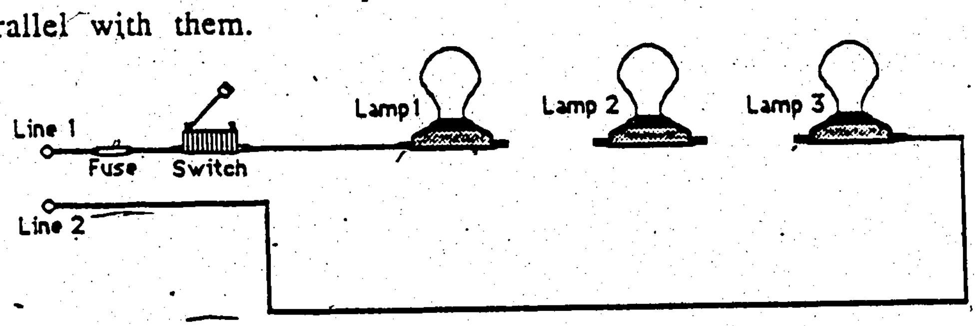
Circuit 11.

Complete a circuit where lamps 1 and 2 are in parallel, and lamp 3 is in series with them.



Circuit 12.

Complete a circuit where lamps 2 and 3 are in series, and lamp 1 is in parallel with them.



Attitude Instruments

Pretreatment

The following page was administered to the subjects as a pretreatment attitude instrument on the afternoon of March 18, 1987.

R

Attitude Survey

This form was designed to find out how first year electrical apprentices feel about using computers in education.

Your answers are neither right or wrong. Please read each question carefully before answering, but do not spend too much time on any one question. This information will be used in a statisical survey and will be kept confidential. Thanks for your cooperation.

Apprenticeship ID Number: ____________

Please circle the response which best describes your feelings.

SA - Strongly Agree
A - Agree
U - Unsure
D - Disagree
SD - Strongly Disagree

1. A Computer could make learning more fun for me.	SA	A	U	D	SD
2. Given a little time and training, anybody could learn to use computers.	SA	A	U	D	SD
3. Using a computer could be enjoyable.	SA	A	U	D	SD
4. Computers are so complicated I would rather not use one for learning.	SA	A	U	D	SD
5. Even though computers are valuable and necessary, I still have a fear of them.	SA	A	U	D	SD
6. I feel very negative about computers in general.	SA	A	U	D	SD
7. Computers do not scare me at all.	SA	A	U	D	SD
8. Working with a computer would make me very nervous.	SA	A	U	D	SD
9. I am sure I could do work with computers.	SA	A	U	D	SD
10. I'm not the type to do well with computers.	SA	A	U	D	SD
11. Once I start to work with the computer, I would find it hard to stop.	SA	A	U	D	SD
12. I will do as little work with the computer as possible.	SA	A	U	D	SD

(Please add any additional comments below, or on the back.)

Posttreatment

The following pages were given to the subjects as a posttreatment attitude instrument on the afternoon of March 19, 1987.

Attitude Survey

This form was designed to find out if your feelings have changed about using computers in education.

Once again, your answers are neither right or wrong. Please read each question carefully before answering, but do not spend too much time on any one question. This information will be used in a statisical survey and will be kept confidential.

Thanks for your cooperation.

Apprenticesbip ID Number: ___________

<u>Question A.</u>

Would you have liked to [illegible]d more time on the program? ______

If so, how much more time?
(Circle the correct answer.)

(5 min) (10 min) (15 min) (20 min) (30 min) (more than 30 min)

<u>Question B.</u>
Answer this question if you worked on the program with another apprentice.

How well did you know the person you worked with?
(Circle the correct answer.)

(very well) (well) (somewhere in-between) (slightly) (not at all)

Please answer the questions on the next page.

Please circle the response which best describes your feelings.

SA - Strongly Agree A - Agree U - Unsure D - Disagree
SD - Strongly Disagree

1. A Computer could make learning more fun for me.	SA	A	U	D	SD
2. Given a little time and training, anybody could learn to use computers.	SA	A	U	D	SD
3. Using a computer could be enjoyable.	SA	A	U	D	SD
4. Computers are so complicated I would rather not use one for learning.	SA	A	U	D	SD
5. Even though computers are valuable and necessary, I still have a fear of them.	SA	A	U	D	SD
6. I feel very negative about computers in general.	SA	A	U	D	SD
7. Computers do not scare me at all.	SA	A	U	D	SD
8. Working with a computer would make me very nervous.	SA	A	U	D	SD
9. I am sure I could do work with computers.	SA	A	U	D	SD
10. I'm not the type to do well with computers.	SA	A	U	D	SD
11. Once I start to work with the computer, I would find it hard to stop.	SA	A	U	D	SD
12. I will do as little work with the computer as possible.	SA	A	U	D	SD
13. I found the program difficult to use.	SA	A	U	D	SD
14. The program helped me learn about circuitry.	SA	A	U	D	SD
15. Using the program was a waste of my time.	SA	A	U	D	SD
16. The instructions were clear and easy to follow.	SA	A	U	D	SD
17. I would not want to use other programs designed like this.	SA	A	U	D	SD
18. If I used another program like this, I would want to work alone.	SA	A	U	D	SD

(Please add any additional comments below, or on the back.)

