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STUDENT UTILIZATION OF COMPUTER ASSISTED
INSTRUCTION MADE AVAILABLE IN
ELEMENTARY UNDERGRADUATE MATHEMATICS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
John J. Pfetzing, B.S., M.Ed.

* * * * *

The Ohio State University
1972

Approved by

[Signature]
Adviser

College of Education
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Special appreciation must also go to my wife, Yvonne, and my son, John David, for their continuous support in this endeavor.
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Minor Fields: Mathematics
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I. INTRODUCTION

The first chapter orients the reader to the experiment by giving a background to the study, making a statement of the problem, outlining the experimental procedures and design, and discussing the anticipated outcomes.

A BACKGROUND FOR THE STUDY

The United States has a traditional commitment to mass education. In addition, the President today talks about quality education for everyone. It would appear that educators are charged with the responsibility of teaching masses of people in such a way that each person is afforded the opportunity to reach his full potential.

Large numbers of people have traits in common, but each individual has traits peculiar to him. Thus it would seem that if people are to be educated to the wishes of the President and of society they cannot be handled in an assembly line fashion where everyone is treated alike. Many educators, such as Grace Galton (Galton, 1972), would say that individual differences must be taken into account. To some this might appear as a new phenomenon in education, but it isn't. For example, in 1916 the publisher of the Studebaker Economy Practice Exercises in Arithmetic stated

"With the increasing scientific studies in education, the traditional 'average' child has passed out of existence
and the complexity of the teaching problem has become much more apparent. Consequently educators have ceased their attempts to apply "average" methods of instruction. It is now fully realized that if the processes of education are to yield adequate return for the effort, time and money spent, the extreme and numerous individual differences always present in every class must be recognized and treated." (MacPherson, 1972)

So the recognition and educational implications of individual differences are not new. But what has been done since 1916? Certainly this author has viewed mostly traditional, mass methods of teaching at the several schools where he was employed as a teacher. Most would agree that in most schools, the traditional classroom unit still exists. This is not to say that educators and schools aren't trying to individualize their instruction, but the process does seem to be slow.

At The Ohio State University, though, a new program especially designed for the individualization of instruction is being tried by the Department of Mathematics. This new program, called CRIMEL, attempts to individualize through using different grading procedures, separately paced classes, and multi media teaching resources.

One of the supplementary teaching techniques which could be used in such a project is Computer Assisted Instruction (CAI). Computer Assisted Instruction is considered by many to be an excellent tool for the individualization of instruction (Jerman, 1972). This research study will look at CAI as a possible teaching technique to be used in conjunction with CRIMEL.
PROBLEM STATEMENT

There are several questions to be asked in this study. The preponderance of these questions are aimed at answering one central question. This is: Do students perceive Computer Assisted Instruction as an aid to their learning of mathematics?

The best indicator this experimenter could find of whether or not students viewed CAI as an aid to their learning was to see how many students would continue to use the computer once they had tried it. Another indicator of student interest, but not as strong as the first, was to see how many students would sign up for an additional program.

Using four questionnaires, the experimenter evaluated student opinion of the computer facilities, and made comparisons of three CAI programs.

DESCRIPTION OF THE STUDY

The description of the study is broken down under the headings: the computer programs used in the study; the setting of the study; the treatments in the study; and anticipated outcomes and significance of the study.

The Computer Programs Used in the Study

The research was done using three CAI programs produced by the Department of Mathematics at The Ohio State University. The three programs were produced by three different authors. The first program, on Linear Inequalities (called LINEQ), was authored by this writer;
the second, on Absolute Value (called FREMAT), was authored by a member of the Department of Mathematics; and the third on Functions (called CONFUN), was authored by a graduate student in the Faculty of Science and Mathematics Education. Since these three programs were produced independently, by different authors at different times, the effects observed in the study were not due entirely to the writing abilities of a single author.

All three programs were intended to be used with students in beginning, pre-calculus college mathematics courses. However, the experiment was run in conjunction with a mathematics course for students who were not quite ready for college mathematics. This was done because it allowed the experimenter to have better control of some key variables. Each of the three authors concurred that his program was appropriate for this lower level of mathematical achievement.

The program on Linear Inequalities (LINEQ) was intended to be straightforward, with little typing ability necessary; no non-standard notation was used. In contrast, the program on Absolute Value (FREMAT) was quite sophisticated and involved. Because the keyboard on the terminals did not have symbols used with this area of mathematics, new notation became necessary, and, along with this new notation, a great increase in the student's typing ability was called for. This was primarily due to the amount of backspacing necessary to produce the new symbols which were used in the answers that the students were expected to type. The third program on
Functions (CONFUN) was a sophisticated program, but did not require special typing ability.

Setting

As mentioned above, the experiment was performed in a mathematics course made up of students not quite prepared for college mathematics. The course was taught on television three days a week and recitation classes were held the other two days. The television instructor knew all the details of the experiment, and even tried the CAI programs himself. His cooperation had been fully assured. All the recitation instructors were told about the experiment, and were given an opportunity to try the computer programs if they wished.

The topic of Linear Inequalities was introduced the fifth week of the quarter and was tested on the second examination, the sixth week of the quarter. Absolute value was introduced the sixth week of the quarter and was tested on the third examination in the ninth week. Functions were introduced the ninth week and were tested on the final exam. For a complete schedule of topics and when they occurred see Figure 1.

The Treatments

This study had three treatments with each treatment applied to three classes; hence nine experimental classes were used. The first treatment had students take the CAI program on Linear Inequalities and watch the television lecture on the same topic. The second treatment had students take the CAI program, but not watch the TV
### Figure 1

<table>
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<tr>
<th>Monday</th>
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<td>Recitation</td>
<td>Ineq. and Eqs. with rat. exps.</td>
<td>Recitation</td>
<td>No Class</td>
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<td>Quadratic Ineq.</td>
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<td>Fns and Inverses</td>
<td>Recitation</td>
<td>Review</td>
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lecture. The third treatment had students just watch the TV lecture, just take the computer program, or do both. (See Figure 2).

Figure 2

<table>
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<th>Classes</th>
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<td>X</td>
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<td>9</td>
<td></td>
<td></td>
<td>X</td>
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</tbody>
</table>

The students were randomly assigned to classes, and the nine classes used in the experiment were randomly selected from among the forty-three classes in the course.

All the students who signed up for LINEQ were given a short questionnaire to fill out immediately upon completing the program. The intent was to obtain the immediate reactions of the students toward LINEQ and CAI in general. A comparison of the results of this questionnaire and another questionnaire given later acted as a check on the stability of student responses.
Later, one of two questionnaires was given to each of the students in the experiment. If students took the CAI program they were asked questions concerning how they felt about the program and about the difficulties they encountered. If they did not take the CAI program, they were asked why they didn't and about their feelings toward the course in general. This was done to try to identify the type student who rejected the chance to try this new method.

It was fully explained to the students in the experiment, both verbally and in writing, that these questionnaires were non-threatening. Students were told that none of the recitation instructors, and neither of the two television instructors, would see any results until the course was completed and their grades turned in. They were also informed that telling the things they disliked could be as helpful to the study as telling the things they liked. So in order to be most helpful to the experimenter and the Department of Mathematics they should answer the questions as honestly as they could.

The questionnaires were primarily made up of multiple choice items; however, there were some open ended questions which allowed students to to elaborate upon their feelings.

A week after the topic of Linear Inequalities was covered the students began discussing Absolute Value. All the students in the nine experimental classes were then given the opportunity to take a CAI program on this new subject. This was done to see how many of the students valued the first program enough to try a second. All
students who tried the second program were given a questionnaire concerning their attitude toward, and problems with, this program.

Two weeks after the topic of Absolute Value was introduced, the topic of Functions was begun. At this time all the students in the nine classes were given the opportunity to try a third CAI program, this one on Functions. As before, this was done to see how many of the students valued CAI enough to actually sign up and try a third program.

In the two experimental designs below the symbols used are: R for random selection of students; \( X \) for treatments; and \( O \) for observation. The designs are explained in more detail in Chapter III.

**Figure 3**

<table>
<thead>
<tr>
<th>Design for Counting Students Who Continued to Use CAI</th>
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<tr>
<td>R ( X_1 ) ( 0 ) ( X_4 ) ( 0 ) ( X_5 ) ( 0 )</td>
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<td>R ( X_2 ) ( 0 ) ( X_4 ) ( 0 ) ( X_5 ) ( 0 )</td>
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<td>R ( X_3 ) ( 0 ) ( X_4 ) ( 0 ) ( X_5 ) ( 0 )</td>
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**Figure 4**

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<th>Design for Measuring Attitude Through Questionnaires</th>
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<td>R ( X_1 ) ( 0 ) ( 1 ) ( X_4 ) ( 0 ) ( 2 ) ( X_5 ) ( 0 ) ( 3 ) ( X_6 ) ( 0 )</td>
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<td>R ( X_2 ) ( 0 ) ( 1 ) ( X_4 ) ( 0 ) ( 2 ) ( X_5 ) ( 0 ) ( 3 ) ( X_6 ) ( 0 )</td>
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*Note: This design will be explained in detail in Chapter III; however, the reader should be aware that treatments \( X_5 \) and \( X_6 \) are
applied to only a portion of the original groups randomly selected.

Anticipated Outcomes and Significance of the Study

It was hoped that a large percentage, at least half, of the students would continue to use CAI once they tried it. In addition, the researcher tried to measure the attitude of the students toward CAI by having the students respond to questionnaires, and by frequently visiting the classrooms. During the classroom visits the researcher would encourage the students to express their feelings about what they were doing and to ask whatever questions they wished.

Although the study was primarily concerned with attitude toward CAI, this was not the sole concern. It was possible that a student might have an extremely positive attitude, but that the CAI program not be academically beneficial. For this reason a test was used to decide whether the first program was interfering with the student learning. To do this, four questions concerning Linear Inequalities which appeared on the second midterm examination were graded for each of the three groups plus a fourth group of three classes, randomly selected, to act as a control. A Chi Square test was performed to determine if a significant difference between the groups existed at the 5% level.

A correlation was run on the responses to the six questions common to the two questionnaires on LINEQ. A high correlation would imply few changes of opinion occurred over a time span. This should help assess the stability of the two questionnaires.
Lastly a comparison of the grade distribution of all students and of CAI students was made to see whether the distribution of CAI users differed measurably from the distribution of the whole group.

