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ABSTRACT

This is a report on the evaluative study of computer-assisted instruction (CAI) in ESEA Title I mathematics projects in Kentucky compared to non-computerized programs under Title I. Results of remedial mathematics instruction for disadvantaged students in grades three through seven during the 1971-72 school year are compared. The report describes the CAI program and the non-CAI program; reviews the literature on experiences others have had with CAI; and includes data on the attitudes of students and teachers toward the programs, on comparison of students in each program on the basis of standardized test scores, and on costs of the programs. The study concludes that CAI programs were not more effective than non-CAI programs in generating student development in mathematics, recommends that both types of programs be strengthened, and makes three suggestions for guidelines for programs in compensatory mathematics funded under Title I. (DT)

Computer-Assisted Remedial Math

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Computerized Instruction in Mathematics versus Other Methods of Mathematics Instruction Under ESEA Title I Programs in Kentucky

June 1972

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FOREWORD

The Elementary and Secondary Education Act was passed by the U. S. Congress in 1965. Subsequently the Act has been amended several times. Title I of the Act is designed to provide compensatory education programs for educationally deprived children who reside in school attendance areas with a high incidence of low income families. Thus, the main thrust of ESEA, Title I is compensatory education services for children who are not experiencing success in regular school programs.

For many years, in the school systems of our nation, we have subscribed to the philosophy of a tuition-free public school program for all children. In theory, we recognized the worth of the individual, but we stopped short of providing a comprehensive curriculum or program for learners which would meet the needs and interests of each child.

A look at the past will reveal the grim fact that the educational needs and interests of our children have not been met. The situation in a great number of school districts is characterized by a high dropout rate, declining attitude toward school, and poor academic achievement for many students. These conditions have been most evident with children who come from a disadvantaged socio-economic environment. The relationship between socio-economic disadvantage and educational deprivation is a fact which cannot be ignored if we truly recognize the worth of each individual and would provide a school curriculum designed to meet the needs and interests of our children in a democratic society.

Educational deprivation may result from one or a combination of reasons including physical and mental handicaps, poverty, neglect, delinquency, or cultural and linguistic isolation. Deprived children have real problems, and children with problems require a special and unique educational service to effect desired change and educational achievement.

In designing compensatory education programs for deprived children, we must recognize that the basic philosophy is unique and different in many respects as compared to that of the general education program. The unique facets of a compensatory education program are evident in the program's scope and design, organizational pattern, instructional approach, selection of materials and equipment, involvement of educational supportive services, inclusion of pupil welfare services, and identification of the program participants.

In our effort to mount an attack upon the highly resistive problems encountered in bringing educational programs to deprived children, the Division of ESEA, Title I, in the Kentucky Department of Education approved the request of certain school districts in Eastern Kentucky to provide computer-assisted instruction in compensatory math programs under ESEA, Title I, during the 1971-72 school year through a contractual arrangement with the Eastern Kentucky Educational Development Corporation.

The information in this Bulletin is a report on the evaluative study of computer-assisted instruction in ESEA, Title I math projects. The study was conducted by the Bureau of School Services, University of Kentucky. The evaluation team included highly qualified personnel who possess a wealth of expertise in the area under consideration. The scope of the study covered a review of the relative literature and project descriptions, assimilation of data, and a report of findings, conclusions and recommendations of the evaluation team.

John H. Bruce, Director
Division of ESEA, Title I
Department of Education
Commonwealth of Kentucky

NOTE: The study reported here was done by the Bureau of School Services under contract with the State Department of Education, May 1—July 15, 1972. It could not be done in the "ideal" way. That is, matching groups could not be established beforehand; a "control" group of school districts which were judged to be generally equal culturally and economically to those using the computer-assisted instructional programs provided the best available substitute for a predesignated control. Only the pre- and post-data which were available through routine testing programs in the schools made possible the comparisons of amounts of change taking place in the performance of students in arithmetic during the year under study. Unfortunately, neither standard scores nor raw scores (from which standard scores might have been derived) were available—so that the grade-equivalent scores provided had to be used as the measurement base for comparisons of the "experimental" (computer-assisted instructional) group to the "control" (non-computer-assisted instructional) group.

Recognizing such make-shifts as necessary in execution of its assignment, the study team made every effort to obtain an adequate sampling—indeed, using all there were available in the districts included in the study. Furthermore, it broke down categories of data, by sex and grade level, to check against the possibility that imbalances in the samples provided by the two groups would invalidate the comparisons.

It is with recognition of such limitations that this report is presented.

Special thanks are due the leadership in the unnamed school districts who generously provided the data for this study!

COMPUTERIZED INSTRUCTION IN MATHEMATICS versus OTHER METHODS OF MATHEMATICS INSTRUCTION UNDER ESEA TITLE I PROGRAMS IN KENTUCKY

June 1972

A report by the Bureau of School Service, College of Education, University of Kentucky, comparing different methods of mathematics instruction of disadvantaged students.

Part I

This study was an attempt to determine the comparative values of a computerized instructional program in mathematics operated under ESEA Title I funding in some school districts of Kentucky to the values of non-computerized programs under Title I in the state.

Value Base for the Evaluation

To the naive, the most obvious purpose of a mathematics instructional program is simply to teach mathematics. To those who have reflected somewhat upon the complexities as well as the purposes of mathematics, however, the teaching of it is far from simple. Some questions are: Are knowledge and skill in mathematics ends in themselves? Or are they tools? If tools, tools for what? Are mathematics skills of value apart from knowledge or understanding of how to apply them? Does the *way* skills are learned affect the *way* they may be applied? Are skills without applicability useful? Are understandings which call for application of mathematics of value if skills are lacking?

Mathematics is most generally prized as a tool. True, many people "love" mathematics, just as some do reading. But neither reading nor mathematics skills—both representing the ability to interpret abstract symbols to obtain meanings—are of value as skills; they are of value as they satisfy needs of the user. Few people work purely abstract arithmetic exercises for fun any more than they read the dictionary just because reading words—any words—is fun. Rather, if the user does arithmetic "for fun," it is to explore possibilities for use of it, or to challenge himself to cope with problems generally—just as the reader reads not to improve his word-recognition skill nor his ability to abstract a paragraph but to enjoy a vicarious projection of himself into some satisfying character role or to "find out" something. The skills are simply means to the end of his dealing with life more effectively.

It is not enough, therefore, that the student of mathematics become able to exhibit just the skills, or even knowledge of the abstract concepts (of division, multiplication, addition, etc.), of mathematics—any more than a carpenter might exhibit the ability to saw a piece of wood without regard to making something of it. Rather, skills, concepts, understandings of how to make application—involving habits, insights, even attitudes—must be blended into coordinated patterns that can be applied effectively in real situations. It is one thing for a pupil to recite his addition and subtraction combinations; it is another for him to make change at the grocery store. (It is even one thing for him to be able to solve a simple problem with pencil and paper, another for him to do so without the pencil and paper.)

Measuring What is of Value

An obvious problem in assessing the basic value of something taught, therefore, is how to measure the over-all ability, or "growth" in ability, of a student to use what is taught. This is why the way a thing is taught is important. Indeed, this was John Dewey's point in insisting that *what* is taught and *how* it is taught are one—that *subject matter* and *method* are the same thing—that we learn what we *do*. The classic joke about the child who was forced to write "I have gone" one hundred times because he had made a grammatical error, who concluded his task by adding, "I have wrote it 100 times and have went home," illustrates the point. Conversely, so also does the rather sophisticated student who understands what an infinitive is and that he should not split it but somehow forgets the concepts of both *infinitive* and *split* when he is writing or speaking.

Another consideration is the attitude of the student toward the subject, or the experience he has with it. Practice in touching hot stoves does not usually teach the child to touch hot stoves—rather the opposite. Repetition of an unrewarding or distasteful exercise is more likely to teach *avoidance* than proficiency in the exercise. It is important to determine whether the activities of the mathematics program generate a distaste for the subject or are a challenge to the student.

Then, it must be kept in mind that no two students are alike and that it is never the purpose of a program to make them alike. Rather, the program is to foster individual growth potentials of each student as a person. While common learnings are a necessity in mathematics, it is important that each student be given opportunity to apply those learnings in terms of his own needs. If machines, work books, programmed materials, and the like are used, it is important that they free the student and teacher for individualized work—rather than that they regiment activities.

Criteria Questions

In light of the above considerations, the study team, in planning this study, recognized the criteria represented in the following question:

1) Do the measuring instruments used in appraising the program measure the over-all development of the student in mathematics—as opposed to measuring only some limited facet or facets of mathematics de-

velopment? (I.e., does the student perhaps perform well with a machine, a work book, a programmed learning manual, or other special materials, yet remain unable to apply mathematics generally?)

2) Does the program tend to leave the student dependent upon special help (machine or teacher or special aid), or does it help him become independent? (I.e., does he become locked in the "remedial" program or does he develop toward returning to the regular program with other students?)

3) Does the program tend to "sour" the student on mathematics or on school generally, by boring him or by making him feel stigmatized by his identification with the program? (I.e., do students tend to improve generally in their school work and to remain in school toward graduation?) Conversely, does the program introduce a novelty, either in method or equipment, which is "artificial" motivation with the possibility of producing the Hawthorne effect, motivation which "wears off" when the novelty fades?

4) Does the program adapt to differing needs and interests of students—as opposed to being a rigid pattern through which all students must move?

The Programs Compared in This Study

What were the programs like which were examined in this study?

The stated objectives of both the computer-assisted instructional programs and of the non-computer-assisted, as set forth in their proposals for funding, did not differ basically. They were essentially alike in including such objectives as:

1) To individualize instruction.
2) To reduce the numbers of students scoring below grade norm.
3) To increase the percentage of students who master the basic addition, subtraction, multiplication, and division facts.
4) To improve the student's attitude toward the study of mathematics.

Description of the Computer-Assisted Instructional Program

Computer-assisted instruction (CAI) in the schools used in this study was a time-sharing arrangement with the Eastern Kentucky Educational Development Corporation (EKEDC). The program was contracted by EKEDC for a selected number of hours per day, with each student getting a "turn" at the computer for approximately 5-6 minutes per day. The student goes to the area where the machine is located, seats himself at the teletype terminal and activates the device by pushing the start button. The machine proceeds to type, "PEASE TYPE YOUR NAME AND NUMBER." The student types in a four-digit number and first name. The computer types his last name and the drill and practice lesson gets underway.

The initial lesson is a pre-test composed of material of different difficulty levels. According to the student's percentage of correctness relative to the pre-test, the computer selects the next material to be offered. The student's performance on each lesson determines the degree of difficulty for following lessons. The last lesson on the concept is a post-test composed of problems of the same difficulty level as the pre-test. Summary reports of test data and daily progress are made available to the teachers. The computer informs the child immediately whether he has made a right or wrong answer. If the child continues to make the wrong response, he is given the correct response and proceeds to type in the correct answer. When his lesson is completed, he receives, via the machine, a printout of the number of problems in the lesson, the percent correct, and the time taken.

The evaluation team saw computer-assisted instruction being used with a wide variety of approaches and varying degrees of efficiency. For example, in one school the study team was dismayed to see the machine located in a narrow room (broom-closet type) with children unsupervised, attempting to make use of the machine. While one child would be attempting to use the machine, other children remained close by and—as all normal children would—"horseplayed" around in the immediate vicinity. Some children were observed waiting for the machine to give them the right answer. Some children, after completing the lesson and receiving their printouts, immediately tore them up and threw them either at the closest wastebasket or at their nearest friend.