APPENDIX C

Sample screen printouts from the CAI program --

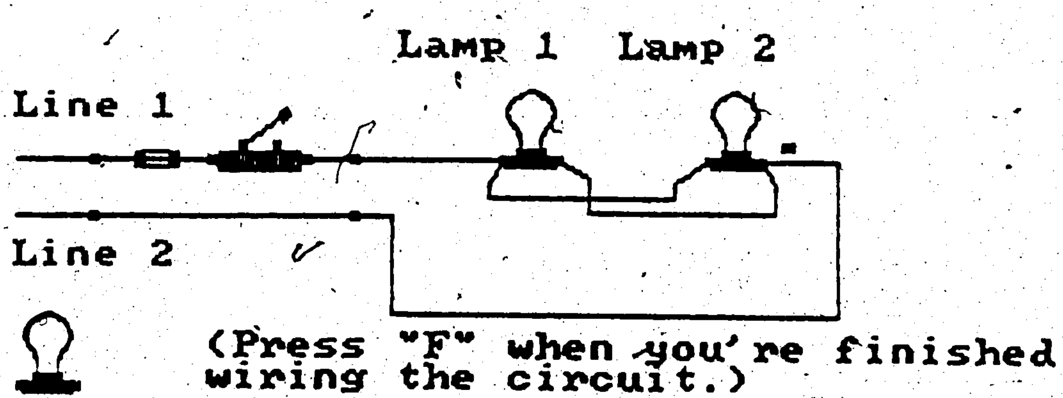
Series/Parallel Circuit Practice

SERIES AND PARALLEL CIRCUIT PRACTICE

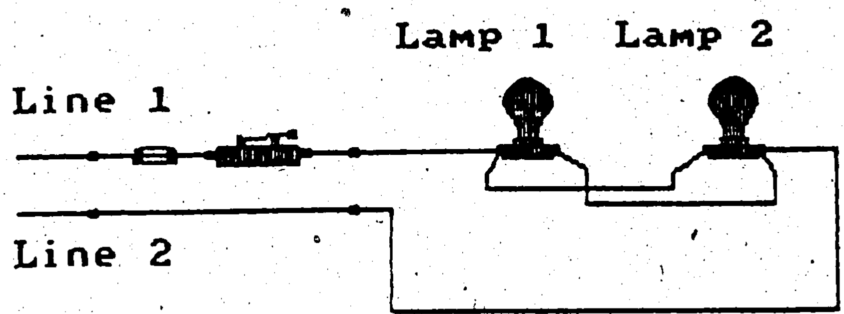
1. EXIT
2. Circuit Definitions
3. Circuit Demonstration
4. Circuit Practice
5. Circuit Challenge

(Use Arrow keys to move, ENTER to choose.)

The arrow keys, (← – →), move the marker. Press ENTER at each END of the wire which is to be drawn or erased.

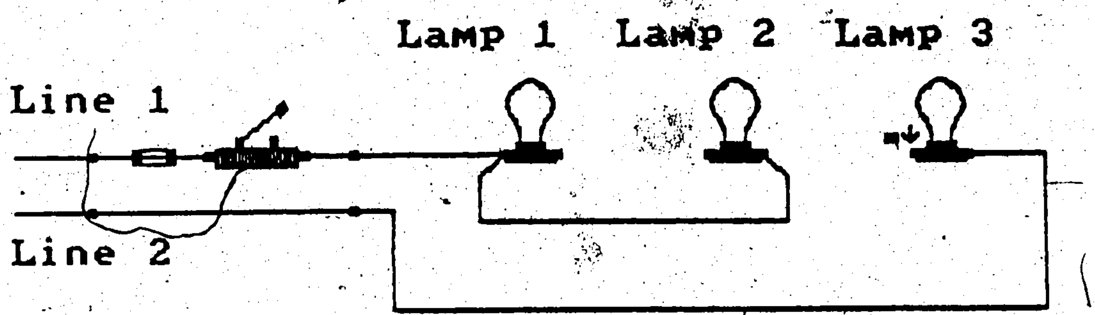


Lamps 1 and 2 are in parallel.