Chapter II reviews the literature closely related to this study. Chapter III gives an account of the development of LINEQ, and presents the details of the experimental procedures. Chapter IV is a presentation of the data collected and an analysis of that data. The last chapter, Chapter V, gives conclusions, implications, and suggestions for future study.
II. REVIEW OF LITERATURE

Chapter II will review some of the more recent literature closely related to four areas. The first area is basic to this study, that is, the individualization of instruction. The second area is the use of CAI as a learning media. The third area is student and teacher attitude toward CAI, and the fourth area is concerned with some of the problems of implementing CAI into an educational system.

Should the reader want a more complete review of the last three topics, namely those directly related to CAI, it is suggested he look at a recent dissertation Computer-Oriented Instructional System for Teaching Analytic Geometry by Robert Jurick (Jurick, 1972). For a closer look at individualized instruction the reader might want to see The Mathematics Teacher, May 1972, (White, 1972; Indelicato, 1972; MacPherson, 1972), The Arithmetic Teacher, January 1972, (Trafton, 1972; Graham, 1972; Herdmon, 1972; Galton, 1972), and Perspectives in Individualized Learning (Weisgerber, 1971).

INDIVIDUALIZATION OF INSTRUCTION

"Each student has a particular level of ability, achievement, and motivation. None of these three characteristics is less significant than the other" (Graham, 1971). Thus there are individual differences among students which would cause them to progress at
different rates. But individualized instruction is more than this, and should be considered as a point of view towards pupils and their learning (Trafton, 1972). Each student need not always be engaged in a separate activity, but an assessment of each student's needs is important. With a combination of group activity and individualized activity a successful program can be produced (Galton, 1972).

Accompanying the individualization of instruction are different modes of instruction. But what does a different mode of instruction allow? "What any mode of instruction really does is permit a child to learn what he can learn that way, teach him to learn that way, and at a rate possible for that mode of instruction." (MacPherson, 1972). It would seem then, that different modes of instruction are desirable from the standpoint that if a student doesn't learn from one mode he has alternatives available to him.

A strong case can be made for the necessity of individualized instructions within an instructional program (White, 1972; Indelecato, 1972; Weisgerber, 1971). As evidence of the extent to which educators are concerned about individualized instruction, a special evaluation model has even been developed (Emrick, 1969).

One form of individualized student learning which holds great promise is computer assisted instruction (Ianni, 1970).

**CAI AS A LEARNING MEDIA**

CAI is not a passing fancy. It is a proven method of instruction which has the possibility of being an excellent teaching aid.
"CAI is here to stay as a viable means of individualizing instruction. Costs will go down ... There is no doubt in my mind that the computer will prove to be the greatest teaching aid we ever had," (Jerman, 1972).

Suppes describes three levels of CAI. The first is drill and practice. The second is tutorial and the third is dialogue with the computer (Suppes, 1968). A true dialogue CAI system is not available at the present nor is it expected in the near future (Jerman, 1972). However, there are many programs written on the tutorial level and they have been shown to be useful in concept learning (Dick 1970; Majer 1970). The results of studies do not show the best way to use CAI in concept learning. (Schoen, 1971) But studies show drill and practice as a useful tool in learning (Suppes, 1968; Hartman, 1967).

On achievement, most studies have shown either no significant difference or a significant difference in favor of the CAI group. An example of this is a project done by Bitter where in a calculus course, homework was done by CAI and a significant difference in favor of the CAI group was found (Bitter, 1970).

**TEACHER AND STUDENT ATTITUDE TOWARD CAI**

Teacher changes of attitude toward individualized instruction that accompany the use of CAI within the classroom are contingent upon what system is used and how long the program takes. Programs on an efficient system that minimize the amount of class time required produced more favorable changes toward individualized instruction (Hansen, 1968).
It might be that teacher training in the use of the computer is a necessity for achievement and acceptance.

"In every case that I know of over the past five years, when teachers have been provided with an adequate workshop in which they were given training in the use of the CAI system their students were going to use, when they had experience in preparing objectives and planning the year's work, and when they had taken time to re-examine the mathematics involved, then the students in their teacher's classes have made significantly greater gains in achievement than did students in their control groups. This has been particularly true with drill and practice programs. Teachers are inclined to accept and use something with which they are familiar; their acceptance of CAI has been exceptionally good when well-planned workshops have been given. The opposite is true, however, when there have been either no workshops or poorly conducted workshops. In these cases it has been reported that the teachers do not coordinate the CAI program with other instruction and the students give no evidence of making significant gains in achievement." (Jerman, 1972).

Well, if workshops and careful planning affect teacher acceptance and student performance then the reader might ask if they also affect student acceptance.

"Students do accept CAI. But this acceptance must be backed up with carefully coordinated classroom work or CAI can soon become a thing students do to get out of the regular class. Students like CAI. This is well documented. But, they may not see any connection between what they are doing in the CAI program and what they are doing in the classroom unless the teacher has done some careful advance planning and coordination." (Jerman, 1972).

In a study done by Melnick titled "The Effects of a Short Computer Course on Attitude Toward the Computer", there was no significant difference in the amount learned or the ease of understanding. But, the students using the computer had a more favorable attitude toward the computer than those not using it. The experimental group
also thought the computer to be more interesting than the traditional methods. (Melnick, Murry, and others; 1969).

An interesting transfer of attitude was suggested in a study done for the Board of Education of Montgomery County in Rockville, Maryland.

"Since fewer favorable attitudes toward mathematics were expressed by the non-CAI group, and because the CAI group's experiences were primarily in the subject area of mathematics, it is possible that there may be a direct transfer of attitudes in these two categories." (Dunn and Wastler, 1972).

Also in the Dunn and Wastler study the students ranked seven uses of the computer as to preference. The following is in the students' preferential order.

1. to learn new material
2. to practice on difficult material
3. to review old material
4. to do computations
5. to take tests
6. to write programs
7. to play games

PROBLEMS OF IMPLEMENTING CAI INTO A SYSTEM

The first source from which difficulties can arise is the CAI facilities.

"... many who have tried to program CAI units have found that the hardware (i.e. the computer itself, the terminal, and/or the programming language) seems incapable of doing all the programmer wishes." (Kalin, 1969).
In science and mathematics special symbolization, exponents, and
subscripts are often used. Since a standard terminal keyboard
doesn't allow for the use of these things the programmer at times is
limited in what he can write. So for efficient use of the facilities
"The instructional terminal should be adequate to present the desired
content in the desired format." (Jerman, 1972).

There sometimes is non acceptance of CAI because of the over-
emphasis of individualized instruction. This problem is presented
by Kalin:

"... the trouble may not arise so much from the limitations
of CAI as from the blindly complete commitment of some of
its advocates to individualize instruction alone. There
seems little doubt that improved learning would result from
an appropriate balance of group and individualized
instruction ...". (Kalin, 1969).

"Educators are often as guilty as computer salesmen when it comes to
overselling their colleagues on the potential benefits of CAI."
(Jerman, 1972).

With today's budgetary problems, the cost of an instructional
aid cannot be ignored. According to the cost estimates of Kopstein
and Seidel the instructional costs of CAI as compared to Tradition-
ally Administered Instruction (TAI) are quite different for colleges
as compared to elementary and secondary schools. In elementary and
secondary schools the TAI costs total $.35 - $.36 per student hour
as compared with $3.73 per student hour for CAI. In the case of
higher education the cost difference not only is less but may actually
favor CAI. In this case the TAI costs rise to $2.76 per student hour
whereas the CAI costs are $2.61 per student hour. Should the reader want to know more about the costs of TAI versus CAI, it is suggested he read the paper by Kopstein and Seidel as it is one of the most comprehensive articles found by this researcher. (Kopstein and Seidel, 1969).

The cost in developing a CAI curriculum is approximately $6000 per student hour (Hansen, 1968). For the next ten years, it will be prohibitively expensive for students to receive a major part of each day's instruction by the computer (Coulson, 1970).

Educational institutions must weigh a multitude of factors in deciding if, how, when, and how much CAI is to be included in their learning resources. MacPherson illustrates some of the cost questions to be considered.

"Computers are expensive. Storing data in computers is expensive. Storing more data is more expensive. Teletype terminals cost money. More sophisticated terminals cost a lot of money. There is no question but that a massive infusion of CAI would make individualization more feasible. But so would a major reduction in student teacher ratios. So would a quadrupling of funds for supplies and resource materials. It is unrealistic to propose any of these while not asking who is going to pay for them. Where computers are involved, we must persist in asking what the whole system is going to cost to run, even after development costs are written off." (MacPherson, 1972).

The reader has seen in this chapter what some of the more recent literature has to say about four areas related to this study. Chapter V will compare some of the results of this study with those described in the literature.
III. EXPERIMENTAL PROCEDURES AND DESIGN

In this chapter, following a restatement of the problem, a discussion is presented concerning the writing and programming of LINEQ, and the procedures used in performing the experiment.

Using LINEQ, FRBMAT, and CONFUN, three CAI programs developed by associates of the Department of Mathematics, an experiment was designed to try to determine whether or not students would continue to use CAI once having tried it. In addition, the attitude of these students toward this type of CAI was measured through questionnaires, and a test was designed to see if the first of these programs had any detrimental effect on the students.

If students showed a desire for such programs, then CAI could be beneficial as one of the multimedia techniques used in the CRIMEL project. But before any great quantity of time and money is spent toward further development, an evaluation of whether students perceive this type of CAI as beneficial enough to warrant their actually using it should be made.

THE DEVELOPMENT OF LINEQ

Starting in the Autumn of 1970 a CAI program on Linear Inequalities, called LINEQ, was written in the IBM language of Coursewriter III. The program was written in the tutorial mode for the IBM 360 computer. Remote access to the computer was obtained through the use
of IBM 2741 terminals. The terminals were located in various buildings throughout the Ohio State campus. The location of the computer itself was on the West Campus of The Ohio State University.

A programming function which would allow better utilization of computer storage space by permitting forty-eight students to register under one student number was used. This Coursewriter facility is called the RMP function. Although this function was not necessary for the experiment, it will be beneficial if this program is ever used with a large number of students.

LINEQ was intended to be one hour in length with a minimal amount of typing ability necessary for the student. The inputting of this program into the computer was done by the aide of the CAI department and the writer of LINEQ. The aide was a student in the Dental School who worked part time for the office of computer assisted instruction.