Some principals, teachers, and students told the study team of the frequency of "down time" caused by the malfunctioning of the computer. One school reported not just days but weeks of lost computer time when the computer was out of repair.

Some students and teachers, on the other hand, seemed to enjoy the computer type of program and value it highly, as reports which follow will show. In some schools, it was clearly evident that the program worked more efficiently than in other schools. As stated above, the evaluators observed the computers being used in a variety of situations with varying degrees of efficiency.

Description of the Non-Computer-Assisted Instructional Program

The schools in the non-computer-assisted instructional programs used the available funds to establish, staff, and equip special classes for children needing remedial mathematics instruction. These special classes were in addition to the school's regularly scheduled mathematics program.

The study team observed classes under Title I mathematics non-computer-assisted instruction using Individualized Learning Laboratories, manipulative devices such as the Quisenaire Rods, programmed books, the Ginn Easy Reading Books to develop vocabulary, several different types of duplicated material, films, filmstrips, record players, flash cards and transparencies.

Some non-CAI schools had the use of a teacher aide in the program.

In one classroom an aide put the correct answers on the chalkboard while the children checked their own work and evaluated themselves. The teacher described the aide as her "right arm" with audio visuals. The aide presented flash cards to groups, collected and checked papers. The children seemed to enjoy having someone whom they could ask questions and to whom they could show things.

The non-CAI schools, in listing their objectives, were concerned that children use concrete objects in their math work. Their in-service training programs reflected a desire to acquaint teachers with a variety of contemporary approaches.

The Populations of the Study

The computer-assisted instructional program in compensatory education under ESEA Title I in Kentucky was operated in grades 3 through 7 during the 1971-72 school year in seven school districts in the northeastern part of the state. These districts had almost 1,600 students enrolled in such programs. Only three other districts in the state had compensatory mathematics programs fully financed under Title I. They enrolled some 1,000 students. Two of these districts were in south-central Kentucky on the margins of Appalachia. One in southern Kentucky was in typical Appalachian country.

It seemed necessary to assume that the cultural and general educational characteristics of these three districts did not differ significantly from those of the seven districts using computer assistance, though a major point in treatment of the data was to control for differences in cultural and educational characteristics (as well as for variables of sex and grade level). That is, comparisons were made between progress made *before* the compensatory education experience and progress made including the experience. It was assumed that the effect of the program upon the rate of mathematics growth of the pupil *after* he entered the program would be independent of the effects of such variables *before* he entered the program. For instance: If a girl learns mathematics more quickly than a boy, she may be expected to do so as much *after* as *before* she enters the program independently of the effects of the program. If the child in one culture learns more slowly than that in another, any change in their respective rates can be reasonably attributed to the influence of the program.

The study team debated whether or not to randomize their sampling among either the CAI or non-CAI student groups, or both, anticipating that some problems might arise because large enough groups at various grade levels, for instance, might not be available. The decision was to obtain as complete a sampling as possible, so that if matching groups became a problem the greatest possible number of options would be available. The result was a "dragnet" approach to get every available sample. (Necessarily, the student whose records of pre-test, post-test, age, sex, and grade level were not available had to be omitted.) Since such information had to be obtained at considerable labor anyway, the team decided to use the entire population represented by those for whom complete data were available*

The study team conjectured considerably regarding the hazard that some selective influence might skew the samplings of one of the populations (by comparison to the other). The question raised was: Does the fact that a student missed a test or otherwise had an incomplete record represent a "screening" process that would make the sample a misrepresentation of either or both groups—but especially of *one* and *not* the other. The judgment of the study team was that the attrition by such gaps in the records could reasonably be expected to operate as greatly in one group as in the other, even if, by some fortuity, it did indeed tend to alter the patterns of the groups. The samplings actually used, therefore, are assumed to be representative in every practical sense. The number of usable samples was substantially smaller than the total population simply because the minimum of information was not available on many students.

Rationale for the Evaluation

The question this study was to answer was: Is a computer-assisted instructional program in mathematics superior, or equal, or inferior to one using other aids and methods—both financed under ESEA Title I for compensatory education? Basic to the study, therefore, was some performance comparison between groups of students who had had the computer-assisted instruction in mathematics to those who had had other kinds.

Additionally, views of both students and teachers in the two different programs were gathered as judgmental data to reflect their respective appraisals.

The pattern of the study took this form in outline:

Comparison-of-student-growth phase

1) Change was measured in grade-equivalent scores from pre- to post-test, both in direction and in amount—CAI group versus non-CAI-group—by sex and by grade level, for *computation*, *concepts*, and *application* sections of the tests when they were available, and for *composite* scores of sections of the tests in all instances.
2) Change was measured in rate-of-growth in mathematics. That is, rate-of-growth since age six up to pre-test was compared to rate-of-growth since age six to post-test. (A ratio was determined thus:

$$\frac{\textit{Score at pre-test}}{\text{Age at pre-test minus 6 years}} : \frac{\textit{Score at post-test}}{\text{Age at post-test minus 6 years}}$$

This ratio was presumed to measure the change in learning rate in mathematics generated by the program.)

* Some scores were reported as composites of three parts of the tests, *computation*, *concepts*, and *applications*, in grade-equivalent form. Others provided all four scores.

This ratio, again, was calculated for the *computation*, *concepts*, and *application* sections of tests when scores were available, and for composite scores of sections of the tests in all cases.

Comparison of Attitudes of Students

Students were asked to rank mathematics among six subjects in the ordinary school curriculum. These rankings were assumed to represent the students' positions on a polarity running from "subject most liked" to "subject most disliked." Again, comparisons were made between "scores" represented by these rankings by CAI-program students to those by non-CAI program students.

Comparison of Views of Teachers

Views of teachers in both kinds of programs were solicited by a questionnaire, using open-end questions for the most part. (One forced-choice question called for the teacher to choose among computer assistance and other kinds of aids. Another called for rating of CAI along an assumed scale from "not worth the extra cost" to "clearly worth the extra cost.") This same questionnaire was used for both groups, though it was recognized that each group might lack information for comparison of the elements of their own program to the elements of the other. Responses were distributed into admittedly crude (but perhaps practical) categories for comparisons between the two groups.

Hypotheses Tested in the Study

The attempt in the design was, therefore, to test these hypotheses, stated in null form:

1) There is no significant difference between CAI and non-CAI groups in the directions and amounts of growth in mathematics as indicated by the scores available for sections of the test and for the composites, when variables of sex and grade level are controlled.
2) There is no significant difference in the ratio of pre-test growth in mathematics to post-test growth when the CAI group is compared to the non-CAI group.
3) CAI students rank mathematics no more highly than do non-CAI students.
4) Teachers of compensatory mathematics using computer assistance value that assistance no more nor less than other teachers of compensatory mathematics value the aids provided in their respective programs.

In addition, this study provides interpretations of the views of students and teachers as they reflect upon issues relevant to comparative advantages and disadvantages of the CAI and non-CAI programs under Title I in the state.

Part II

EXPERIENCES OTHERS REPORT WITH CAI

In order to do this evaluation, it was necessary to explore what was already known relative to drill, practice and the application of the computer to classroom instruction. The discussion which follows summarizes what was found to have direct relations to the evaluation.

Several studies reflect the comparatively recent interest in Computer-Assisted Instruction. Unanswered questions are numerous and quite provocative. Fejfar (1969) reports a program of CAI used in a teaching situation about 200 times by elementary school children of various ages, grades, and backgrounds working in the area of multiplication. The apparent results and some questions raised were:

1) The students communicated well with the computer.
2) Students were enthusiastic about the use of the computer.
3) Improvement was made in multiplication.

Among the unsolved problems with which the author is concerned are:

1) Do the children learn to think and solve problems, or do they just learn to "parrot" responses?
2) Can concepts be taught by the computer?
3) How does the role of the "live" teacher change?

Suydam (1969) elaborates on the strengths and limitations of CAI, seeing the program as a highly useful instrument for a capable teacher to use in individualizing instruction. Cited also as a benefit is the ability of the machine to focus the attention of the child, forcing him to be active rather than passive.

Suydam also points out that CAI is unable to do the whole teaching job. Among the things she identifies as tasks which cannot be achieved by the computer are:

1) To instigate interaction among learners.
2) To react to human needs.
3) To respond spontaneously to questions and issues.

The literature repeatedly reflects the desirability of having the computer used as a supplementary tool. Travers (1971) writes very positively regarding the use of the computer. It is, however, interesting to note that in the section of the article dealing with the computer's role in drill and practice he describes drill and practice as a mode of instruction at the lowest level of complexity with the computer serving merely as a supplement to the work of regular classroom teachers. He cites the value of rapid feedback to the student and the ability of the computer to collect detailed information on the performance of each student as important strengths.

Studies relating to computation and drill are enlightening. Post (1971) says that the long-standing position that a major objective of the primary-grade mathematics program should be the development of computational facility is no longer tenable in terms of modern educational thought. He agrees that while it may be effectively argued that the attainment of speed and accuracy in computational tasks does have a place in the elementary curriculum, it must, at the same time, be stated that the danger of having the importance of this goal enlarged out of proportion is a very real one.

In Project GROW, done in the City of Philadelphia and reported by Diamond (1969), computer-assisted instruction was used in the teaching of biology and reading in two junior high schools and two senior high schools in that city. The achievement of the students in CAI was compared to that of comparable students in traditionally-taught classes. The test results were equivocal. In reading, the students did significantly better than comparable students in traditional classes. Computer "down time" made it impossible to determine differences between the CAI and traditional biology classes. Also a factor in this situation was a lack of sufficient content validity in the standardized biology test. An attitude survey constructed especially for the project showed that the students liked to work on the machines, but they were frustrated when the system did not function properly.

Parkus (1970), in an article published by ERIC, describes briefly several modes of CAI. In a CAI overview, the drill and practice mode is focused on elementary and secondary education, with reference to the relationship relative to the improvement of education and the attempt to deal with socio-economic problems. Parkus made a plea for a more economical CAI system to be developed.

Hall (1970), in reporting on the status of CAI in Pennsylvania, says that three characteristics of CAI make it suitable for individualizing instruction: adaptive response by the student, continual evaluation of the students' responses, and adaptability of instruction to the individual's responses and his achievement levels. CAI systems in Pennsylvania are being used for laboratory computing, record-keeping, simulation and tutorial instruction. CAI cannot easily be compared with traditional instruction, says Hall, because of differences in objectives and techniques. He says that CAI in Pennsylvania needs appropriate curriculum materials which have not been available. Cost of the machines also requires much after-school use of facilities in areas such as in-service work and administrative applications to get full return on the investment.

Gipson (1971) reports on a pilot study undertaken to determine the effectiveness and utility of a computer-assisted drill program in mathematics with disadvantaged seventh graders. The materials used were Suppes' drill and practice lessons. Twenty students participated for a period of two months. At the end each student was interviewed and asked to complete a written questionnaire. Pre-test scores were used in assigning certain concept blocks to students. Each student was then branched to one of five levels of instruction based on his performance on a non-standardized internal pre-test. Each day all teachers and students received a printout of the lesson. Concepts studied included addition, subtraction, multiplication, and division of fractions and decimals. The results showed that although students achieved significant gains when measured by an internal test directly related to the instructional content, they did not achieve significantly more as measured by scores on the wide-range achievement test.