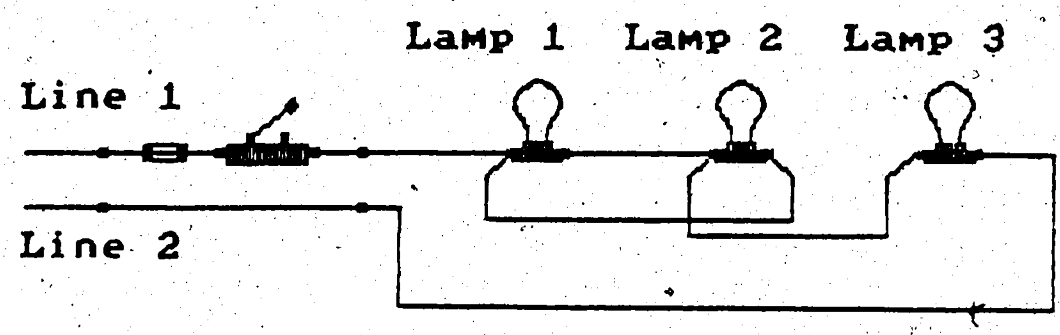
(Press the SPACE BAR to continue)

The arrow keys, (← - →), move the marker. Press ENTER at each END of the wire which is to be drawn or erased.

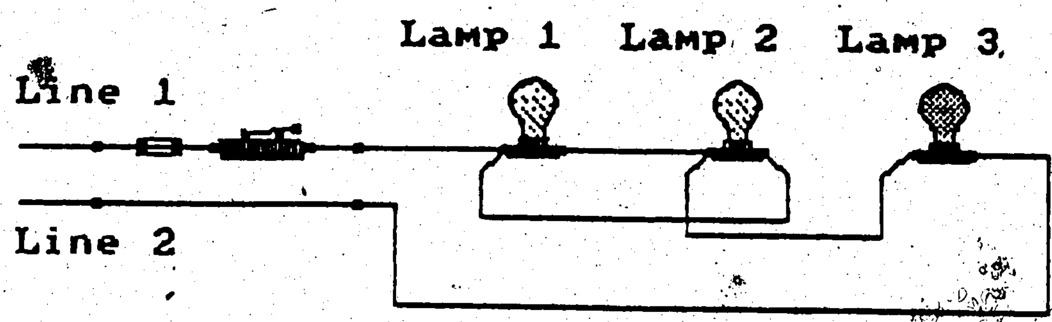


(Press "F" when you're finished wiring the circuit.)

Press the SPACE BAR when ready
to close the switch.



Lamps 1 and 2 are in PARALLEL,
and lamp 3 is in SERIES with them.



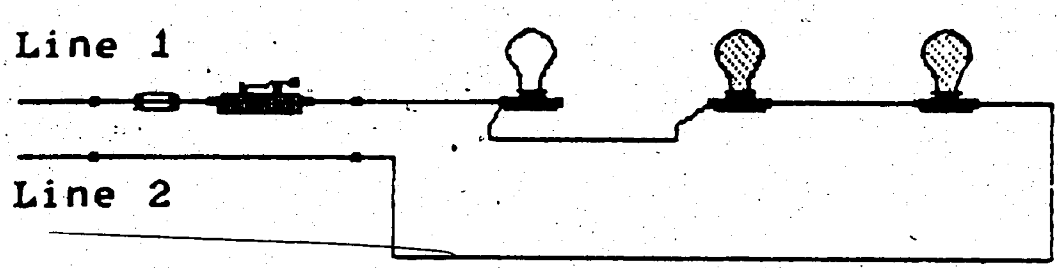
(Press the SPACE BAR to continue)

Challenge: 2 Attempt: 1 Level: 1

Connect a circuit with Lamp 2 and Lamp 3 in SERIES.

Right!

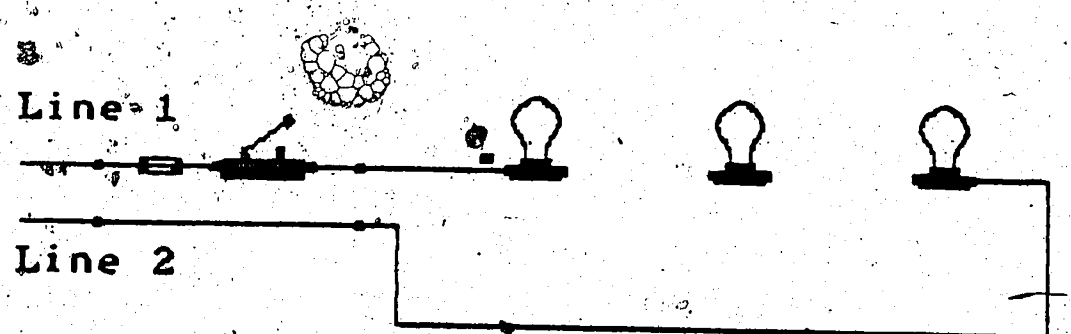
Lamps 2 and 3 are in series.