The Time Involved in Producing LINEQ

The initial writing and input of the course took approximately two hundred hours. To this time the revisions, additions, and debugging added about four hundred fifty hours. Most of this time was spent in debugging as the desire was to have zero-defects in the program. Should a more experienced team of two write and input a similar program the total of six hundred fifty hours would be substantially reduced. Both the aide and experimenter were new at using Coursewriter with the result that many hours spent in learning.
They estimate that a new course could be written in about two thirds the time, even aiming at a zero defects program.

Procedures Used in Debugging

As the writing and input progressed, pilot runs of what was on the computer were initiated. After each student ran those portions of the program completed, he returned the printed copy of what he had done along with comments written in the margin. Also, each of these students were met individually to try to obtain an even better feeling for his likes and dislikes relative to the program. This procedure was very useful in that not only were many program errors caught quickly, but changes in the presentation were made on the basis of suggestions and comments of students. The changes in presentation were primarily due to two factors. The first was the clarity of the program itself. To the writer of the program each piece of output from the computer to the student was explicit and understandable. The student, however, did not always perceive this output in the same manner. The second factor involved the programmed learning aspect of CAI. Each question should follow logically from the preceding, but for the student this was not always the case. Occasionally a question would appear to be completely unrelated to the material preceding it.

In addition to the use of students in debugging, the CAI aide and the experimenter spent a considerable amount of time themselves trying to find programming errors. After each section was inserted into the computer, all the anticipated and some unanticipated
responses were tried.

It was certainly easier to make program changes as the need for them occurred rather than after the complete program was written. As a matter of fact, these changes were kept in mind as the later parts of the program were written.

As mentioned previously, programmed learning is a major part of CAI. It was therefore necessary to take a close look at the jumps made from question to question. The goal in this area was to have the average student answer correctly eighty-five to ninety per cent of the time. This goal was, for the most part, attained due primarily to the help of the volunteer students making pilot runs. Approximately twenty students were used before completion of the program.

After the program was in its final form, ten students and former students of the experimenter were asked to try it. The mathematical ability of these students ranged from poor to excellent. As before, their criticisms were asked for, and received. Only minor changes resulted from the comments of these ten students. Perhaps it should be noted that changes were not necessarily made because a criticism was noted. All criticisms were carefully considered though to see if changes should be made.

Approval for the Use of LINEQ with Classes

Upon the completion of all changes and testing, LINEQ was presented to the CAI office at Ohio State for its approval. A member
of the CAI department tested the program and gave his approval in the form it stood.

Originally, the experiment was to use six classes with thirty to thirty-five students in a class. From this, the anticipated maximum number of students involved would be two hundred. After the program had been completed, debugged, and approved, the coordinator of CAI at Ohio State decided that too much computer storage space would be used if two hundred students were used in the experiment. Since the design of the experiment was already approved, an argument was made to keep this design as it stood. As will be seen later, this turned out to be unnecessary. The CAI coordinator, to insure efficient use of the computer, refused to allow the experiment and program to run in its completed form. A compromise was reached where the BMP function would be inserted into the program. This would be done by one of the CAI staff so no extra programming on the part of the author would be necessary. The BMP function would allow up to forty-eight students to use a single student number. Some experimental information would be lost, but this information was not critical to the experiment.

**Difficulty Programming the BMP Function**

The insertion of the BMP function was to be completed in four days, and the program to be used by the students in three weeks. Unfortunately, the insertion was not completed until a full week after it was to be done.
While checking the program after the addition of the RMP function, many parts of LINEQ were found not to be running properly. One week was spent trying to find the programming errors. Some of the minor troubles were corrected; however, the major one which randomly seemed to have a large section of the program skipped, still existed. One of the advisors of this dissertation suggested removing the function since the time until students would be using the program was so short. It was felt by the researcher that this could have put the program in even worse shape because numerous inter-related changes had been made. The week before the program was to run, a switch, not allowed with the RMP function, was found still in the program. By changing to an allowable switch the program appeared to run correctly. Two days of testing with students yielded no new errors, but the researcher would have liked another week of testing. Luckily, LINEQ did run correctly during the experiment.

EXPERIMENTAL PROCEDURES

The Design

Within the experiment two studies were being conducted. The first was to see how many students continued to use CAI once they tried it. (See Figure 5). The second was to evaluate the CAI programs, evaluate the CAI facilities, and measure the general attitude of the students toward CAI. (See Figure 6).
Random selection of subjects.

Observation of counting the number of students taking the program.

X1: Students are forced to watch the television lecture and take the CAI program on the topic of linear inequalities.

X2: Students are forced to take the CAI program and not watch television on the topic of linear inequalities.

X3: Students are allowed to watch the television lecture or take the CAI program or do both on the topic of linear inequalities.

X4: Students are given an opportunity to take a CAI program on the topic of absolute value.

X5: Students are given the opportunity to take a CAI program on the topic of functions.

* Note: Treatments X5 and X6 are applied to only a portion of the original groups randomly selected.
O₁: Observation made by one of four questionnaires
     \( i = 1,2,3,4 \).

\( X_1 \): Students are forced to watch the television
         lecture and take the CAI program on the topic
         of linear inequalities.

\( X_2 \): Students are forced to take the CAI program
         and not watch television on the topic of
         linear inequalities.

\( X_3 \): Students are allowed to watch the television
         lecture or take the CAI program or do both on
         the topic of linear inequalities.

\( X_4 \): A time interval between observations.

\( X_5 \): Students are given an opportunity to take a
         CAI program on the topic of absolute value.

\( X_6 \): Students are given the opportunity to take a
         CAI program on the topic of functions.

Selection of Treatment Groups

An attempt to randomly select students for the three experimental
groups was made in the following manner. At each class hour when the
students were to take mathematics recitation, they reported to the
TV instructor's office where he assigned them to a recitation class
by giving them an admission card. In an effort to randomize the
students among the treatments, the admission cards were arranged
alternately by classrooms. Every class was given a number, 1 through
\( 43 \), and a table of random numbers was used to select the six classes
to be used in the experiment. Upon finding the sizes of the classes
were from half to two thirds the expected size, three more classes
were included in the experiment. The selection of these three classes
was not completely random due to time constraints imposed upon the
experimenter at this stage. The time constraints were due to
teaching duties that conflicted with recitation class meetings.
Although none of the recitation times were eliminated, those recita-
tion classes too far from the experimenter's own class were not
included in the selection process for picking up the three additional
classes because it was felt the researcher could not adequately meet
his teaching responsibility and meet the recitation classes as often
as necessary if they were not relatively close to each other. Since
there was no reason to believe one recitation class to be better or
worse than any other, no bias should enter into the experiment due
to the elimination of some classes. This double selection process
resulted in the following nine classes being used:

1. Time
   a. One class at eight o'clock.
   b. Two classes at ten o'clock.
   c. Three classes at twelve o'clock.
   d. One class at three o'clock.
   e. Two classes at four o'clock.

2. Instructors
   a. Eight different instructors taught the nine classes.
   b. Of the eight instructors seven were teaching associates
      and one a full time faculty member of the Mathematics
      Department.
   c. Of the seven teaching associates, five were mathematics
      majors and two were mathematics education majors.
   d. The one instructor who had two experimental sections
      was a mathematics education major.
   e. Of the eight recitation instructors, five were male
      and two female.
   f. The full time faculty member was female.

As was shown in Figure 2, there were three experimental groups
with each consisting of three classes. The first group was required
to watch the television lecture and take the CAI program over the
topic of linear inequalities. This will be called group A. The
second, called group B, took only the CAI program, and the third,
group C, had a choice of doing either or both.

Instructor Involvement

In order to insure that the students in the second group were
not being unjustly affected by only taking the CAI program, the
television instructor and coordinator of the course took the
computerized program himself. He not only approved the program but
said he felt it went into greater depth then he would go on
television. In addition to obtaining the television instructor's
approval, each of the recitation instructors, whose classes were
selected, had the experiment explained to him and was given the
opportunity to try the program. Each recitation instructor was also
given the opportunity to remove his class from the experiment. None
did, and four of the eight instructors tried the computer program
themselves. None of the instructors had ever tried a CAI program
before this time, and all but two appeared to be apprehensive about
having anything to do with computers themselves. All four instructors
who ran through LINEQ became enthusiastic about the experiment and
the potential uses of CAI. This was demonstrated by the manner in
which they encouraged their students to try it. They were also able
to answer questions their students had about what might happen while
working with the computer. The other four instructors who did not
try the program appeared to take a more neutral stand toward the
whole project.

The Questionnaires

There were five questionnaires involved in the experiment. (See Figure 7). They were designed to determine the attitude of the students toward CAI, and to try to evaluate the procedures used by the students in running a CAI program. The use of each will be explained later in this section.

To help insure the content validity of the questionnaires two precautions were taken:

1. All the questions were direct in nature. That is, if the experiencer wanted to know how a student felt about something he simply asked the student his feeling or opinion.

2. Expert review was used. The persons examining the questionnaires were three faculty members from The Ohio State University. Two were from mathematics education and one from mathematics.

In an attempt to secure valid responses to the questionnaires, the students were informed both in writing and verbally by the researcher that their responses would in no way affect their grade; that the researcher was the only person who handled the questionnaires during the quarter; and that none of the recitation instructors nor the television instructor would be allowed to see any of the results until the course was completed and grades turned into the Registrar. In addition to these precautions it was explained that there were no correct or incorrect answers to the questions. The objective was to find information; not to justify preconceived notions.
The first questionnaire was to be answered immediately after a student completed the linear inequalities program (LINEQ). (See Appendix A) Its purpose was to obtain an immediate reaction upon completion of the program. After everyone had been given ample opportunity to attempt the program, approximately ten days, two other questionnaires were handed out in the classes. One of these questionnaires was for those students not trying the CAI program. (See Appendix B) It asked why they had not tried it, and their attitude toward the course in general. The other questionnaire was for those students who had tried LINEQ. (See Appendix C) It asked questions like those in the first questionnaire to try and see if there were changes of opinion. In addition, other questions were asked to get a more detailed picture of the students' likes, dislikes, and problems in using a CAI terminal and running LINEQ.

A fourth questionnaire, similar to the third, (See Appendix D) was given to students completing the program on absolute value, called FREMAT. The final and fifth questionnaire, similar to the third and fourth, was given to students completing the last program on functions. (See Appendix E) The name of the program on functions was CONFUN.