Sears and Feldman (1968), in an article entitled "Changes In Young Children's Classroom Behavior After a Year of Computer Assisted Instruction," report findings regarding several non-performance aspects of children's behavior. The children used in the study were 45 first-graders who received CAI instruction for 35 minutes during each day of the school year. Their academic and social behaviors, as measured by 66 categories of a behavior survey instrument, were compared to the behaviors of 27 other students who were teacher-taught without the use of CAI. The data-gathering was by point sampling. Reliability of observation was achieved by two-man teams independently judging the same behavior. The range in percents of agreement were from 60% to 98%. Between the beginning and the end of the school year, the social behavior scores for the CAI students decreased significantly while the corresponding scores for the non-CAI group significantly increased, suggesting that the CAI instruction made students less socially oriented while the unvarying group setting of the non-CAI students tended to increase their social skills. The findings are interpreted as suggesting that CAI may reduce the expected positive relations among academic behavior, IQ, and achievement.

In September 1968, the New York City Board of Education initiated a project reported by Weiner (1970) for a large-scale-test demonstration of a computer-assisted program for drill and practice in elementary arithmetic. This was a modified version of an arithmetic drill and practice program based on work done by Suppes (1968) of Stanford University. It is a study of a particular group of students at schools where there were CAI terminals compared with similar groups in schools where there were no CAI terminals.

Questions to be answered were:

1) To what extent is the learning attributable to CAI and not other variables?
2) How do alternative instructional techniques compare with CAI?

The method of analysis used in the study was to treat the achievement test data at each grade level by using:

1) Analysis of covariance on total groups.
2) Analysis of variance of gains on total groups.

3) Analysis of variance of post-test scores on matched sub-groups.

The evaluation examined the amount of CAI work completed and the effect of the CAI drill and practice program on:

1) Arithmetic achievement at each grade level, from grades 2 through 6.
2) Arithmetic achievement of high and low achievers at each grade level, grades 2 through 6.
3) Arithmetic achievement of high and low achievers in grades 3 and 5 with the time factor removed.
4) The error rates and latencies of high and low achievers in grade 4.
5) Reading achievement of high and low achievers in arithmetic in grades 3 through 6.
6) Pupil opinions and attitudes toward CAI, toward arithmetic, and toward learning in general.
7) Teaching procedures in elementary arithmetic.
8) The opinions and attitudes of teachers, school administrators and parents.

Subsidiary questions to be answered were:

1) How is the CAI treatment influenced by the pupil's sex and race?
2) Did CAI affect learning of arithmetic concepts as measured by tests less familiar to pupils than MAT?
3) Did the ten-second time limit on CAI exercises interfere with learning for the pupils at the lowest achievement level.

Conclusions of the study were:

1) At all grade levels, the average number of concept blocks completed by pupils was much smaller than expected. On the average, 55 CAI lessons were completed by a sample of 138 fourth-grade pupils. The original expectation intended by the designers of the program was that the pupils would complete between 140 and 168 CAI lessons.
2) With the exception of the fifth grade, there was a greater amount of CAI work completed by high than by low-ability pupils despite the fact that the five difficulty levels in the program were to have made it possible for all pupils to proceed through the material at a comparable rate. The provision in the CAI program for matching differences in pupil ability to different difficulty levels was insufficient to lead to comparable achievement between high and low ability pupils as measured by the number of items completed, percent correct, number of time-outs, and item latencies.
3) Although in general the CAI program as implemented in New York City during 1969-70, reported by Abramson (1971), did not lead to losses, it did not lead to gains in measured achievement in arithmetic computations beyond those gained by comparison groups. These results contrast sharply with the results obtained in the 1968-69 CAI

evaluation. Two explanations seem to be plausible: First, the effect of the CAI innovation may cause an initial increase in pupil achievement where it is first instituted, but this level of performance may not be subsequently maintained when the program becomes a more accepted phase of the day-to-day school activity. Secondly, more CAI drill and practice exercises may have been completed by the pupil whose achievement was measured during the first year of the program.

4) When the comparison between CAI and non-CAI groups was examined for pupils at different grade levels, with different abilities, different sexes, and different ethnic backgrounds, somewhat conflicting results were obtained. At grade five, the significant difference favored the CAI pupils while at grade six the difference favored the non-CAI pupils. Other than these, the differences obtained were few and scattered and showed no consistent pattern.

5) In general, exposure to the CAI arithmetic program could not be said to have affected reading ability.

6) The results of an untimed test based upon the work presented to the pupils at the CAI terminals tended to indicate that the program was not ideally adjusted for low-ability level pupils.

7) Although the CAI teachers reported spending more time on preparation than the non-CAI teachers, observers generally found little difference between CAI and non-CAI teachers in the length of their arithmetic lessons or the amount of time they devoted to drill and practice.

8) Observers reported that arithmetic lessons were generally not well-coordinated with work at the terminals but that there was a greater degree of coordination the second year than the first.

9) A large percentage of all categories of respondents to interviews or questionnaires had a favorable attitude toward CAI and indicated they would like to see the program continued. They also felt the work at the terminals helped the children learn arithmetic better, and the teacher indicated that this was especially true of the pupils in the middle-ability range.

10) Although CAI and non-CAI pupils did not respond differently about the amount of communication dealing with school work that they had with their parents, the CAI parents felt that their children spoke to them more often about school in general and arithmetic in particular than did the non-CAI parents.

Abramson and Weiner (1971) describe the outcome of the second year of a large-scale CAI program for drill and practice in grades 2 through 6 in New York City for the year 1969-70:

1) Software did not appear to compensate appropriately for individual differences in ability.

2) Achievement test results showed no consistent pattern favoring CAI or non-CAI groups.

3) The amounts of drill and practice in CAI and non-CAI classes were not observably different.

4) Attitudes toward the program of pupils, teachers, administrators and parents were favorable.

5) Pupils were exposed to about one-third the number of CAI lessons as had been originally intended.

Experience of Other States

The study team canvassed the state departments of education in the fifty states for reports of experiences with computer-assisted instruction in mathematics. The following information was received from the 34 state departments which replied to the questionnaire used in the canvass.

The question was asked, "Are there computer-assisted instructional programs in mathematics under ESEA Title I grants in the state?" Eight reported they had such programs. The replies of those who reported they did not have programs may be tabulated thus:

25—No, because no proposals have been received requesting CAI.
4—No, thought it too expensive.
1—No, proposal for CAI had been turned down.
2—No, but no reason reported.
1—No, because not of high enough priority.
Some reported more than one reason.

In answer to the question of those reporting programs, "Under what titles are those computer-assisted instructional programs in mathematics?" replies were:

3—Title I.
2—Title III.
3—Both titles I and III.
One reported additionally locally funded programs.

The question, "Do the CAI programs cost more or less per child in the program than other Title mathematics programs?" was answered:

1—About the same.
5—More by about $75-100 per year per child.
2—Information not available.

Responses of state departments reporting programs to the question, "Do you find CAI programs in mathematics more or less effective generally than other ways of instruction?" were:

1—Much more effective.
3—Somewhat more effective.
2—Little difference.

When the state departments which had CAI programs were asked to compare the advantages of CAI with the advantages of other methods of instruction by checking which they favored on listed advantages, the tallies were as Table I indicates:

TABLE I

COMPARISON OF COMPUTER-ASSISTED MATHEMATICS INSTRUCTION FOR DISADVANTAGED TO OTHER METHODS AS JUDGED BY STATE DEPARTMENTS OF EDUCATION

Advantages of CAI	as compared to	Advantages of Other Methods
3	Improves computational skills	1
3	Improves ability to apply skills—carry-over to every day use	2
2	Increases insights and understanding of principles of mathematics	3
5	Generates immediate interest in mathematics	0
1	Generates a lasting interest in mathematics	3
6	Individualizes instruction more	0
0	Strengthens personalized relations between teacher and pupils	5
2	Makes the student more independent of both teacher and special equipment	3
3	Tends to help students "catch up" and return to regular mathematics class and study. (Note: Some items were not checked.)	1

In answer to the question, "On the basis of experience in your state, how do you regard CAI instruction in mathematics for the disadvantaged?" replies were:

5—An innovation yet to demonstrate its usefulness.

1—A time-tested tool and procedure.

3—Just another tool teachers should have available, but not on a regular routine basis.

1—Valuable, but not as valuable as other aids of equal cost.

1—Valuable, but not worth the extra cost.

Judgments reported on this question were based on the following:

3—Teachers' opinions.
4—Outside evaluators.
4—Test results.
1—Professional journals.

Summary

Reports of experiences with computer-assisted instruction in mathematics from the literature and from responses gathered by the study team from state departments of education provide little that is conclusive regarding the problem of this study. The literature does appear to imply that computer assistance should be regarded as a proper part of the repertoire of teaching tools which the modern teacher should have available for the particular needs it can be used to fill. It is probably not *the* answer, but rather one of a variety of ways and instruments a teacher ideally should have to use to deal with a variety of individual student needs and interests. On the other hand, it would appear that the profession should be open to experimentation and to further attempts to develop possibilities for more effective use of computer assistance in instruction. It appears that, like any tool, computer-instructional equipment—assuming it is mechanically functional—is neither good nor bad except as it is properly or improperly used. This viewpoint becomes particularly germane in this study considering the variety of ways the study team perceived computer assistance as being used in the schools it visited.

Psychological Theories Relating to Teaching of Mathematics

Through the years, theories of learning have influenced how arithmetic was taught and the character of the materials used in the classroom. Two theories have had a sustained influence upon the teaching of arithmetic.

In the early 1920's, Thorndike's "connection" or "stimulus-response" theory had marked effect upon educational practice. Buswell (1951) wrote that this theory played a principal role when the school subjects underwent scientific study. Arithmetic textbooks were planned and evaluated in light of this psychology. While Thorndike was aware of the interrelatedness of arithmetic knowledge, the fact remains that this theory led to drill and the abolishment of the multiplication tables which emphasized system.

Brownell (1935), writing of the popularity of the drill theory, referred to the reliance by the teacher upon flash cards, workbooks, and drill-type exercises. The teacher became concerned with speedy responses from his pupils, but, at the same time, was eager to keep the pupils interested in pursuing the study of arithmetic, demonstrated by his search for games, races, and other means of motivating the student.

The development of the "field theory" of learning, perhaps better known as *Gestalt Psychology*, brought another shift in the teaching of arithmetic. This form of psychology emphasized pattern and parts in relation to wholes and field properties. Now, the teaching of arithmetic was concerned with the organization and the systematic arrangement of the whole field of mathematics rather than the learning of isolated parts.

Buswell (1951) states that in this theory two concepts emerged that gave drill, in teaching arithmetic, a different position. First, facts must be developed concretely and clearly understood before they are practiced. Second, drill must reinforce the meaning of other parts of the program in arithmetic and must emphasize the logical order of the number system. This brought back the multiplication table, but it was presented in several forms and not just one.

According to Buswell, the field theorists considered understanding of first importance, instead of materials that would lead the pupil from a concrete portrayal, or understanding, of a process to an abstract representation in mathematical symbols.

In a recent yearbook of the National Council of Teachers of Mathematics, Engen and Gibb (1960) have written a chapter entitled "Structuring Arithmetic," which demonstrates the continued influence of the Gestalt theories in the teaching of arithmetic. These writers refer to the method and material of Catherine Sterns which has incorporated the Gestalt theory of structure into the learning of a number system.