(Press the SPACE BAR to continue)

Challenge: 7 Attempt: 1 Level: 3

Connect a circuit with Lamp 2 and Lamp 3 in SERIES, and Lamp 1 in PARALLEL with them.



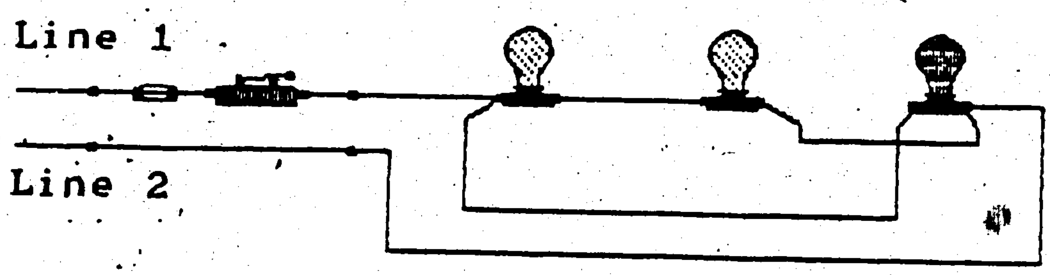
(Press "F" when you're finished wiring the circuit.)

Challenge: 7 Attempt: 1 Level: 3

Connect a circuit with Lamp 2 and Lamp 3 in SERIES, and Lamp 1 in PARALLEL with them.

Sorry!

Lamps 1 and 2 are in SERIES, and lamp 3 is in PARALLEL with them.



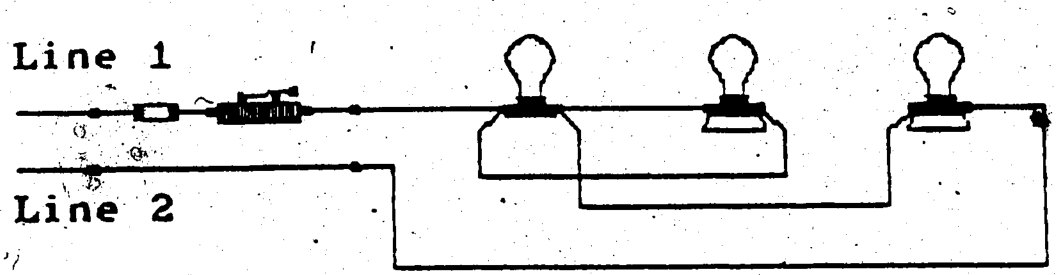
(Press the SPACE BAR to continue)

Challenge: 8   Attempt: 2   Level: 3

Connect a circuit with Lamp 1 and Lamp 3 in SERIES, and Lamp 2 in PARALLEL with them.

Sorry!

You just BLEW the fuse!!!



(Press the SPACE BAR to continue)

APPENDIX D

Attitude instrument comments

Students had the opportunity to respond to the attitude pretreatment instrument and posttreatment instrument in more detail if desired. Few took advantage of this opportunity, and all comments that were received are recorded below.

<u>Pretreatment</u>:

1. A computer is not as good as a teacher: Human input
2. Computers are OK as long as you have a working knowledge of the basics. Since I haven't worked with one, I am unsure. But they are only as smart as the operator and when the operator makes mistakes they can have a profound affect on your life.

<u>Posttreatment</u>:

1. I found the program very basic and therefore rather boring it would be better if it were something that took time to figure out.
2. It would have been better if we had a little more instructional time.
3. I think the computer learning was a good supplement to class learning and would like to use it one period every day.

APPENDIX E

Comments recorded by the observers

Observers recorded some typical comments that were overheard during the sessions. The comments are listed below.

1. Its been a blast!
2. I think that's a good idea.
3. Lets try this.
4. Boy, we screwed that one!
5. That would have worked.
6. Wait a second, I think we should have gone from here to here.
7. Maybe its better to put it in series first.
8. Does that look good to you?
9. Do we have to quit?
10. Can we come back and do this this afternoon?
11. It was really good. I liked it.

APPENDIX F

Definition of terms

In the context of this study, terms which may otherwise be ambiguous have the following meanings:

Computer-assisted instruction (CAI) refers to a form of computer-based education where the student receives instruction or lesson content by means of the computer.

Computer-based education (CBE) refers to any general application of computers in education.

Computer managed learning (CML) refers to a form of CBE where the computer is used to issue appropriate tests and to track the progress of each individual student.

Pair refers to two students grouped together for the purpose of working together on the CAI program.

Pairs refers to the total group of students who worked on the CAI program together with a partner.

Single refers to a student who worked alone on the CAI program.

Singles refers to the total group of students who worked alone on the CAI program.