Figure 7
Questionnaires

<table>
<thead>
<tr>
<th>Number</th>
<th>Answered by</th>
<th>Concerned with</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Students who took LINEQ</td>
<td>Immediate reaction to LINEQ</td>
</tr>
</tbody>
</table>
Class Visitations

The first visit to the classes involved in the experiment was during the fourth week of the quarter. During this visit the experiment was explained to the students in the following manner. They were told that the Mathematics Department was trying to determine if it should spend the time and money necessary to develop CAI programs of the nature of LINEQ; that the students could help us in making correct decisions concerning the future of CAI by their involvement in the experiment and by filling out a questionnaire after having tried the program. It was explained that the only way a true picture of the situation could be obtained was through their answering the questions as honestly as they could; that negative responses were as important as positive ones if that was in fact the way they felt.

In addition to their helping the department it was hoped the computer program would aid the students in understanding some of the material in their mathematics course. The design of having three experimental groups for the first program was explained and they were then told what group they were in.
The only group the experimenter feared might balk at the idea was the one that was to watch the TV lecture and take the computer program. There was an overall sigh of disappointment from each of the three classes in this experimental group when told of this. After a more involved discussion about the experiment, the students expressed the thought that perhaps they might be in the best position for answering questions on the test since they would have seen the material twice.

The group using CAI only had a few objections about not being able to watch the television. Some were afraid that they might be at a disadvantage on the test since some of the test questions might not have been covered by the computer. This objection was easily handled by assuring them that the television instructor had taken the program himself, and informed the researcher all possible test questions were covered by the computer program. The students were also told that if they still were unsure to talk to the television instructor about their apprehensions. None did.

The third group, who had a choice of TV or CAI, or both, reacted primarily with the notion of being happy to be able to miss a TV lecture, and do something different in its place.

In addition to an explanation of the experimental design for the first part of the experiment, the students were given instructions on how to turn on the terminals, and tie in with the computer. Along with this explanation a list of terminal locations and times they could be used was supplied. Finally, the students were told that two other CAI programs would be made available to them on a
voluntary basis later in the quarter.

The overall reaction of most of the students seemed to be a willingness to participate along with a slight fear of the computer. Because of this initial fear and in order to be available for possible questions, all the classes were visited twice a week.

On the second visit to the classes, it was found that about ten percent of the students who were to use the computer had done so. None of the optional group had tried it. There were no problems other than one student who had difficulty signing on.

Another programmer/author who had done a CAI study the quarter before had forewarned this researcher of the possible difficulty of getting students to the terminals. With this in mind it was not really surprising to find that by the following week only fifty percent of those needing to use the terminals had done so.

During the class visits encouragement was given to plan ahead in using a terminal because of the possibilities of someone else being on the terminal, all the lines to the computer being tied up, or even possible computer breakdown. But it was, however, becoming easier to find terminals available and computer lines open because two other CAI courses in other departments were ending.

The midterm was on Tuesday and a great number of students used the weekend before to run LINEQ. By the midterm, almost all of the students who were instructed to use the computer had complied with the request. This last minute rush to use the computer has serious implications toward how CAI facilities can best be used, but this will not be discussed here. Such a discussion will appear in
Chapter V.

During the recitation period following the midterm all classes were visited for two purposes. The first was to sign up any students who wanted to try the program on Absolute Value, FREMAT. The second was to distribute questionnaires two and three.

Questionnaire two was for the students who did not try LINEQ. The majority of these students were from the optional group. There were some students, though, from the first two experimental groups who were supposed to try LINEQ, but did not. In this case the student usually was not attending class.

Questionnaire three was for students who took LINEQ and was similar to the first questionnaire but asked more questions. Some identical questions appeared on both questionnaires to see if there were any major changes of opinion after having taken a test over that material.

In signing up for the program on Absolute Value, FREMAT, the students were not overtly encouraged nor discouraged. As far as they knew, these programs were being offered as kind of a reward for what they had done previously.

It was explained to the students that if they did option any of the additional programs they would be asked to fill out a questionnaire similar to the first and third. They were told that was being done to help evaluate the CAI programs the Department of Mathematics currently had available. None of the students objected to doing this.

If a student registered for FREMAT, he was not under any
obligation to use the computer. The object of registering was to give the student a number with which he could get onto the computer. For convenience, if a student registered for FREMAT, he was given the questionnaire concerning this program at the time he signed up.

The experimenter's job at this point became much easier because little more needed to be done than visit the classes, answer questions, and collect questionnaires. The reader should remember that it was spring, with the first nice weather appearing. Fewer and fewer students were attending classes, and fewer people were trying FREMAT than had signed up to do so. This was to be expected though, as a student could sign up even if he was not sure he would be running the program. Both signing up and actually running through the program are indicators of interest in using CAI facilities. One is just a much stronger indicator than the other.

Immediately after the third midterm the students were asked to sign up for the last program on functions, CONFUN, if they thought they might want to try it. In light of the lateness in the quarter and atmosphere of springtime, the experimenter was surprised that as many as forty-seven signed up. This was half the number of students who tried LINEQ. As with FREMAT, the questionnaires for this last program were distributed at the time the students signed up. If this last program were tried after June 3, the students were asked to return the questionnaires to the experimenter's office; otherwise they would be collected in class.

The greatest number of questions the students had at this time were concerned with the sign-on procedure, and if it was the same as
for LINEQ. Unfortunately the sign-on procedures were not the same; however, they were close enough to the original that when supplied with a set of instructions few difficulties were encountered.

As a follow-up to this experiment, during the Autumn Quarter, 1971, students were offered a chance to use LINEQ in conjunction with another course. This course had the same format of TV lectures and recitation classes as the course in which the experiment was performed. The Vice Chairman of the Department of Mathematics and the experimenter were on television Monday, Wednesday, and Friday with recitation classes being held on Tuesday and Thursday. The enrollment of this course was eight hundred four students. When reaching the part of the course dealing with inequalities, the students were told by the experimenter, on television, that there was a CAI program on Linear Inequalities available to them. It was briefly explained what CAI was, and that if they would like to try this program they could sign up for it by stopping by the researcher's office. Only twelve students took the program.

This completes the description of the procedures used in the experiment. In Chapter IV the results of the questionnaires and an analysis of the data will be presented.
IV. DATA

In previous chapters the reader has been introduced to the problem, seen a review of the literature, and looked at the design of the study. In this chapter a presentation is made of the data collected in the study. To organize this presentation the following eight categories are used:

1. Three comparisons: (1) the number of students who signed up versus the number of students who tried the programs; (2) the number of students in each of the three treatment groups who tried the different CAI programs; (3) the number of students who tried an additional program as opposed to what would happen by chance.

2. Comparison of the number of students in each treatment group (and a control group) who answered each of four test questions correctly.

3. List of six questions common to two questionnaires and a correlation of each to check changes of opinion over a time span.

4. Changes of attitude, as indicated by the first questionnaire, about CAI after trying the first program.

5. Favorable and unfavorable responses to each of the programs on three questions common to each of the questionnaires.

6. Grade distribution of CAI students and the entire course population.

7. Responses to the questionnaires.

8. Two open ended questions.
THREE COMPARISONS

In order to measure interest in Computer Assisted Instruction the researcher looked at both how many students signed up for an additional program and how many actually tried it. The reader should be aware that seventy-two of the ninety-four students who tried LINEQ were forced to do so. The table below makes a comparison of the number of students signed up for each program and the number who, in fact, ran it.

Table 1

<table>
<thead>
<tr>
<th>Program</th>
<th>No. of Students Signed Up</th>
<th>No. of Students Using the Computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINEQ</td>
<td>118</td>
<td>94</td>
</tr>
<tr>
<td>FREMAT</td>
<td>46</td>
<td>18</td>
</tr>
<tr>
<td>CONFUN</td>
<td>45</td>
<td>25</td>
</tr>
</tbody>
</table>

The table below is obtained from Table 8 by splitting the number of students who signed up for each program into dichotomous groups of those who went ahead and used the computer and those who did not. This was done so a Chi Square test could be made to see if an unusually high (or low) number of students who signed up, tried the program.
Table 2

<table>
<thead>
<tr>
<th>Program</th>
<th>Used the Computer</th>
<th>Did Not Use the Computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINEQ</td>
<td>94</td>
<td>24</td>
</tr>
<tr>
<td>FREMAT</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>CONFUN</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>

The value of Chi Square obtained was 26.67 and is significant at the .01 level.

In order to see if forcing students to use the computer, in contrast to their using it voluntarily, made a difference in their using it again, a comparison of treatments and programs was made. Table 10 makes a comparison among the treatment groups in the number of students trying each of the CAI programs.

Table 3

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of Students Trying LINEQ</th>
<th>No. of Students Trying FREMAT</th>
<th>No. of Students Trying CONFUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI &amp; TV</td>
<td>33</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>CAI only</td>
<td>39</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>Optional</td>
<td>22</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

To help measure whether any of the treatments caused an unusually high (or low) number of students to try additional programs a Chi Square test was made. The Chi Square value
obtained was 2.1, whereas the critical value at the 5% level and
four degrees of freedom is 9.48. Thus, there was no statistically
significant difference.

The primary question to be asked was whether or not students
would continue to use CAI once they tried it. Of the 94 students
who took LINEQ, 25 elected to try at least one more program and
69 elected not to do so. To try and measure if these numbers are
significant a Chi Square test against pure chance was made.

Table 4

<table>
<thead>
<tr>
<th>Number Trying Additional Program</th>
<th>Number Not Trying Additional Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>25</td>
</tr>
<tr>
<td>Expected by Chance</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>47</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 20.59 \quad p < .01 \]

When compared with pure chance there is a significant difference
in the student's choice of whether or not to try an additional
program.

FOUR TEST QUESTIONS

To help assure that the program LINEQ was not harmful to
students learning the concept of Linear Inequalities, four test
questions on the second midterm covering that concept were graded
for each of the three treatment groups and a control group. Table 12
compares the four groups on the number of correct answers for the four test questions. The entry in each cell is the number correct followed by the percentage correct in parenthesis.

Table 5

<table>
<thead>
<tr>
<th>Group</th>
<th>Test Question</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CAI &amp; TV</td>
<td>28(85%)</td>
</tr>
<tr>
<td>CAI only</td>
<td>32(82%)</td>
</tr>
<tr>
<td>Optional who used CAI</td>
<td>12(55%)</td>
</tr>
<tr>
<td>Control</td>
<td>33(70%)</td>
</tr>
</tbody>
</table>

To check statistically for a difference among the four groups in the learning which took place on the concept of Linear Inequalities a Chi Square test was made. The critical value for nine degrees of freedom and at the 5% level is 16.92. The value obtained was only 2.47. Hence, no statistical difference was measured.