Learning theory is a highly relevant topic to be considered when evaluating the effectiveness of any innovation. Doctors Peel and Sudduth (1970) relate that learning theories are many and the differences in the many theories are multitudinous. There is, however, a commonality of thought expressed by all the theories and that is that, in learning, human beings go from the simple to the complex and from the concrete to the abstract. There is wide agreement that beginning concepts must be deeply imbedded in the concrete, multi-sensory, manipulative materials.

Instructional materials in arithmetic have, through the years, been used by teachers who were intent on making the study of arithmetic meaningful and interesting for children. Grossnickle, Junge, and Metzner (1951) advocate the use of a wide variety of instructional materials for growth in understanding to be attained. According to Almy (1955), the symbols and processes of arithmetic need to be introduced in various ways. through a variety of materials which will allow children of varied backgrounds to gain the meaning necessary for present understanding and future generalizations.

Smith (1911) in discussing the teaching of algebra, said there were two ways for a person to express concepts and thoughts: one was through graphics and one was through symbols. He reasoned that a young child often knows the picture before he knows the word. Dale (1954) believes sense and mathematical symbols can be related through the use of models and various other sensory materials. It would seem that the proper place to begin the study of mathematics, especially for children, would be with graphic material.

The acceptance of the viewpoints of a given "school" of psychology ultimately becomes a somewhat personal choice. It appears likely that each is "feeling a different piece of the elephant" and that each has some value in its respective position. It would seem proper, however, that the educational practitioner recognize the basic psychological tenets of his practice, that he may be consistent and rational in what he does.

Computer-assisted instruction would appear to draw heavily from Thorndike's "connection" or "stimulus-response" theory in its rationale. By the fact that it requires reading by the student—which may be a real handicap in mathematics for slow third-graders, for example—it does require the student to place his arithmetic learnings in a context "beyond" arithmetic. That is, he is required to become verbally articulate in terms of what might otherwise be isolated arithmetic skills or concepts. Written language is necessary if he is to use the machine. The machine, however, does not emphasize association of skills and concepts with either concrete or graphic materials. Rather, the machine necessarily deals more with the abstract and symbolic, since it cannot supply models or objects directly. Obviously, the machine can at best only supply part of the experience which "new math" emphasizes—namely, the experiences which help the child bridge the gap between the concrete and the abstract; and the machine can hardly begin with the concrete as the "new math" teacher would.

Part III

ATTITUDES OF STUDENTS AND TEACHERS

Did the computer-assisted mathematics instruction programs affect the attitudes of students toward mathematics as a subject differently from the way non-computer-assisted instructional programs did?

A surprising finding was that the students in the non-computerized programs ranked mathematics more highly as a subject than did those who were in the computer-assisted program. This finding is based on the following procedure and analysis of results:

Students were given a simple questionnaire (see inside back cover) which asked them to rank the three subjects they liked most and the three they disliked most, with mathematics listed among six subjects. (A few substituted an unlisted subject for mathematics and did not report it at all.) Values were assigned as follows, the larger score representing the more positive attitude:

Most liked = 6
Second most liked = 5
Third most liked = 4
Third most disliked = 3
Second most disliked = 2
Most disliked = 1

On this scale, the computer-assisted instructional group expressed a mean ranking of mathematics of 3.569, ($N = 621$) compared to the non-computer-group's ranking of 3.840, ($N = 608$), the difference significant at approximately .02 on a two-tailed "t" test. (This means that the difference, though small, has only an approximate 2% probability of being produced by an accidental variation in the data.)

One member of the team, after visiting with students, makes the observation that they seemed to be enthusiastic about the computer (which some of them used in both mathematics and reading) but did not associate it with mathematics as a subject. That is, the computer-instructional machine was one thing; mathematics was another! Possibly the student is attracted to the facility of the machine in responding to him and instructing him but regards the mathematics performance it requires of him as only incidental; that is, he eats the spinach in order to get dessert. This is the only explanation the study team has for the phenomenon that, though many of the computer-assisted group seemed to like the machine, they as a group regarded mathematics less highly than did those who did not have it.

It must be noted, however, that the group without computer assistance were not just a "normal" group; that is, they were in a special program also, often with aides and special materials which may have influenced them considerably in enhancing their views of mathematics. This is simply to suggest that this study cannot be interpreted as implying that the computer-assisted program "sours" students' attitudes toward mathematics. Rather, the implication is that the special Title I program without computer assistance tends to be more supportive of a positive attitude toward mathematics than does the computer-assisted program.

Views of Title I Compensatory Mathematics Teachers

The teachers whose students were in computer-assisted instruction (the CAI group) and the teachers who taught the other special mathematics classes (the non-CAI group) responded to a questionnaire designed to solicit their opinions concerning the Title I mathematics programs. Eight of the eleven questions of the questionnaire were open-ended, therefore the wording of the answers varied with the individual teacher, resulting in a wide range of answers. The answers used in the following report of the teacher questionnaire were those that fell into the categories about which comments are offered. For a more detailed report of the response to the questionnaires, see pp. 44-52 of the appendix. Both the CAI and non-CAI groups answered the following questions:

Responses to Question One

The first question asked: What do you consider to be the main purpose of the Title I program in mathematics?

The majority of teachers in the CAI group saw the main purpose of CAI to be drill and practice, to develop speed and accuracy, and to develop independent learners of mathematics.

Other responses were: to individualize instruction, to help slow learners, to improve math skills, and to "make" a child become more alert.

The majority of teachers in the non-CAI group believed the mathematics program was an attempt to help children overcome the gap between their knowledge of mathematics and the requirements of their grade level so they could rejoin their class.

Other responses reflected concern for assisting students whose mathematics comprehension was slow and assisting students in understanding the relevance of mathematics in daily living.

Responses to Question Two

To the request that teachers list the unique advantages of their particular Title I program in mathematics, the CAI group answered as follows: It helped the children think faster. It individualized instruction. It helped each child to work on his own level and to work independently.

Some teachers felt there were *no* advantages. Others saw CAI as giving slow learners something to do and giving children an opportunity to work on a teletype machine.

The non-CAI group said it provided individual instruction by a person who could communicate to the child his interest in helping the child to learn mathematics. This person, it was felt, could adjust the pace of his instruction, could control the difficulty of the subject matter, and could use a variety of materials to diversify the learning approaches.

Responses to Question Three

Answering the question concerning the identification of any distinct disadvantages of the Title I mathematics program, the majority of the teachers in the CAI group reported mechanical failure. The breakdown of the machines changed class scheduling, disrupted class work, and caused much confusion. Some felt there were not enough computers, so that computer time was too limited. Since the computers were located in small rooms in the buildings, the teachers listed noise, confusion, and disruption of discipline as real disadvantages. A few reported *no* disadvantages.

The non-CAI group's response to this question was varied. The answers ranged from complaints of lack of understanding of the Title I program by other teachers, by students, and by parents, to no complaints. Some reported a sparsity of materials, inadequate classroom space, insufficient time, poor scheduling, and selection of students with poor potential for learning (I.Q. below 60).

Responses to Question Four

Question four dealt with whether or not the student who experienced success in the Title I program experienced the same degree of success in the regular classroom.

The teachers in the CAI group were almost evenly divided between "yes" and "no" answers, with the latter slightly in the majority. This came about through their qualifying some of the "yes" answers. Some students did not enjoy the machines; some experienced difficulty in learning to use them; some found the material too difficult; and some liked using the machines at certain times.

In the non-CAI group, the teachers reported improvement that often carried over to other subjects and improvement in the student's ability to do mathematics. A small number of teachers answered "no" to the question of carry-over.

Responses to Question Five

When asked how much more time the regular classroom teacher was able to give her class because of the Title I program, half the CAI group reported "none" and one teacher said she had less time. A few said it was of some help, perhaps a few minutes a day.

The non-CAI group reported that the assistance given by the Title I mathematics program saved them from as much as forty minutes to as little as ten minutes per day. All said they were able to give more individual help to the students in their classrooms and the majority reported they had more time to work with individual students in other areas of the study.

Responses to Question Six

The teachers were asked to estimate the number of children who were helped enough by the Title I mathematics program to move out of the remedial or below-grade-level work to grade-level or normal class work in their regular classrooms.

The following tables list the number of teachers reporting the number of children in their respective classrooms who benefited enough from CAI to be moved back to the regular classroom. By multiplying the number of children by the number of teachers, a rough estimate of the number of children returned to the regular classroom was obtained as indicated in Table II.

TABLE II

TEACHERS' ESTIMATES OF NUMBERS OF STUDENTS HELPED BY CAI TITLE I PROGRAM

Number of Teachers	CAI Group— Children Helped by Program	Total Children Helped
13	0	0
1	1	1
4	2	8
5	3	15
5	4	20
2	5	10
1	7	7
2	9	18
3	10	30
1	12	12
1	28	28
1	30	30
1	32	32
1	41	41
41	184	252

One teacher said he was not sure but would guess four or five had been helped enough to return to regular class. Another said he really did not know whether students were helped by CAI and five gave no answer at all. Another teacher reported 56 children or 40% had benefited from CAI instruction over a two-year period and one said 25% of his children made progress. These responses are not included in Table II.

In summary of the above table and answers there were perhaps some 325 children out of approximately 1600 in the experimental program of Title I mathematics who were returned to the regular classroom.

TABLE III

TEACHERS' ESTIMATES OF NUMBERS OF STUDENTS HELPED BY NON-CAI TITLE I PROGRAM

Number of Teachers	Non-CAI Group Children Helped by Program	Total Children Helped
1	4	4
1	7	7
1	8	8
1	12	12
1	17	17
1	20	20
1	30	30
1	63	63
8	161	161

Of the non-CAI group, one teacher returned one-fifth of the students in the Title I program in his class each year to the regular classroom. Another returned all the students who were behind one grade level to their regular class. (These do not appear in Table III.) Two teachers did not answer the question.

In summarizing Table III and the answers from the non-CAI schools selected for this study, it appears that some 161 students were returned to their regular classroom for work in mathematics.

Responses to Question Seven

This question was an attempt to determine the attitude of the majority of children toward the Title I mathematics program as judged by the teacher.

Forty-four teachers in the CAI program reported positive attitudes of most of their students toward CAI instruction while 10 teachers reported a negative attitude of most of their students.

The 13 teachers in the non-CAI group saw most of their students reacting favorably toward the Title I mathematics program.*

Responses to Question Eight

In response to a question regarding the applicability of the mathematics learned in the Title I program to real life situations, 21 teachers in the CAI group commented favorably. Five were on the opinion that it covered the basic math, that it was "straight equations" or simply drill of basic facts.

Seven in the CAI group did not answer the question and three replied "unknown."

* It may be noted that, in the non-CAI group, work with youngsters in the Title I program was their primary assignment, whereas many teachers in the CAI had other primary responsibilities.

Twelve teachers in the non-CAI group reported the mathematics taught presented very real-life situations. Two more teachers qualified their answer by agreeing that it was related to real-life situations with the exception of the "fundamentals." One teacher did not answer the question.

Responses to Question Nine

In answering the question regarding whether there was an increase or decrease in the child's ability to become an independent learner through the Title I mathematics program, most CAI teachers (42) reported they felt students had achieved from a *slight* to a *real* increase in ability to do independent work. Several teachers qualified their answers by such statements as, "in two or three cases," "a few," and "all but two."