Table 13, below, was obtained from Table 12 by putting together all the CAI students and comparing them to the control group. This was done to more directly compare the CAI students with the regular students.
With three degrees of freedom the probability of obtaining these same results by chance is less than ninety percent. Thus there is no statistical significant difference between the groups and it can be said that CAI neither helped nor harmed the students.

**SIX COMMON QUESTIONS**

The six questions listed below appeared on the first questionnaire, taken immediately upon completion of LINEQ, and on questionnaire three, taken from three days to two weeks after trying LINEQ. Each of the six were correlated for the two questionnaires using the Pearson r. The correlational value for each question is given immediately below the responses.

1. What was your feeling about CAI before taking this course?
   a) Positive 
   b) Slightly Positive 
   c) Neutral 
   d) Slightly Negative 
   e) Negative 
   \[ r = .92 \]

2. What is your feeling about CAI after having taken this program?
   a) Positive 
   b) Slightly Positive 
   c) Neutral 
   d) Slightly Negative
b) Slightly Positive
e) Negative
\[ r = 0.86 \]

3. If you were to give this CAI program a letter grade what would it be?

A B C D E
\[ r = 0.83 \]

4. To what degree was the program a waste of time?

(totally) 1 2 3 4 5 6 7 (not at all)
\[ r = 0.76 \]

5. If there were other CAI programs available from the Mathematics Department would you take them?

yes no possibly
\[ r = 0.57 \]

6. Did the program get you to think?

(not at all) 1 2 3 4 5 6 7 (constantly)
\[ r = 0.75 \]

**ATTITUDE CHANGE**

On the first questionnaire there were two questions concerning the student's feeling toward CAI. The first question asked how he felt before trying the program and the second asked how he felt after having tried it. The table below shows the distribution of answers to the first question (before) and the second question (after).

Table 14 will use the following notation: P - positive, SP - slightly positive, SN - slightly negative, N - negative.
Table 7

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>SF</th>
<th>Neutral</th>
<th>SN</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>21</td>
<td>16</td>
<td>38</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>After</td>
<td>47</td>
<td>30</td>
<td>7</td>
<td>7</td>
<td>3</td>
</tr>
</tbody>
</table>

To measure for a significant change of attitude by the students, after trying the CAI program LINEQ, a Chi Square test was made on the above table. The value obtained was 37.4 and at the 5% level with four degrees of freedom the critical value is 9.49. Thus, there was a significant change of attitude in the positive direction.

FAVORABLE AND UNFAVORABLE RESPONSES

There were three key questions on the questionnaires for each of the three programs. These questions were used to help determine the attitude of the students toward each CAI program. The three questions were:

1. If you were to put a letter grade on the program you just took, what would it be?
   
   A  B  C  D  E

2. To what degree was this program a waste of time?
   
   (total) 1  2  3  4  5  6  7 (not at all)

3. Did the program get you to think?
   
   (not at all) 1  2  3  4  5  6  7 (constantly)

Favorable responses were taken to be:

   A or B in question 1
5, 6, or 7 in question 2
5, 6, or 7 in question 3

Unfavorable responses were taken to be:
D or E in question 1
1, 2, or 3 in question 2
1, 2, or 3 in question 3

Table 8

<table>
<thead>
<tr>
<th></th>
<th>LINEQ</th>
<th>FREMAT</th>
<th>CONFUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favorable</td>
<td>223(79%)</td>
<td>13(24%)</td>
<td>56(75%)</td>
</tr>
<tr>
<td>Unfavorable</td>
<td>26(9%)</td>
<td>40(74%)</td>
<td>9(12%)</td>
</tr>
</tbody>
</table>

The reader should be cautioned at this point that there is a population shift from program to program. In order to answer more important questions this was necessary. The students who tried FREMAT and CONFUN were a subset of the original group who tried LINEQ. In just trying an additional program they demonstrated a positive attitude toward CAI thus could not be equitably compared with the overall population that tried LINEQ.

A Chi Square performed on the above table yielded a value of 111.8. The critical value at the 5% level is 5.99; thus a statistical difference exists. No implication can be made from this difference though.
GRADE DISTRIBUTION

The following grade distribution occurred for the Mathematics course in which the experiment was performed.

Table 9

Grades

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Students</td>
<td>17%</td>
<td>24%</td>
<td>37%</td>
<td>12%</td>
<td>10%</td>
</tr>
<tr>
<td>CAI Students</td>
<td>22%</td>
<td>18%</td>
<td>35%</td>
<td>14%</td>
<td>11%</td>
</tr>
</tbody>
</table>

In order to check whether the grade distribution of the CAI students was unusually dissimilar to the distribution of all the students, a Chi Square goodness of fit test was made. To make this test the percentages in the above table were converted to raw data based on 94, the number of students taking at least one CAI program. The observed row lists the actual distribution of the CAI students, and the expected row lists the distribution as it would have occurred if there were only 94 students and the same distribution percentages for the whole class held.

Table 10

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>21</td>
<td>17</td>
<td>33</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Expected</td>
<td>16</td>
<td>23</td>
<td>35</td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>
With four degrees of freedom and at the 5% level the critical value for Chi Square is 9.49. The value obtained was 3.70 so the two distributions were not measurably dissimilar.

RESPONSES TO THE QUESTIONNAIRES

This last section of this chapter will list each of the multiple choice questions and give the responses that occurred in percentages. The listing will be grouped by questionnaire in the following order:

- Questionnaire I (Answered immediately upon completion of LINEQ)
- Questionnaire III (Answered from three days to two weeks after completing LINEQ)
- Questionnaire IV (Answered from three to ten days after completing PREMAT)
- Questionnaire V (Answered from three to ten days after completing CONFUN)
- Questionnaire II (Answered by students not trying LINEQ)

Questionnaire I

This first questionnaire was given to those students who tried LINEQ and was to be filled out immediately after completing the program. The sample size for this questionnaire was 94.

What was your feeling about CAI before taking this course?

- 20% Positive
- 18% Slightly Positive
- 43% Neutral
- 14% Slightly Negative
- 5% Negative
What is your feeling about CAI after having taken the program?

50% Positive
31% Slightly Positive
7% Neutral
7% Slightly Negative
4% Negative

If you were to give this program a letter grade what would it be?

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>28%</td>
</tr>
<tr>
<td>B</td>
<td>50%</td>
</tr>
<tr>
<td>C</td>
<td>13%</td>
</tr>
<tr>
<td>D</td>
<td>7%</td>
</tr>
<tr>
<td>E</td>
<td>1%</td>
</tr>
</tbody>
</table>

To what degree was the program a waste of time?

<table>
<thead>
<tr>
<th>Degree</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>(totally) 1</td>
<td>2%</td>
</tr>
<tr>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>3</td>
<td>4%</td>
</tr>
<tr>
<td>4</td>
<td>4%</td>
</tr>
<tr>
<td>5</td>
<td>21%</td>
</tr>
<tr>
<td>6</td>
<td>28%</td>
</tr>
<tr>
<td>7 (not at all)</td>
<td>39%</td>
</tr>
</tbody>
</table>

If there were other CAI programs available from the Mathematics Department would you take them?

<table>
<thead>
<tr>
<th>Choice</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>66%</td>
</tr>
<tr>
<td>no</td>
<td>7%</td>
</tr>
<tr>
<td>possibly</td>
<td>27%</td>
</tr>
</tbody>
</table>

Did the program get you to think?

<table>
<thead>
<tr>
<th>(not at all)</th>
<th>(constantly)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4%</td>
</tr>
<tr>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>3</td>
<td>7%</td>
</tr>
<tr>
<td>4</td>
<td>12%</td>
</tr>
<tr>
<td>5</td>
<td>29%</td>
</tr>
<tr>
<td>6</td>
<td>26%</td>
</tr>
<tr>
<td>7</td>
<td>21%</td>
</tr>
</tbody>
</table>

Did you complete the program in one sitting?

<table>
<thead>
<tr>
<th>Choice</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>63%</td>
</tr>
<tr>
<td>no</td>
<td>37%</td>
</tr>
</tbody>
</table>

How difficult was it to get a line into the computer?

<table>
<thead>
<tr>
<th>Difficulty</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Got on the first time</td>
<td>76%</td>
</tr>
<tr>
<td>Had to try 2 or 3 times during the day</td>
<td>15%</td>
</tr>
<tr>
<td>Had to try 4 or 5 times during the day</td>
<td>7%</td>
</tr>
<tr>
<td>Had to try more than 5 times before getting on</td>
<td>24%</td>
</tr>
</tbody>
</table>
What trouble did you have with the system?

7% Signing on - the lines were tied up
39% Signing on - did not use the correct procedure
10% Mechanical failure of the whole system
3% The terminals were in use
10% The terminal typewriter did not work properly
30% Other

What time did you use the terminal?

<table>
<thead>
<tr>
<th>Time</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-10 AM</td>
<td>12%</td>
</tr>
<tr>
<td>10-12 noon</td>
<td>22%</td>
</tr>
<tr>
<td>12-2 PM</td>
<td>26%</td>
</tr>
<tr>
<td>2-4 PM</td>
<td>17%</td>
</tr>
<tr>
<td>4-6 PM</td>
<td>10%</td>
</tr>
<tr>
<td>6-8 PM</td>
<td>6%</td>
</tr>
<tr>
<td>8-10 PM</td>
<td>6%</td>
</tr>
<tr>
<td>10-11 PM</td>
<td>1%</td>
</tr>
</tbody>
</table>

What times would you prefer to use the terminals?

<table>
<thead>
<tr>
<th>Time</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-10 AM</td>
<td>16%</td>
</tr>
<tr>
<td>10-12 noon</td>
<td>26%</td>
</tr>
<tr>
<td>12-2 PM</td>
<td>11%</td>
</tr>
<tr>
<td>2-4 PM</td>
<td>16%</td>
</tr>
<tr>
<td>4-6 PM</td>
<td>8%</td>
</tr>
<tr>
<td>6-8 PM</td>
<td>12%</td>
</tr>
<tr>
<td>8-10 PM</td>
<td>7%</td>
</tr>
<tr>
<td>10-11 PM</td>
<td>0%</td>
</tr>
</tbody>
</table>

Questionnaire III

This questionnaire was also given to students who tried LINEQ, but in contrast to the first questionnaire a time span, which included a midterm, had elapsed from the time the student took the program and answered the questionnaire. The sample size was again 94.

Have you participated in a CAI project before?

yes   no
1%    99%
What was your feeling about CAI before taking this course?

- 20% Positive
- 18% Slightly Positive
- 43% Neutral
- 14% Slightly Negative
- 5% Negative

What is your feeling about CAI after having taken this program?

- 51% Positive
- 32% Slightly Positive
- 10% Neutral
- 5% Slightly Negative
- 2% Negative

If you were to give this CAI course a letter grade, what would it be?

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>25%</td>
</tr>
<tr>
<td>B</td>
<td>50%</td>
</tr>
<tr>
<td>C</td>
<td>17%</td>
</tr>
<tr>
<td>D</td>
<td>8%</td>
</tr>
<tr>
<td>E</td>
<td>0%</td>
</tr>
</tbody>
</table>

To what degree was the program a waste of time?

<table>
<thead>
<tr>
<th>Degree</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>(not at all)</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>1</td>
<td>14%</td>
</tr>
<tr>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>4</td>
<td>10%</td>
</tr>
<tr>
<td>5</td>
<td>13%</td>
</tr>
<tr>
<td>6</td>
<td>36%</td>
</tr>
<tr>
<td>7</td>
<td>31%</td>
</tr>
</tbody>
</table>

If there were other CAI programs available from the Mathematics Department would you take them?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>63%</td>
</tr>
<tr>
<td>no</td>
<td>6%</td>
</tr>
<tr>
<td>possibly</td>
<td>31%</td>
</tr>
</tbody>
</table>

Did the program get you to think?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>(not at all)</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>3</td>
<td>4%</td>
</tr>
<tr>
<td>4</td>
<td>10%</td>
</tr>
<tr>
<td>5</td>
<td>26%</td>
</tr>
<tr>
<td>6</td>
<td>38%</td>
</tr>
<tr>
<td>7</td>
<td>18%</td>
</tr>
</tbody>
</table>

Would you recommend:

- 1% Not making CAI available at all
- 70% Making CAI available, but completely optional
1% Require all students to use CAI
6% Use CAI to introduce new ideas
11% Use CAI to supplement new ideas already introduced by the classroom instructor
11% Use CAI as a review before tests

How long would you prefer to spend at the computer in one sitting?
19% $1\frac{1}{2}$ hour
66% 1 hour
11% 1 $\frac{1}{2}$ hours
2% 2 hours
0% more than 2 hours

Did you feel this program required too much typing ability?

yes no
1% 99%

Which of the following would be the closest to your typing ability?
nonexistent hunt & peck typist
2% 45% 52%

Why did you usually sign off?

6% Mechanical failure
3% Program failure
5% Boredom
31% Lack of time
9% Became tired
47% Finished with the section or program

Estimate the time it took to run the complete program.
10% Less than $\frac{3}{4}$ hour
14% Between $\frac{3}{4}$ & 1 hour
11% Between 1 & 1 $\frac{1}{4}$ hours
30% Between $1\frac{1}{4}$ & $1\frac{1}{2}$ hours
34% Between 1 \frac{1}{2} & 1 \frac{3}{4} hours
1% More than 1 \frac{3}{4} hours

Relative to each other, the usefulness of the methods of instruction.

Method of Instruction

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Most useful</td>
<td>10%</td>
<td>26%</td>
<td>17%</td>
<td>48%</td>
</tr>
<tr>
<td>Second</td>
<td>17%</td>
<td>18%</td>
<td>33%</td>
<td>32%</td>
</tr>
<tr>
<td>Third</td>
<td>22%</td>
<td>39%</td>
<td>28%</td>
<td>11%</td>
</tr>
<tr>
<td>Least useful</td>
<td>51%</td>
<td>17%</td>
<td>20%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Do you feel this questionnaire was:

1% A complete waste of the student's time
31% Possibly of some use, but basically more of the same garbage students get asked to fill out
68% Worthwhile in allowing the student to express his or her feelings about the possible use of new materials

Questionnaire IV

This fourth questionnaire was answered by students trying FREMAT, and had a sample size of only 18. The reader should realize that these students are a special subset of the first group. By their electing to try FREMAT they have already demonstrated a positive attitude toward CAI.

If you were to give the Absolute Value program a letter grade, what would it be?

(excellent) A B C D (failure)
11% 11% 17% 61%
To what degree was this program a waste of time?

(total) 1 2 3 4 5 6 7 (not at all)
56% 17% 6% 6% 0% 11% 6%

Did the program get you to think?

(not at all) 1 2 3 4 5 6 7 (constantly)
56% 6% 6% 6% 0% 11% 17% 6%

Did you feel this program required too much typing ability?

yes no
50% 50%

Why did you usually sign off?

22% Mechanical failure
22% Program failure
11% Boredom
6% Lack of time
22% Became tired
17% Finished with the section or program

Relative to each other, how would you rank the following methods of instruction as to usefulness on the concept of Absolute Value?

Method of Instruction

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Most useful</td>
<td>11%</td>
<td>0%</td>
<td>17%</td>
<td>72%</td>
</tr>
<tr>
<td>Second</td>
<td>6%</td>
<td>11%</td>
<td>61%</td>
<td>17%</td>
</tr>
<tr>
<td>Third</td>
<td>28%</td>
<td>56%</td>
<td>11%</td>
<td>6%</td>
</tr>
<tr>
<td>Least useful</td>
<td>61%</td>
<td>33%</td>
<td>6%</td>
<td>0%</td>
</tr>
</tbody>
</table>
How would you rank the two CAI programs you have taken?

<table>
<thead>
<tr>
<th>LINEQ</th>
<th>FREMAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>More useful</td>
<td>94%</td>
</tr>
<tr>
<td>Less useful</td>
<td>6%</td>
</tr>
</tbody>
</table>

Would you be interested in trying a third type of CAI program?

<table>
<thead>
<tr>
<th></th>
<th>yes</th>
<th>no</th>
<th>possibly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>78%</td>
<td>11%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Questionnaire V

The 25 students who tried CONFUN responded to this fifth questionnaire. As in the previous case these students form a special group in that they have displayed a positive attitude toward CAI just by being willing to try this last program.

If you were to give the Functions program a letter grade, what would it be?

(excellent) A  B  C  D  E (failure)  
13%  71%  13%  4%  0%

To what degree was the program a waste of time?

(total) 1  2  3  4  5  6  7 (not at all)
0%  8%  8%  4%  24%  32%  24%

Did the program get you to think?

(not at all) 1  2  3  4  5  6  7 (constantly)
0%  4%  12%  20%  16%  28%  20%

Did you feel the program required too much typing ability?

<table>
<thead>
<tr>
<th></th>
<th>yes</th>
<th>no</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Why did you usually sign-off?

31% Mechanical failure
0% Program failure
0% Boredom
50% Lack of time
19% Became tired
0% Finished with the section or program

How difficult was it to get a line into the computer?

67% Got on the first time
29% Had to try 2 or 3 times during the day
0% Had to try 4 or 5 times during the day
4% Had to try more than 5 times before getting on

What trouble did you have with the system?

0% Signing on - the lines were tied up
27% Signing on - did not use the correct procedure
53% Mechanical failure of the system
7% The terminals were in use
13% The terminal typewriter did not work properly
0% Other

Relative to each other, rank the usefulness of the following teaching methods in learning about Functions.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Most useful</td>
<td>10%</td>
<td>24%</td>
<td>19%</td>
<td>48%</td>
</tr>
<tr>
<td>Second</td>
<td>14%</td>
<td>43%</td>
<td>5%</td>
<td>38%</td>
</tr>
<tr>
<td>Third</td>
<td>19%</td>
<td>24%</td>
<td>52%</td>
<td>5%</td>
</tr>
<tr>
<td>Least useful</td>
<td>52%</td>
<td>14%</td>
<td>24%</td>
<td>10%</td>
</tr>
</tbody>
</table>
How would you rank the three CAI programs you have taken?

<table>
<thead>
<tr>
<th></th>
<th>LINEQ</th>
<th>FREMAT</th>
<th>CONFUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best</td>
<td>68%</td>
<td>4%</td>
<td>28%</td>
</tr>
<tr>
<td>Second</td>
<td>32%</td>
<td>4%</td>
<td>64%</td>
</tr>
<tr>
<td>Last</td>
<td>5%</td>
<td>80%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Do you think the Mathematics Department should invest more time and money in developing additional CAI programs?

Yes 100%  No 0%

Questionnaire II

This questionnaire was administered to those students who did not try LINEQ. The sample size here was 45.

Do you attend the TV lecture:

- 47% Always
- 38% Frequently
- 7% About half the time
- 7% Infrequently
- 2% Never

Do you attend recitation class:

- 42% Always
- 42% Frequently
- 7% About half the time
- 9% Infrequently
- 0% Never

Do you consider Math 101 to be:

- 11% A very good course
36% A good course
29% An average course
20% A poor course
4% A complete waste of time

Do you consider requests such as being asked to try a CAI program:

13% Reasonable and should be done by the student
84% Reasonable but the choice of doing it left up to the student
24% Unreasonable

TWO OPEN ENDED QUESTIONS

Appearing on the questionnaires for each of the three programs were two open ended questions concerning the student's likes and dislikes of the program. These two questions were:

What did you like most about the program?
What did you like least about the program?

LINEQ

The most positive statements about the program were of the nature "liked the whole thing." More specific items that students thought were good are: the solutions to problems missed; the immediate response of the computer; the allowing of a student to take as much time as needed; a chance to work numerous examples; the forcing of students to interact with the material; and a chance from the television lecture.

The most often mentioned negative aspect of this first program was not really a fault of the program but was a psychological problem of the bouncing ball typing so rapidly that it made the
student quite nervous. Some of the students thought: the program was too long; the sign-on procedure was too complicated; some of the responses were too personal; and, like the common objection to TV, students cannot ask questions at that time.

FREMAT

There were no positive responses to the question concerning things students liked about the program.

The dislikes were: the program was too long; too much notation; could not understand the questions; and too much typing skill required.

CONFUN

The thing most liked about this program on Functions was the ability of the student to pick whatever section he wanted to study. In addition, students thought the following items were good about this program: at the end of a section the number of correct and incorrect answers were told to the student; mistakes on a missed problems were shown; and the length of each section. Also, several students commented that they thought the explanations were easy to follow.