Two teachers' replies were, "They [the children] do not tie in computer drill with classroom mathematics." Two teachers said the program was basic drill while another answered by saying he did not know.

Twelve teachers in the non-CAI group reported increases in the child's ability to become an independent learner. One teacher believed students in his mathematics classes had depended upon others for so long that making them independent learners was an almost impossible task.

Responses to Question Ten

This question read, "On the basis of your experience, how do you regard Computer-Assisted Instruction in mathematics for the disadvantaged? (Please check as many as apply.)"

Table IV interprets the results of this question for both the CAI and non-CAI groups:

TABLE IV

HOW TITLE I TEACHERS REGARDED COMPUTER-ASSISTED INSTRUCTION

	CAI Group	NON-CAI Group
I do not feel well enough informed to judge	7	9
Still an innovation yet to demonstrate its usefulness	11	1
Now a time-tested instructional tool and procedure	12	0
Just another tool teachers should have available, but not on a regular, routine basis	5	2
Of value, but not worth extra cost	16	0
Clearly worth extra cost	11	0

One noteworthy comment from a CAI teacher was, "The computer would be of much more value if it were used in a more controlled, less hectic situation than exists at our school."

Response to Question Eleven

This question read, "If to assist you in your future mathematics instruction you were allowed to choose only *one* from the following, which one would represent your first choice?"

The following table tabulates the results of this question for both the CAI and the non-CAI groups.

TABLE V

FORCED-CHOICE SELECTIONS OF TEACHERS

Choice	CAI Group	Non-CAI Group
Computer	18	0
A human teacher aide	20	9
Material aids	13	3
No answer	0	1

There were two noteworthy comments from the CAI group. One wrote, "I believe a small math class and lots of individual time and explaining is the best way to help the student." The other answered the question: "A human aid who can choose materials to aid in the learning process of his particular group of children."

One person in the non-CAI group did not respond to the question.

Summary

The returns from students indicate that the non-CAI program supported a more positive attitude toward mathematics than did the CAI program. It appears likely that students do have a positive attitude toward the machine but that they do not identify it with mathematics in many instances.

The responses from teachers have no clear balance favorable to one program or the other; some teachers were enthusiastic about CAI; others were critical, especially of how it operated in their particular programs. Since the non-CAI teachers appeared to have no basis for evaluating CAI—and the study team tried to avoid any questions which would lead them, except in the last forced-choice question—they gave little evidence of a desire to have computer aid.

Part IV

COMPARISONS ON BASIS OF STANDARDIZED TEST SCORES

As previously explained, the study team assembled data on pre- and post-test results of the two groups, using three sub-scores of the mathematics tests when they were available and, in every instance, the composite score. These pre- and post-test scores were respectively compared in the patterns which will each be described as it is used.

Actually, there is a redundancy in these comparisons, committed intentionally to make sure that some imbalance in the sampling of the two groups would be identified if it existed. For instance, comparisons were made between the total samples from the two groups, then, to "catch" any skew that might appear because one group had, for example, substantially more upper-level students than the other, the grades were paired. Since sex affects school achievement, a break-down comparison was made of the groups by sex. Finally, a comparison was made on the basis of whether or not and how much the learning rate (in mathematics) was affected by the experience between pre- and post-test.

Comparison on Basis of Grade-Equivalent Scores

As already indicated, data available to the study team were generally in the form of grade-equivalent scores on *computation*, *concepts*, *application*, and *arithmetic composite*, only the latter being available in many instances. These scores were taken from actual school office records or, in a few instances, from printouts of machine-scored results obtained from the State Department of Education which provides scoring services for certain grade levels for schools of the state. In most instances, data were from machine scoring by the test manufacturer of the *Comprehensive Test of Basic Skills* produced in different levels and forms by McGraw-Hill. A few were from the forms of the *Stanford Achievement Test* produced by Harcourt, Brace & World, Inc. In all instances, the pre- and post-tests were a form of the same test. While it is recognized that a considerable degree of accuracy had to be sacrificed because standard or "scale" scores which would represent finer intervals were not available—so that it was necessary to assume the adequacy of the comparatively crude *month* intervals represented in the grade-equivalent scores—the rationale for using grade-equivalent scores seems clear. The examiner's manual for the *Comprehensive Test of Basic Skills*, advising users on selecting of appropriate scores, states:

> Scales of equal units have the statistical advantage over other scales in that scores from these scales can be averaged. Percentile ranks come from a scale in which all units are not equal. For this reason it is not an acceptable statistical practice to report or to

> use averages of percentile ranks. Although the scale for grade equivalents on a particular test may consist of units that may for all purposes be considered equal, the size of the units on a scale of grade equivalents for another test will not equal those of the first test. Therefore, an average of grade equivalents for several students on the same test is statistically acceptable, but it is not appropriate to average for any one student his grade equivalents on several tests.

Obviously, the treatment here was of mean grade-equivalent scores on the same tests. It is generally recognized that tests become less reliable as they are used at the extremes of the levels they are to measure; i.e., a test for grades 6, 7 and 8 is likely to be more trustworthy for grade 7 than for 6 or 8. Also, the score of a youngster who scores several grades above or below his own grade placement is likely to be less trustworthy. That is, tests are more accurate for the mid-range of the span of their measurement than for the "fringes" of their span.

It was necessary, considering the circumstances of this study, to assume that such vagaries in the data were self-correcting; that is, that they operated as much in one direction as in the other in both the groups which provided the data. To safeguard as much as possible against any fallacy in this assumption, the somewhat redundant cross-comparisons mentioned previously provide further basis for confidence in the findings.

The gross samplings from the two groups presented grade-equivalent scores displayed in Table VI, with an analysis-of-variance test for differences in change:

TABLE VI

MEANS OF GRADE-LEVEL EQUIVALENT SCORES OF CAI AND NON-CAI GROUPS WITH MEAN CHANGES IN SCORES COMPARED

		CAI Group Mean				Non-CAI Group Mean			
	N	Gr. Level Pre-Test	Gr. Level Post-Test	Chg.	N	Gr. Level Pre-Test	Gr. Level Post-Test	Chg.	Level Sig.
Computations	508	4.5	5.2	.7	379	3.9	4.7	.8	<.01*
Concepts	508	4.5	5.3	.8	380	3.5	4.4	.9	>.05
Applications	509	4.3	5.2	.9	375	3.7	4.3	.6	<.05[1]
Composite	621	4.4	5.2	.8	608	3.4	4.3	.9	>.05

* = Significant difference in amount of change (favoring non-CAI group).
[1] = Significant difference in amount of change (favoring CAI group).

Times between pre-tests varied from 5 to 9 school months. This variation is ignored in the table dealing with grade-equivalent scores.

Three important observations may be made regarding the table above:

1) The achievement levels of the two groups are not equal, because the CAI group appear to have more capable students and probably also because there was a substantial block of second-grade students in the non-CAI group while the CAI group included none below grade 3.
2) The CAI group gained significantly more than did the non-CAI group in *application*, but gained significantly less than did the other group in *computation*. While the mean gain in *concepts* and *composite* scores favored the non-CAI group, the differences must be assumed as possibly chance.
3) The increases (which one naturally would expect) did occur in each comparison, and obviously at statistically significant levels (which were actually tested by a one-tailed "t" test.)

To clarify matters even more, Table VII arrays the learning ratio (ratios) of the two groups in parallel to display the differences between their ratios both at pre- and post-test. In all instances, they differed significantly at a figure beyond the .01 level. Clearly the CAI group represented a higher-achieving group in mathematics to start with, and respective learning-rate scores (ratios) were higher for them in all four categories and at both pre- and post-test. The ratios for post-test were calculated, of course, with adjustments to variations in pre-to-post time intervals.

Most significant, however, is the fact, which can be noted by comparing pre- and post-test learning-rate scores for each group, that all of those for the CAI group dropped at post-test and that one for the non-CAI group, *application*, did so—when both programs are deliberately aimed at *increasing* the learning rates of disadvantaged youngsters!

TABLE VII

COMPARISON OF RATIOS OF GRADE-EQUIVALENT SCORES OF CAI AND NON-CAI GROUPS TO TIME IN SCHOOL*

	CAI Group		Non-CAI Group			Significant
	N	Ratio	N	Ratio	Difference	Level of Dif.
Pre-test						
Computation	509	1.186	380	0.964	.222	<.01
Concepts	509	1.175	380	0.964	.330	<.01
Application	509	1.109	378	0.867	.242	<.01
Composites	621	1.185	608	0.845	.340	<.01
Post-Test						
Computation	506	1.112	391	0.967	.145	<.01
Concepts	506	1.138	391	0.854	.284	<.01
Application	507	1.091	390	0.853	.238	<.01
Composites	621	1.108	608	0.889	.219	<.01

* Two-tailed "t" test for differences between group means. Tests, administered by the schools, were the *Comprehensive Tests of Basic Skills* or the *California Achievement Test*.

Losses Instead of Gains!

The study team noted, in recording pre- and post-test scores, that a substantial number of regressions occurred—that is, students scored lower on post-test than on pre-test. This phenomenon is not unusual, considering the vagaries of test measurement and administration but did occur with such frequency that it would seem well for Title I teachers and administrators to consider that, by putting a child in a remedial program and publishing his placement there, they may be "branding" him, damaging his self-confidence, and destroying any zest he may have for the subject—with consequent reversals in scores.

A comparison of the two programs simply in terms of regressions (failure to score higher on post- than on pre-test) and of decreases in rate of learning appears in Table VIII.

TABLE VIII

DIFFERENCES BETWEEN CAI AND NON-CAI GROUPS IN TERMS OF GAINS AND LOSSES BETWEEN PRE- AND POST-TEST

	In Grade-equivalent Scores						
	CAI Group			Non-CAI Group			Level of
	Gained	No Change	Lost	Gained	No Change	Lost	Sig.
Computation	373	28	107	307	17	55	<.05**
Concepts	378	38	92	278	14	88	<.01**
Application	362	39	108	252	10	113	<.001**
Composite	502	24	95	528	22	58	<.01**
	In Learning-rate Ratios:						
	CAI Group			Non-CAI Group			Level of
	Gained	No Change	Lost	Gained	No Change	Lost	Sig.
Computation	183	1*	324	188	2*	189	<.001**
Concepts	237	1*	270	195	2*	183	>.95
Application	229	2*	278	176	0*	199	>.05
Composite	228	0*	393	359	2*	247	<.001**

* Numbers removed from contingency tables during calculation of chi-square values.
** Difference significant, favoring non-CAI group, by chi-square two-tailed test.

Obviously, the non-CAI group tended to gain both in grade-equivalent score and in learning rate more often than did the CAI group.

Comparison on Rates of Growth in Mathematics

As previously explained, a ratio was calculated between the grade-equivalent score and the age of the student in months minus 72 (6 years assumed to be age of school entrance). This ratio is used in the table immediately above. It is recognized as a crude device at best, though the results of its application emerged as substantially rational. For instance, as one would expect, the ratios varied around 1, which would be the ratio obtained if a student entered school at age 6 and learned at a normal rate. Even if the "yardstick" in this instance is not exactly a "yard" long, it still provides a commonsense basis for comparing the two groups, for it is applied alike to both.