On the negative side: some of the comments were not appreciated; there were too many additional problems if one was missed; and the time was too long.

This concludes the presentation of data. In the final chapter the reader will first find a summary of the study. This is followed by the conclusions and observations of the researcher along with a discussion of each.
V. SUMMARY, CONCLUSIONS, AND IMPLICATIONS FOR FUTURE RESEARCH

Chapter five will first give a summary of the experiment and then present the conclusions and a discussion of the conclusions based on the results of Chapter IV. Following this will be a presentation of the observations of the researcher and a discussion of these observations. Last will be implications for future research.

SUMMARY

A CAI program dealing with the concept of Linear Inequalities, LINEQ, was produced to be used with two other CAI programs in an experiment to see if students would continue to use CAI once having tried it. The two other programs were FREMAT, a program about Absolute Value; and CONFUN, a program dealing with Functions.

In the experiment there were three treatment groups. The first group was forced both to use LINEQ and to attend TV lectures in studying Linear Inequalities. The second was forced to use only LINEQ in covering the topic, and the third was allowed to do either or both. Later in the course all the students in the experiment were given the opportunity to try FREMAT, and after that to try CONFUN.

In addition to seeing how many students continued to use the computer, questionnaires were presented to the students at various times to try to measure their attitudes toward CAI in general and the programs in particular, and to help evaluate the CAI facilities. The questionnaires were answered immediately after the first program,
just before the second program, after the second program, and after the third program.

The experimenter visited the classes frequently during the quarter to sign up students for the various programs, pass out questionnaires, answer any questions students had about the experiment, help the students if they had difficulties, and to gather impressions of how the students were reacting to the various programs.

The complete experimental design was presented in Chapter III, and the statistical analysis along with the responses to the questionnaires were given in Chapter IV.

CONCLUSIONS

No conclusions were reached about the non CAI users in the experiment. Five conclusions that resulted from the study concerned students who tried one or more of the CAI programs. For convenience these are first listed and then discussed.

1. There was no significant difference among the three treatments in the number of students who optioned to try an additional program.

2. Comparing the three programs there was no significant difference between the number of students who signed up and the number of students who then actually tried the program.

3. There was a significant difference in attitudes toward CAI, after having tried the first program. The shift in attitudes was in the positive direction.

4. There was no significant difference among the treatment groups
and control group in the number of correct answers on the four
test questions dealing with Absolute Value.

5. There were high positive correlations for five of the six
questions common to the two questionnaires concerned with the
first program. The sixth question gave a moderately high
correlation.

DISCUSSION WITH COMMENTS ON THE CONCLUSIONS

Of the 94 students who ran LINEQ, 18(19%) also tried FREMAT and
25(26%) tried CONFUN. Whether or not this is a sufficient number,
or percentage, of students to warrant further investment in this
type of CAI is a question that can only be answered by the decision
makers of the Department of Mathematics. Such a decision would,
presumably, be made on a cost/benefit ratio. With CAI, cost becomes
a much more important question than with most other teaching aids
because both the initial and maintenance costs are relatively high.

It would appear that just the fact of trying a CAI program
produces a positive change in attitude; however, the indicated change
in attitude is not strong enough to attract a majority of the students
to actually use the computer again. The reader might also question
whether the percentages of students continuing might not have been
lower if the experimenter had not visited the classrooms frequently.
Although the students were not overtly encouraged nor discouraged,
just the presence of the experimenter might have made a difference.

There was no significant difference among the three treatment
groups as to the number of students willing to try an additional
program. So there is no evidence in this study to indicate that
forcing a student to take a CAI program had any effect on his trying another.

Although there was no significant difference among the treatment groups and control group in the number of correct answers on any one of the four test questions, it is interesting to note that the CAI and TV group always had the highest percentage of correct answers. Second highest was always the CAI-only group.

Five of the six questions common to the two questionnaires on LINEQ had correlations of .75 to .92. The other question had a correlation of .57. These correlations, significantly different from zero, help establish the stability of these questionnaires.

OBSERVATIONS OF THE RESEARCHER

In the course of programming LINEQ and running the experiment the researcher met with individual students, met with classes, met with instructors involved in the experiment, and made observations pertaining to the study. From the various meetings, observations, and from the data in Chapter IV a number of remarks about the study were formulated. These remarks are listed as the conclusions were, and are followed by a discussion.

1. As the students viewed the four elements of instruction, they found the recitation instructor the most helpful and the text the least helpful with the television instructor and computer between the two.

2. Some of the interest generated by CAI Spring Quarter did not die quickly.
3. When the availability of a CAI program was announced during a TV lecture, little interest was generated.

4. The results of this study were not totally consistent with other findings.

5. The students thought LINEQ and CONFUN were good programs and FREMAT was a poor program.

6. The most common problems encountered in using the CAI system were failure to follow the sign-on procedure correctly, the complete system shutting down on the student, and the terminals not working properly.

7. The CAI facilities were not uniformly used throughout the quarter and this caused students some inconvenience.

8. The types of mathematical concepts which can easily be programmed for CAI on the present system at The Ohio State University are severely limited by the terminal design.

9. LINEQ was a success in two ways: (1) it was an error free program; (2) as judged by the questionnaires, the students seemed to view it as an aid to their learning Linear-Inequalities.

10. It takes approximately 400 hours to produce one hour of CAI.

11. Unexpected occurrences can cause a research timetable to be set back.

12. Producing a CAI program tends to lessen one's interest in producing another.

13. Debugging a CAI program in sections as it is produced yields desirable results.
DISCUSSION OF THE OBSERVATIONS

Students seemed to have an interest in CAI as a learning device, but the methods of measuring used in this study were too crude to pinpoint just how deep this interest was. Also, the students were limited to one type of CAI, namely, the tutorial program. But even with these limitations some rough evaluations can be made. On three different occasions the students were asked to rank the four methods of instruction they received in the course. Overall, CAI was in the middle.

The interest in using Computer Assisted Instruction did not die with the experiment. During the two quarters following the experiment, several students heard about the CAI programs and came to this author's office to see if they were still available.

On the negative side, just announcing the availability of a CAI program had little impact. Only 12 out of 804 registered students in Autumn, 1971, elected to use the computer.

As the reader might recall from Chapter II, some of the literature claims students enjoy using CAI and view it as a valuable aid to their learning. There were indicators in the responses to the questionnaires used in this study which would support this view; however, the more demanding test of whether or not students would use CAI when given a completely free choice resulted in a different outcome. Perhaps this shows that what students say about CAI and what they will actually do in using it are quite different.

In comparing the three CAI programs, LINEQ and CONFUN appeared to be successful in the eyes of the students whereas Fremat was not.
When the students who took all three programs were asked to rank them, LINEQ was first, CONFUN a strong second, and FREMAT a poor last. In Table 15, the numbers are interesting and would appear to support what the author is saying. But certainly no firm conclusions can be drawn from this table since not all of the same subjects were reacting to the three CAI programs. Since the students who took FREMAT and CONFUN were subsets of the original group, it would appear that these people already had a somewhat favorable attitude toward CAI. This makes them a special group, possibly quite different from the original group from which they came.

In attempting to use the computer, three areas of difficulty seemed to bother students more than others. These were: using the sign-on procedure correctly; a complete shutdown of the system; and the terminal typewriter not working properly.

Though the students seemed to feel initially that a simpler sign-on procedure should be used, it was noted that once a student had signed-on correctly he ceased to think that the procedure was really difficult.

There is little that can be done about a system failure and the students seemed to resign themselves to this; however, they did find it annoying to be stopped in the middle of a program and thus forced to return at another time.

The terminal typewriter caused more serious frustrations. The typewriter would run out of paper, the paper would become misaligned and tear, and the plastic shield over the place where the ball was typing would become so dirty with ink that the student could not read
the printout. Perhaps the terminals should have more routine maintenance.

During the spring of 1971, the number of terminal hours per week and the number of students using the CAI facilities during the week were not uniform throughout the quarter. A peak of 999 terminal hours was reached the third week with a substantial drop to only 464 terminal hours by the sixth week. Students who tried using the terminals before the fifth week often could not find open terminals or open lines to the computer. It would seem that, to achieve the maximum use of the CAI facilities, the programs need to be spread more evenly through the quarter. The number of students estimated to use each program must also be considered. These questions have been raised and efforts to answer them have been made since this study was completed.

The terminal typewriter was the major limiting factor in the ease with which FREMAT could be run. The keyboard was standard and did not have the special symbols needed for the program. Not only did this make the programming difficult, but it required a considerable amount of typing ability on the part of the student in order to respond. Also, it led to the use of nonstandard symbols. This use of nonstandard symbols was a problem with CONFUN too, but to a much smaller degree. It would seem that, if mathematical concepts are to be taught by use of CAI, special terminals and/or keyboards are necessary to do an efficient job.

The following are a few facts about the production of LINEQ which any future CAI author/programmer/researcher might wish to note.
Producing a CAI program takes a considerable amount of time. As mentioned earlier, it took approximately 650 hours to produce 1 \( \frac{1}{2} \) hours of program. A person should allow even more time than this for unexpected occurrences. For example, in the case of LINEQ, the RMP function was added after the program had been written. This created some difficulties. One of the time consuming and sometimes frustrating jobs in programming is debugging. The debugging method used in making LINEQ, as described in Chapter III, was felt to be so successful that it is recommended to future programmers. Briefly, each section was debugged immediately after it was programmed into the computer. By debugging a section at a time the completed program had only a few, easily correctable, errors in it.

The most negative aspect of creating LINEQ was the effect it had on the author/programmer. Once the program had been completed there was little desire to produce another. This feeling was shared by three other CAI authors with whom this researcher was associated. This seems unfortunate in that it makes it difficult to find experienced people to produce CAI programs. Although it seems unlikely that all writers of CAI programs will share this feeling, this author was impressed by the number of people who were affected negatively.

**IMPLICATIONS FOR FUTURE RESEARCH**

All three programs were intended for use with students having greater mathematical ability than those in the experiment. It would be interesting to see if the results and ranking of the three programs.
would be the same if the experiment were replicated using better prepared students.

FREMAT had students type the correct answer rather than pick it from a group of possible answers. To eliminate the complicated typing necessary in FREMAT, a person might consider producing the same basic program but using the multiple choice format. A comparison in attitude and learning could then be made to see which format would be more beneficial.