It may be, for instance, that the CAI group, who turned out to have mean ratios slightly above 1 in every instance, were not actually above average in learning rate. Clearly, however, they were above the non-CAI group in achievement; and when the mean ratio in each group established at pre-test is compared to the respective mean ratio established at post-test, the proportional gain or loss in learning rate respectively for each group in the interval between tests becomes apparent. Indeed, the study team regards the comparison of these changes in learning rates of the two groups as the most rational strategy for attacking the problem question: Which of the two approaches to mathematics instruction has the greater influence on learning rate?

Table IX provides one interpretation based on the achievement ratios of the two groups at both pre- and post-test.

TABLE IX

CHANGE IN RATIOS OF GRADE-EQUIVALENT SCORES OF CAI AND NON-CAI GROUPS TO TIME IN SCHOOL (ASSUMING AGE 6 ENTRANCE)

CAI Group	N	Pre-Test Ratio	Post-Test Ratio	Change	Significant Level of Change
Computation	509	1.186	1.112	–.074	<.01*
Concepts	509	1.175	1.138	–.037	>.05
Application	509	1.109	1.091	–.018	>.05
Composite	621	1.185	1.108	–.077	<.01*
Non-CAI Group					
Computation	380	.964	.967	.003	>.05
Concepts	381	.845	.854	.009	>.05
Application	378	.867	.853	–.014	>.05
Composite	608	.845	.889	.044	<.01*

* Change figures taken to be significant at ≤.05 by a one-tailed "t" test. That is, likelihood that difference occurred by accident is less than 5 out of 100.

It may be noted that all the changes in ratios for the CAI group pre-to-post were negative. That is, by the "yardstick" used in this study, they did not achieve at the rate they had previously established at pre-test during the interval between tests. Since there is possibly an error due to the crudeness in the formula by which the pre-test ratio was established, we do not know for sure that they actually did learn at a lower rate *after*, compared to *before*. Since the non-CAI group did gain in all except *application*, however, it is patent that, for the purposes of comparison of each group to its own respective pre-test ratio, the non-CAI group appears to have the advantage. It is to be noted, however, that only one of the changes in rate for each group was demonstrated to have taken place at the ordinarily accepted level of statistical significance (≤.05). That is, the non-CAI group did slightly but clearly increase their learning rate in *composite*. Just as clearly the CAI group declined in learning rate according to their *composite* score. The other changes, both negative and positive, *may* have, considering statistical probability, occurred by accident. On the other hand, it appears clear that the CAI group did not change their learning rate *favorably* more than did the non-CAI group. What evidence there is points contrariwise.

Even more conclusive, perhaps, are the figures in Table X which compare the differences in the changes in the learning rates of the two groups betwen pre- and post-test. While the non-CAI group gained slightly in three of the four categories, even in the category in which it lost, *application*, its loss was not greater than that of the CAI group whose mean ratios declined in *all* categories.

TABLE X

MEAN GROWTH RATIOS OF CAI AND NON-CAI GROUPS WITH MEAN CHANGES IN RATIOS COMPARED

	CAI Group					NON-CAI Group					
	N	X Ratio at Pre-Test	N	X Ratio at Post-Test	X Chge.	N	X Ratio at Pre-Test	N	X Ratio at Post-Test	X Chge.	Level of Significance
Computation	509	1.186	506	1.112	-.074	380	.964	391	.967	.003	<.01*
Concepts	509	1.175	506	1.138	-.037	381	.845	391	.854	.009	<.01*
Applications	509	1.109	507	1.091	-.018	378	.867	390	.853	-.014	>.05
Composite	621	1.185	621	1.108	-.078	608	.845	608	.889	.044	<.0001*

* Significant at <.05 level, by two-tailed "t" test, showing change in ratio favorable to non-CAI group.

Some Comparisons by Grade Level

As indicated in the description of the two kinds of programs, they both operated with great variations. The teacher, the physical setting, even the abilities of the students—since one school in the CAI group included all students in the grades involved—all were variables which must have affected results. Such variations can be expected to express themselves in great variance in the data—in greater *standard deviations* and in the likelihood that means which differ clearly to the eye may not actually test as differing significantly. It means, too, that there is a good possibility that groups within the total may have varied greatly from the total in the way they behaved. CAI may be clearly more effective in one school or grade level, the non-CAI, more in another. Such an expectation does not emerge with any special clarity, however, in the figures displayed in the next table, Table XI, in which comparisons are made grade-by-grade.

TABLE XI

COMPARISON, GRADE-BY-GRADE, OF CAI TO NON-CAI GROUPS IN GRADE-EQUIVALENT SCORES AND RATE-OF-LEARNING RATIOS

	CAI Group Grade Level					Non-CAI Group Grade Level				
	3	4	5	6	7	3	4	5	6	7
PRE-TEST Grade Equiv. Scores										
Comuntation	3.5	3.9	4.3	5.6	6.2	2.5	3.2	4.2	4.4	4.9
Concepts	3.3	3.9	4.2	5.8	6.1	2.4	2.8	3.4	3.6	5.1
Application	3.0	3.6	4.2	5.7	6.1	2.2	2.7	3.7	4.8	4.9
Composite	3.3	3.9	4.2	5.7	6.2	2.2	2.9	3.7	3.9	5.0
POST-TEST Grade Equiv. Scores										
Computation	4.5	4.5	5.1	6.3	6.6	3.6	3.8	5.1	5.1	5.4
Concepts	4.5	4.6	5.3	6.2	7.2	2.9	3.2	5.1	4.6	5.7
Application	4.1	4.4	5.2	6.5	6.9	2.7	3.2	4.7	4.6	5.3
Composite	4.2	4.6	5.6	6.3	6.8	3.3	3.7	4.7	4.8	5.5
PRE-TEST Learning Rate										
Computation	1.785	1.208	1.031	1.058	1.035	1.246	1.037	1.009	0.843	0.746
Concepts	1.683	1.194	1.022	1.097	1.024	1.019	0.979	0.826	0.664	0.788
Application	1.537	1.084	0.994	1.075	1.013	1.018	0.915	0.882	0.785	0.757
Composite	1.616	1.187	1.036	1.081	1.023	1.006	0.934	0.841	0.720	0.769
POST-TEST Learning Rate										
Computation	1.560*	1.113*	1.009	1.029	0.964	1.225	1.089	1.003	0.840	0.744
Concepts	1.560	1.145	1.026	1.056	1.043	0.989	0.896	0.891	0.755**	0.783
Application	1.413	1.094	0.979	1.066	1.012	0.875*	0.909	0.882	0.894	0.722
Composite	1.434*	1.122*	0.973	1.030	0.993	1.075	0.890	0.878	0.768*	0.752

* Significantly lower than respective pre-test ratio on one-tailed "t" test.
** Significantly higher than respective pre-test ratio on one-tailed "t" test.

(NOTE: No tests for statistical significance were made regarding differences among grade-level-equivalence scores, since their tendencies are obvious.)

The next table, Table XII, compares the CAI to the non-CAI group, boys to boys, girls to girls—on the assumption that one sex may learn mathematics more quickly than the other and that, if one of the groups had proportionally more of one sex than did the other the sampling might thus be skewed. Again, the comparisons did not, as can be observed, change basically. That is, the CAI group was not demonstrated to have increased its grade-equivalent scores or its learning-rate ratios more than had the non-CAI group. Indeed, the contrary tendencies which were previously observed appeared for both sexes as the next table indicates.

Intentionally, no break-down is made here for comparisons between schools. It appears, however, that grade-by-grade comparisons produce results generally supportive of other observations, namely that the CAI program did not generate an increase in the rate of mathematics development of students, as measured by objective tests.

Both the break-down for comparisons by grade and by sex interpret relationships between CAI and non-CAI scores which are basically consistent with those made of the gross groups. They are offered here for "cross-checking" purposes.

TABLE XII

COMPARISON, BY SEX, OF PRE- TO POST-TEST GRADE EQUIVALENT SCORES AND RATE OF LEARNING RATIOS FOR CAI AND NON-CAI GROUPS*

	Grade Equivalent Scores											
	CAI Boys						Non-CAI Boys					
	N	Pre-Test	N	Post-Test	Dif.	Level of Significance	N	Pre-Test	N	Post-Test	Dif.	Level of Sifinificance
Computation	263	4.4	261	5.0	.6	<.01	192	3.7	193	4.4	.7	<.01
Concepts	263	4.3	261	5.1	.8	<.01	192	3.3	193	4.5	1.2	<.01
Application	263	4.2	262	5.1	.9	<.01	190	3.7	191	4.2	.5	>.05
Composite	319	4.3	319	4.9	.6	<.01	299	3.4	299	4.3	.9	>.01
	CAI Girls						Non-CAI Girls					
Computation	242	4.7	241	5.5	.8	<.01	159	3.8	162	4.8	1.0	<.01
Concepts	242	4.7	241	5.5	.8	<.01	160	3.4	162	4.0	.6	<.01
Application	242	4.5	241	5.5	1.0	<.01	159	3.5	162	3.9	.4	<.01
Composite	295	4.5	295	5.6	1.1	<.01	227	3.5	227	4.3	.8	<.01

	Rate of Learning Ratios											
	CAI Boys						Non-CAI Boys					
	N	Pre-Test	N	Post-Test	Dif.	Level of Significance	N	Pre-Test	N	Post-Test	Dif.	Level of Sifinificance
Computation	262	1.115	260	1.038	0.007	<.02	192	0.990	193	0.993	.003	<.05
Concepts	262	1.098	260	1.066	–.032	<.05	192	0.874	193	0.903	.029	<.05
Application	262	1.062	261	1.038	–.024	<.05	190	0.894	192	0.874	–.020	<.05
Composite	319	1.112	319	1.042	–.070	<.02	299	0.848	299	0.873	.025	<.05
	CAI Girls						Non-CAI Girls					
Computation	242	1.278	241	1.202	–.076	<.05	159	0.992	162	0.992	.000	<.05
Concepts	242	1.270	241	1.226	–.044	<.05	160	0.840	162	0.829	–.011	<.05
Application	242	1.172	241	1.159	–.013	<.05	159	0.859	162	0.848	–.011	<.05
Composite	295	1.275	295	1.188	–.087	<.02	229	0.879	227	0.900	.021	<.05

One-tailed "t" test.

Part V

COSTS

Costs of the CAI mathematics program were assumed to be above that of other Title I mathematics programs as the study was initiated. Reports from other states suggested figures of $50 and more as additional costs for computer services as part of Title I programs.

The extrication of figures for the mathematics aspects of the Title I programs posed a difficult problem, for funds for mathematics were mixed with those for reading, music, physical education, and the like. One of the non-CAI districts, for example, reported no funds earmarked for mathematics as such, though it provided a complete compensatory mathematics program for 95 students. It appeared that extra elementary teachers and teacher aides under Title I funding were working not only with mathematics but with other subjects also.

It became necessary, therefore, to set up guidelines for making estimates. It appeared that, for comparison of programs, limiting the consideration to items in the "instruction" category of the budgets would suffice. Accordingly, the following categories were established, and the amounts reported in Title I budgets for the districts, as provided by the finance division of the State Department of Education, were included for the calculation:

1) Salaries for elementary teachers and aides assigned clearly for compensatory mathematics service.
2) One-sixth of salaries of elementary teachers and aides who were not clearly assigned to any special area—on the assumption that one period per day would be given to mathematics work.
3) All expenses for tests, audio-visuals, supplies and materials, or rental of these (of teletype for CAI program, for instance) when they were clearly assigned for mathematics.
4) One-sixth of all expenses for tests, audio-visuals, supplies and materials, or rental of these when these were not clearly assigned for secondary school or for any other special use—again assuming mathematics to be approximately one-sixth of the program.

These amounts were summed and, to get percapita student costs, divided by the numbers of students to be served in the mathematics programs as reported in the original funding proposals. The results were:

	Number Students	Amount Assigned Title I Math	Per-Pupil Cost Estimate
CAI Group	1,579	$129,125	$81.78
Non-CAI Group	995	76,970	77.36

On such a basis, it appears that the CAI program cost approximately $4 more per pupil than did the "regular" programs. Now the actual budgeting in the funding proposals provided for machine rental (plus associated instruction and evaluation when it was listed separately) at a mean figure for the CAI group of $43.78—clearly higher than the $4 difference in the above estimates. This fact suggests that perhaps there was a tendency for the computer services to *displace*, rather than *supplement* the "regular" Title I mathematics program. In any case, the difference in cost between the CAI and non-CAI programs appears small by these substantially arbitrary estimates.

Obviously, these guidelines leave much to judgment, both in their obvious arbitrariness in the first place and in the fact that some personnel and materials are sure to be difficult to categorize. They were used as what seemed to be the best available.

Cost as Estimated by Districts

Another approach was to get estimates from those in the districts who had worked centrally with the program. These estimates were considerably at variance with those above, the CAI group tending to report only the actual cost included in the computer services contracts.

Reports from the non-CAI districts included listings of the following as a basis for their estimates:

- Teachers
- Teacher aides
- Drill materials
- Math kits (including manipulative materials and game cards)
- Filmstrips
- Records
- Transparencies
- Math duplication materials
- Flannel board
- Math blocks
- Abacus
- Numbers games
- Books (supplementary)
- Diagnostic tests
- Achievement tests

The mean of the estimates per pupil for the non-CAI group was even higher than that made by the study team—$118.53 per child.

Of the CAI schools, all except one reported simply what was spent for machine services, which apparently included: "terminals, communications, curriculum, teacher training, manuals and supplies, and evaluation" as budget items. One also included computer aides' salaries. The mean of these estimates per pupil (again on the basis of numbers of pupils involved as reported in the funding proposals) was $48.79.

Obviously, either the CAI program is substantially less expensive (on the basis of these estimates) or it is operating at the "expense" of regular staff, equipment, and supplies coming from the other parts of the school program than Title I.

The choices of how to judge actual comparative costs of CAI vis-a-vis non-CAI programs must, on the basis of such information, be quite arbitrary.

Part VI

CONCLUSIONS AND RECOMMENDATIONS

The matter of cost is actually relevant in a choice between the two programs only if one is demonstrated to have a performance advantage over the other. Although the assumption initially was that computer-assisted programs were the more expensive, the investigation into costs does open the possibility that, at least as they were operated, they may have been more economical.

The evidence uncovered in this report, however, is quite conclusive in its revelation that the computer-assisted programs are not more effective. At least for the school year 1971-72, the computer-assisted instructional program under Title I in Kentucky schools was not more effective in generating student development in mathematics as measured by standardized tests than the Title I mathematics program in three other selected school districts in the state. (These districts were selected on the basis of their having fully-funded Title I programs and being rather similar in cultural and economic characteristics to the schools using computer assistance.) Indeed, if costs were equal, the rational choice, on the basis of pre- and post-test results, would be the non-computer-assisted program. Though there are a few deviations in tendency for the results to favor the non-computer group, the conclusiveness is a bit overwhelming.

This statement is made with the reservations, growing out of observations made by the study team in its visits, that the programs (both computer and non-computer) were not operated at any uniform level of efficiency. Certainly the programs varied widely in the way they operated and in the amounts of planning, attention, and concern of teachers and administrators which were invested in them, among schools and among classes in the same schools. The study team noted instances, for example, in which one class group in a school scored well while those in another in the same school regressed frequently or gained little. Variations in the settings provided for the work, particularly for the teletype machines, were even striking–and, certainly, some of the inadequate spaces provided were of necessity! This means that the judgment pronounced here must not be generalized substantively beyond the realities of the setting of the study. What computer-assisted mathematics instruction might be if conditions were ideal is a question unanswered here.

Conclusions based on judgmental aspects of this study seem clear for students though not for the teachers. At a statistically significant level, the non-computer-instructed students tended to rank mathematics more highly as a subject than did those who used computer instruction. The difference is slight, but still statistically significant. It seems likely that the computer-assisted student does not equate the machine (which he appears to like) with mathematics which, though he ranks it slightly above average among six subjects, he does not like as well as do his peers who do not get computer assistance in their mathematics.

Responses from teachers, difficult to categorize and therefore summarize, are equivocal. It appears that the teachers without computer assistance do not generally wish they had it. While those with it found conditions about which to complain, a substantial proportion gave its use support—though, in a forced choice opposing it to other aids, less than a majority were loyal to the computer.

It appears to the study team that, at least as they apply to the situations of this study, the words of DeVault and Kriewall which appeared in the *Yearbook of the National Society for the Study of Education* (1970) represent the position that must as of now be taken:

> It is easy to describe the present position of the schools with regard to automation of instruction. Aside from a very few exceptional schools, computer-assisted instruction is presently of little practical consequence in American elementary and secondary education. This means that there is no teaching of conventional mathematics subject matter being done with the assistance of computers that cannot be done just as effectively and at lower cost by means that do not involve computers. That is where we stand now.
>
> These facts do not mean, however, that technology has no future in elementary and secondary mathematics education. In view of the many problems that remain essentially unsolved in spite of lengthy and strenuous efforts to find effective means of individualizing mathematics instruction without the assistance of computers, it is easy to agree with Suppes when he says that computers offer the only real hope for providing learn'. · experiences that are individually tailored to the unique needs of each pupil. The question seems to be mainly one of time.

Recommendations

An obviously rational recommendation would appear to be that CAI compensatory mathematics under Title I be abandoned in deference to other kinds of programs and that CAI be viewed as still in the experimental stage. Perhaps, however, further study of how CAI is used, even under Title I, would be fruitful. That is to say, the study team hesitates to generalize beyond the experience with CAI represented in the data of this study. The feeling is that this study in reality is not of *a* but of *many* CAI programs. Perhaps *some* of the CAI programs were successful. Certainly *some* programs, both CAI and non-CAI, of those studied, were more effective than others.

The truth is, however, that neither the CAI nor the non-CAI programs appear generally successful. By the formula used in the study, the mean learning rate of students in the CAI group declined in all four categories and in statistically significant amounts for *computation* and *composite* scores. The mean learning rates of the non-CAI group rose significantly only for *composite*. Assuming some rough accuracy of the formula, it appears that the CAI group might have done better had they remained in their regular classes without the program, while the non-CAI group can be said to have demonstrated an advantage only in *composite* score.

It is reasonable to recommend that attempts be made to strengthen both kinds of programs, to establish some continual evaluation procedure that assures more persistent pursuit of the goal of the program which is, obviously, to *increase* the learning rate of the student. If the learning rate is simply maintained, there is no point to the Title I program. The study team makes such a recommendation, after the limited research represented in this report, with the reservation that the specific suggestions for effecting it which are offered here be regarded as untested judgments based on their experience in the study.

Here are the suggestions:

1) CAI programs in compensatory mathematics should be funded under Title I only when there is evidence that:
   a) There is close supervision, follow-up, and individual attention to the child and his use of the machine. Simply scheduling youngsters to take turns at the machine, without the teacher's (as well as the student's) use of the diagnostic potentials of the machine, is likely to teach youngsters something besides mathematics.
   b) Use of the machine is individualized (rather than routinized) so that its schedule is flexible and adaptive rather than rigid.
   c) There is closer and more continual monitoring throughout the programs. (The fact that the pre-test scores of the sampling taken by EKEDC for evaluation purposes had not even been scored, much less used for diagnostic and corrective purposes when the post-tests were administered, illustrates how such programs let the horse be stolen before locking the stable—uncovering the failure of the program after it is too late to correct its weakness. Some tighter monitoring procedures should be established for all such programs, CAI or other.)

2) In light of the "compensatory" intent of the Title I program, standards for selection of students in the Title I program should, in some schools, be made more strict in screening out the above-average student. A considerable number of students, especially in the CAI group, had pre-test scores above expectation for their grade placement. Nevertheless, this suggestion should not be construed as implying that Title I students should be separately identified. It is the judgment of this study team that separating Title I youngsters from their regular class groups, or any identification of them which sets them apart, should be avoided whenever it is at all practical to do so.

3) Preparation programs for teachers and teacher aides should be strengthened. It appears that the goals of the program, the procedures planned,

and proper ways to use materials and special equipment, need consistent emphasis. The program appears to have been well organized in some instances, but not all. The study team was struck by the "spotty" results for both CAI and non-CAI programs, the contrasts between achievement rates of students in different grades or under different teachers in the same school, with one group showing clear, substantial and consistent progress, another evidencing mostly small gains and many regressions.

The variations in the quality of instruction would appear to be the ready explanation for such variations in student growth. Altering and upgrading of personnel, both teachers and aides, would appear to be important—especially that it be done *consistently* in consideration of extremes which appear in results.

APPENDIX

Responses to Question 1 (CAI)

1. What do you consider to be the main purpose of the Title I program in mathematics?

Number of Teachers Giving Response	Response
7	Help a child to be independent
5	Individualize instruction
5	Speed and accuracy
4	Help the slow child think faster
4	Drill and practice
3	To develop speed in math
3	Drill
3	To work independently
2	Help slow students progress closer to their grade level
2	Help students who have difficulty in math
2	Practice in skills already learned
2	Give extra practice
2	Improve math skills
2	Makes a child more alert
1	Supply extra individual help
1	For pupils to receive drill and practice
1	Mainly for practice
1	Increase math skills
1	Skill in basic processes
1	Increase speed and ability
1	Increase speed in thinking
1	Drill and practice on a level they can work
1	Practice in a different form
1	Provide interesting and meaningful drill
1	Practice in developing math skills
1	To teach math easily
1	To increase the students' ability to think more
1	To improve the quality of education
1	An instructional tool to aid student
1	Give the child confidence in math
1	Help the child see his mistakes
1	Serve as a review of math concepts
1	Give the teacher an accurate record of child's weaknesses in math
1	To test

Responses to Question 1 (Non-CAI)

7	To try to help the children to get close to their grade level so they may remain in their home room

3	To provide individual instruction in math
3	To help those who are behind in math but have the ability to do the work
1	To help the child in learning and understanding math in every day life
1	To assist and help individual with the math that they are slow to comprehend

Responses to Question 2 (CAI)

2. What do you believe to be the unique advantages of your particular Title I program in mathematics? (More specifically, what does this program of instruction do that no other equipment, materials, or method can do?)