The only type of CAI program produced for the Department of Mathematics at The Ohio State University has been tutorial. Problem solving programs to be used as homework or as sample midterms could easily be produced. It might be that this type of program would generate more interest in students using CAI. Perhaps they would see more immediate value to this lower level program. There are problems, however, in overloading the CAI facilities for short periods of time. A study involving less than a hundred students would be possible, though, and might shed some light as to student interest and use of this type of program.

Although other studies have found students react positively to CAI, this study has found that students did not use the CAI facilities when given the opportunity. This brings up the question of what it means for a student to react positively. Reacting positively to a questionnaire appears to be quite different from actually running a program when given a free choice to do so. Considering the amount of time and money necessary to produce good CAI programs it would appear that further investigation into student use of CAI is in order.
MATH 101 COMPUTER ASSISTED INSTRUCTION (CAI) QUESTIONNAIRE

Please complete this as soon as you can after completing the program.

Name ___________________________ ID number ________________

1. What was your feeling about CAI before taking this course?
   a) Positive         c) Neutral         d) Slightly Negative
   b) Slightly Positive e) Negative

2. What is your feeling about CAI after having taken this program?
   a) Positive         c) Neutral         d) Slightly Negative
   b) Slightly Positive e) Negative

3. If you were to give this CAI program a letter grade what would it be?
   A    B    C    D    E

4. To what degree was the program a waste of time?
   (totally) 1  2  3  4  5  6  7 (not at all)

5. If there were other CAI programs available from the Mathematics Department would you take them?
   yes    no    possibly

6. Did the program get you to think?
   (not at all) 1  2  3  4  5  6  7 (constantly)

7. Did you complete the program in one sitting?
   yes    no

8. How difficult was it to get a line into the computer?
   a) Got on the first time
   b) Had to try 2 or 3 times during the day
c) Had to try 4 or 5 times during the day

d) Had to try more than 5 times before getting on

9. What trouble did you have with the system. Circle more than one if necessary.

a) Signing on - the lines were tied up
b) Signing on - did not use the correct procedure
c) Mechanical failure of the whole system. (system shut down while you were on)
d) The terminals were in use
e) The terminal typewriter did not work properly
f) Other - describe: ________________________________________________

10. What time(s) did you use the terminal(s)?

<table>
<thead>
<tr>
<th>Time</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 - 10 AM</td>
<td>4 - 6 PM</td>
</tr>
<tr>
<td>10 - 12 noon</td>
<td>6 - 8 PM</td>
</tr>
<tr>
<td>12 - 2 PM</td>
<td>8 - 10 PM</td>
</tr>
<tr>
<td>2 - 4 PM</td>
<td>10 - 11 PM</td>
</tr>
</tbody>
</table>

11. What times would you prefer to use the terminals?

<table>
<thead>
<tr>
<th>Time</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 - 10 AM</td>
<td>4 - 6 PM</td>
</tr>
<tr>
<td>10 - 12 noon</td>
<td>6 - 8 PM</td>
</tr>
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<td>12 - 2 PM</td>
<td>8 - 10 PM</td>
</tr>
<tr>
<td>2 - 4 PM</td>
<td>10 - 11 PM</td>
</tr>
</tbody>
</table>
This questionnaire is for those persons who did not try the CAI program on linear inequalities. Your name will only be used as a means of knowing those persons we've contacted. Your responses will be held in the strictest of confidence. Neither Mr. Klinger nor your recitation instructor will have access to them, thus, they can in no way influence your grade! Please answer as honestly as possible so that we can try to make the correct decisions for improving the department. Thank you.

1. Why did you not try the CAI program?

2. Do you attend the TV lecture: (circle one)
   - always
   - frequently
   - about half the time
   - infrequently
   - never

3. Do you attend recitation class: (circle one)
   - always
   - frequently
   - about half the time
   - infrequently
   - never

4. Do you consider Math 101 to be: (circle one)
   - a) a very good course
   - b) a good course
   - c) an average course
   - d) a poor course
   - e) a complete waste of time
5. Do you consider requests such as being asked to try a CAI program:

a) reasonable and should be done by the student

b) reasonable but the choice of doing it left up to the student

c) unreasonable
This questionnaire will be used to aid Mr. Pfetzing in evaluating students' reactions and opinions about Computer Assisted Instruction (CAI); to see how (if at all) CAI can best be used by the Mathematics Department. Obviously there are no "right" or "wrong" answers. Your honest opinion about those things you liked and those things you disliked is desired. Your time and consideration is greatly appreciated, and with your help we hope improvements will be made.

1. Have you participated in a CAI project before (high school or elsewhere)? ____________
   If yes, under what circumstances? ______________________________

2. What was your feeling about CAI before taking this course?
   a) Positive
   b) Slightly Positive
   c) Neutral
   d) Slightly Negative
   e) Negative

3. What is your feeling about CAI after having taken this program?
   a) Positive
   b) Slightly Positive
   c) Neutral
   d) Slightly Negative
   e) Negative

4. If you were to give this CAI course a letter grade, what would it be?
   (excellent) A  B  C  D  E (failure)

5. To what degree was the program a waste of time?
   (total) 1  2  3  4  5  6  7 (not at all)
6. If there were other CAI programs available from the Mathematics Department would you take them?
   yes  no  possibly

7. What part or features of the program did you like best?
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________

8. What part or features of the program did you like least?
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________

9. Did the program get you to think?
   (not at all) 1  2  3  4  5  6  7 (constantly)

10. Would you recommend: (circle one or more)
    a) Not making CAI available at all.
    b) Making CAI available, but completely optional.
    c) Require all students to use CAI.
    d) Use CAI to introduce new ideas.
    e) Use CAI to supplement new ideas already introduced by the classroom instructor.
    f) Use CAI as a review before tests.

11. How long would you prefer to spend at the computer in one sitting?
    a) $\frac{1}{2}$ hour
    b) 1 hour
    c) $1\frac{1}{2}$ hours
    d) 2 hours
    e) more than two hours
12. Did you feel this program required too much typing ability?
   yes     no

13. Which of the following would be closest to your typing ability?
   a) nonexistent
   b) hunt and peck
   c) typist

14. Why did you usually "sign off"? (circle more than one if necessary)
   a) Mechanical failure
   b) Program failure
   c) Boredom
   d) Lack of time
   e) Became tired
   f) Finished with the section or program

15. Relative to each other, how would you rank the following as to usefulness?
   a) Text          Most useful
   b) Computer      Second
   c) TV Instructor Third
   d) Recitation Instructor Least useful

16. Estimate the time it took you to run the complete program.

17. Do you feel this questionnaire was:
   a) a complete waste of the student's time
   b) possibly of some use, but basically more of the same garbage students get asked to fill out
   c) worthwhile in allowing the student to express his or her feelings about the possible use of new materials
18. In this questionnaire did you think any of the questions were poor?

yes no

If yes, which one(s) and why?


19. Did you feel there were questions which should have been asked but were not?

yes no

If yes, what were they?


20. Would you like some preliminary feedback as to some of the results?

yes no

If yes, please PRINT your name and campus address below.
APPENDIX D
Questionnaire Concerning the CAI Program on Absolute Value

1. If you were to give the "Absolute Value" program a letter grade, what would it be?
   (excellent) A  B  C  D (failure)

2. To what degree was this program a waste of time?
   (total) 1  2  3  4  5  6  7 (not at all)

3. What part or features of the program did you like best?
   _________________________________________________________________
   _________________________________________________________________
   _________________________________________________________________

4. What part or features of the program did you like least?
   _________________________________________________________________
   _________________________________________________________________
   _________________________________________________________________

5. Did the program get you to think?
   (not at all) 1  2  3  4  5  6  7 (constantly)

6. Did you feel this program required too much typing ability?
   yes  no

7. Why did usually "sign off"? (Circle more than one if necessary.)
   (a) Mechanical failure
   (b) Program failure
   (c) Boredom
   (d) Lack of time
   (e) Became tired
   (f) Finished with the section or program
8. Relative to each other, how would you rank the following as to usefulness on the concept of absolute value?

(a) Text Most useful _____________________
(b) Computer Second _______________________
(c) TV Instructor Third _____________________
(d) Recitation Instructor Least useful _____________

9. How would you rank the two CAI programs you have taken?

(a) Linear Inequalities First ____________________
(b) Absolute Value Second ______________________

10. Would you be interested in trying a third type of CAI program?

yes no

11. Please make any comments you might have about either program, both programs, or CAI in general, in the space below. (Use reverse side if necessary.)
Name ______________________ Rec. Instr. ________________

Questionnaire Concerning the CAI Program on Functions

1. If you were to give the "Functions" program a letter grade, what would it be?
   (excellent) A  B  C  D  E (failure)

2. To what degree was the program a waste of time?
   (total) 1  2  3  4  5  6  7 (not at all)

3. What part or features of the program did you like best?
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

4. What part or features of the program did you like least?
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

5. Did the program get you to think?
   (not at all) 1  2  3  4  5  6  7 (constantly)

6. Did you feel the program required too much typing ability?
   Yes  No

7. Why did you usually "sign off"? (Circle more than one if necessary)
   (a) Mechanical failure
   (b) Program failure
   (c) Boredom
   (d) Lack of time
   (e) Became tired
   (f) Finished with the section or program
8. How difficult was it to get a line into the computer?

(a) Got on the first time
(b) Had to try 2 or 3 times during the day
(c) Had to try 4 or 5 times during the day
(d) Had to try more than 5 times before getting on

9. What trouble did you have with the system? (Circle more than one if necessary.)

(a) Signing on - the lines were tied up
(b) Signing on - did not use the correct procedure
(c) Mechanical failure of the system
   (system shut down while you were on)
(d) The terminals were in use
(e) The terminal typewriter did not work properly
(f) Other - describe ______________________________

10. Relative to each other, how would you rank the following as to usefulness on learning the concept of Functions?

(a) Text
(b) Computer
(c) TV Instructor
(d) Recitation Instructor

11. How would you rank the three CAI programs you have taken? If you have only taken two - rank those.

(a) Linear Inequalities       Best  _______
(b) Absolute Value           Second  _______
(c) Functions                Last    _______

12. Do you think the mathematics department should invest more time and money in developing additional CAI programs?

yes  no
13. Are there any particular topics you would like to see on the computer? ________ If yes, what are they? _______________

14. Please make any comments you might have about any of the three programs, or CAI in general, in the space below.
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