11	Helps children think faster
8	Individualizes instruction
6	Helps each child on his own level
6	Helps the child to work independently
5	Nothing
5	Immediate correction and score
4	Child can work on same drill until a concept is learned
2	It can hold the attention of the pupil
2	Gives enjoyment and pleasure in learning for all children like machines
2	Improve pupils over-all ability in math
1	Makes the child feel important
1	Some children like math better
1	Gives the child a second chance
1	One to one teaching
1	With computer instruction a pupil gets the right answer before moving to another problem
1	It creates a new experience for the pupil
1	Gives the slow learner something to do
1	Gives the child a chance to work with teletype
1	Manipulate machines

Responses to Question 2 (Non-CAI)

3	To provide individual instruction for which teachers in the regular
3	Can adjust any area of math to the child's level of understanding and rate of learning
2	Individual help with different materials for a variety of approaches
2	Gives more practice with better materials than they have in a regular classroom
	classroom cannot find time.
1	To provide individual attention which no machine can replace
1	They are with someone who they feel cares for their needs
1	It lets the pupils learn the *why* as well as the how in math

Responses to Question 3 (CAI)

3. What do you consider to be distinct disadvantages of your particular Title I mathematics program?

1	The machine going off and on
20	Mechanical failure of computer

8 Not enough computers
8 Continuous class interruption
6 Children need supervision so each child will do his own thinking
5 Two hours for 108 students is too little time
5 None
4 Not enough time for individual pupils
2 Children need CAI instruction
2 Lack of understanding of work presented
2 Teacher does not have time to check the work done on the computer
2 Children miss class instruction
1 Failure of telephone connection
1 One teacher should teach CAI program
1 No one really in charge
1 Computer unavailable
1 Level I division and multiplication not on child's level of understanding
1 Work too difficult
1 Discipline in computer room
1 Noise and confusion
1 Children cannot ask questions
1 Teacher cannot explain how to work problems for students who can't understand
1 Math teacher is not aware of child's needs in math
1 Causes confusion
1 All children not participating
1 Material does not follow textbook
1 Computers too far from the classrooms
1 Not having a definite time for children to use the computers

Responses to Question 3 (Non-CAI)

2 Not supplied with enough materials
2 Lack of teacher cooperation
1 None
1 The homeroom teacher doesn't try to help the children in the regular class period
1 Classroom too small
1 Lack of understanding from other teachers and students
1 Need lists of objectives and purposes that are specific as to what to teach to make mathematics more applicable for these particular students
1 Trying to create an appreciation rather than cultivate it
1 Selecting pupils who are behind even though they have a low I.Q. (below 60)
1 Should be in Special Education
1 Lack of time
1 Impossible to meet requirements of total group
1 Scheduling
1 Lack of cooperation of parents

Responses to Question 4 (CAI)

4. Did a student who experienced success in your Title I mathematics program experience success to the same degree with his other regular classroom mathematics?

21 Yes

17	No
2	Generally
2	Some students
2	None
2	No answer
2	I don't know
1	Seemed to
1	Most of them
1	Yes, but did not enjoy it
1	Yes, after getting used to the machine
1	Improvement in reading ability carried over to math
1	To some extent, not to a great degree
1	Yes, when on same learning level
1	A good score makes them feel proud
1	Slow learners have not progressed from below grade level
1	He had more success in the Title I Math program
1	Gained more in classroom

Responses to Question 4 (Non-CAI)

3	Yes
2	Improved in classroom grades and achievement scores
2	Most who advance in math advance in other subjects
1	Some did on their own
1	Some were overlooked in regular classroom
1	No, but several experienced rapid growth in mathematics
1	These children do not have any other math but this
1	To some degree
1	No
1	In most cases "no"
1	No answer

Responses to Question 5 (CAI)

5. How much more time were you able to give individual students in the class because of your special Title I mathematics program?

19	None
4	No answer
3	Twenty minutes
3	A few minutes each day
3	Thirty minutes
3	Not too much extra time
2	Fifteen minutes
2	Fifteen to 20 minutes
2	Ten minutes
2	No answer
1	More time
1	More time with the average group (about 20 minutes)
1	Twenty minutes when machines were working
1	One-fourth more time for I did not have to drill
1	Not much more time
1	It helped some
1	About the same amount of time as before Title I math program
1	Able to give those having trouble personal attention

Responses to Question 5 (Non-CAI)

1	Little or very little if any (one person out of the room at a time)
1	Children worked on computers before school
1	I had less time
1	Thirty minutes semi-individual basis
1	Helped each child individually each day
1	Time doubled for each child each day
1	Time varied
1	In lower grade my aides and I can give much more individual help
1	A 40 minute period each day beyond his math in classroom
1	Cannot compare—first year of teaching

Responses to Question 6 (CAI)

6. Estimate the number of children who were helped enough by your Title 1 mathematics program to move out of the remedial or below-grade-level work to grade-level or normal classwork.

11	None
5	4 children
5	3 children
5	No answer
3	10 children
3	2 in my room
2	5 children
2	9 children
1	30 children
1	1 child
1	28 children
1	7 out of 9 children
1	41 children
1	25%
1	12 children
1	About 56 children in 2 years or 40%
1	30 or 40 percent
1	Probably 2 or 3 percent (class below average in math & reading)
1	About 80%
1	32 out of 37 students
1	None due to limited time
1	It helped some of the better students more than it did the slow ones
1	None because of faulty machines and discipline problems in computer room
1	I don't know
1	Not sure, maybe 4 or 5

Responses to Question 6 (Non-CAI)

2	No answer
2	About one third
1	20 children
1	8 children
1	Four 7th graders
1	17 out of 37 8th graders
1	63 of those now enrolled
1	All who were just one year behind advanced

1	About 1/5 of my class per year
1	12 children
1	30 children
1	7 children

Responses to Question 7 (CAI)

7. Did most of the children react positively toward your Title I math program?

36	Yes
6	No
2	50% did
2	At first interest was shown because of a new program. Later it became
1	Yes, especially for those using the computer for the first time
1	They look forward to working on it and try to top their last score
1	Especially those who usually have little success
1	Yes, for a short time
1	Yes, only 2 or 3 don't like it
	just another routine.
1	At first but after a while it became a bore because it so often didn't work

Responses to Question 7 (Non-CAI)

13	Yes

Responses to Question 8 (CAI)

8. How applicable is the mathematics learned in your Title I program to real life situations?

7	No answer
6	Applicable for it dealt with basic concepts
5	It fits into our program well
5	Very much
3	Helpful
3	They were able to apply the math to real life situations in class
3	Unknown
2	They are not based on situations; they are just straight equations
2	None
2	Average
2	It covered the basics
1	Very good
1	Yes
1	It has broadened the experience of each child
1	Teaches them to be prompt and independent thinkers
1	It is only that they must do their own work without help
1	Applicable but still depends on teacher who assigns concept blocks
1	If more time could be given to it in the classroom, it would be more meaningful
1	It helps the student to think more quickly thus responding more rapidly in other situations
1	Yes, but improvements were small
1	I find it relatively easy to relate class lessons to those on computer but the children don't seem to sense any relation; perhaps this is my fault

1 Applies especially weights, measurements, money matters, etc.
1 Title I math is more of a drill of math learned in the classroom

Responses to Question 8 (Non-CAI)

10 Very much like real life
2 Other than fundamentals
1 Very much like real life (especially in upper grades)
1 No answer

Responses to Question 9 (CAI)

9. Does your Title I mathematics program tend to increase or decrease the child's ability to become an independent learner?

38 Increase
2 Slight increase
2 To a small extent it increases independence
2 A few became independent learners
2 No change in attitude. They do not tie in computer drill with classroom mathematics
1 I don't know since the material was presented in class before done on the computer
1 Increase with two exceptions
1 I'm sure it tends to increase—I see no cause to decrease
1 In two or three cases it seemed to have helped
1 It increases independence because they are competing against themselves
1 No answer
1 Basic drill was the extent of the program. Any math program provides this
1 I don't know the change, if there is one, it is minimal

Responses to Question 9 (Non-CAI)

12 It tends to increase
1 Dependence on others for so long makes this an almost impossible task

Responses to Question 10 (CAI)

10. On the basis of your experience, how do you regard Computer-Assisted Instruction in mathematics for the disadvantaged? (Please check as many as apply).

28 Of value, but not as valuable as other aids of equal cost—i.e., paraprofessional or special assistants, materials, models, etc.
16 Of value, but not worth extra cost
12 Now a time-tested instructional tool and procedure
11 Still an innovation yet to demonstrate its usefulness
11 Clearly worth extra cost, if breakdowns were eliminated
7 I do not feel well enough informed to judge
5 Just another tool teachers should have available, but not on a regular, routine basis
1 The computer could be of much more value if it was used in a more controlled, less hectic situation than exists at our school

Respones to Question 10 (Non-CAI)

9 I do not feel well enough informed to judge
2 Just another tool teachers should have available, but not on a regular, routine basis
2 Of value, but not as valuable as other aids of equal cost—i.e., paraprofessional or special assistants, materials, models, etc.
1 Still an innovation yet to demonstrate its usefulness
0 Now a time-tested instructional tool and procedure
0 Of value, but not worth extra cost
0 Clearly worth extra cost

Responses to Question 11 (CAI)

11. If to assist you in your future mathematics instruction you were allowed to choose only *one* from the following, which one would represent your first choice?

20 A human teacher aide
18 Computer
13 Material aids (printed and audio-visual, including individualized instruction (kits, games, models, manipulative devices, etc.)
1 I believe a small class and lots of individual time and explaining is the best way to help the student
1 A human aide who can choose materials to aid in the learning process of his particular group of children

Responses to Question 11 (Non-CAI)

9 A human teacher aide
3 Material aids (printed and audio-visual, including individualized instruction kits, games, models, manipulative devices, etc.)
1 No answer
0 Computer

TEACHER QUESTIONNAIRE

1. What do you consider to be the main purpose of the Title I program in mathematics?

2. What do you believe to be the unique advantages of your particular Title I program in mathematics? (More specifically, what does this program of instruction do that no other equipment, mate . ·, or methods can do?)

3 What do you consider to be distinct disadvantages of your particular Title I mathematics program?

4 Did a student who experienced success in your Title I mathematics program experience success to the same degree with his other regular classroom mathematics?

5. How much more time were you able to give individual students in the class because of your special Title I mathematics program.

6. Estimate the number of children who were helped enough by your Title I mathematics program to move out of the remedial or below-grade-level work to grade-level or normal classwork.

7. Did most of the children react positively toward your Title I math program?

8. How applicable is the mathematics learned in your Title I program to real life situations?

9. Does your Title I mathematics program tend to increase or decrease the child's ability to become an independent learner?

10. On the basis of your experience, how do you regard Computer-Assisted Instruction in mathematics for the disadvantaged? (Please check as many as apply.)
    - ☐ I do not feel well enough informed to judge.
    - ☐ Still an innovation yet to demonstrate its usefulness.
    - ☐ Now a time-tested instructional tool and procedure.

- ☐ Just another tool teachers should have available, but not on a regular, routine basis.
- ☐ Of value, but not as valuable as other aids of equal cost—i.e., paraprofessional or special assistants, materials, models, etc.
- ☐ Of value, but not worth extra cost.
- ☐ Clearly worth extra cost.

11. If to assist you in your future mathematics instruction you were allowed to choose only *one* from the following, which one would represent your first choice?
    - ☐ Computer
    - ☐ A human teacher aide.
    - ☐ Material aids (printed and audio-visual, including individualized instruction kits, games, models, manipulative devices, etc.)

Although we must have your name and school in order to be sure that we can relate groups of data, we assure you of anonymity. Your name or personal identity will not be revealed to anyone beyond the study team. Our reports will interpret results only in terms of groups.

Paul Street, Director, Bureau of School Service, University of Kentucky
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Martha Sudduth, Special Consultant in Mathematics
Nancy Dale Peel, Special Consultant in Mathematics

Name ....

School ....

Grades taught under Title I ....

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