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ABSTRACT

A conference on the instructional uses of the computer was held in New York State in October, 1968. The purpose of the conference was to discuss and analyze new trends in computer-assisted instruction, to disseminate new information on advances in educational technology, to acquaint participants with activities in New York State computer centers, and to consider ways of better coordinating CAI efforts within the state. Reports given by the major CAI users in New York make up the first section of the report. The second section contains a general discussion of the future prospects of computer-assisted instruction. The advance of computer hardware has been so rapid that hardware technology is now four to six years ahead of the user's capability to take advantage of it. There is a general lack of computer software as a concomitant result. CAI is reported to be from five to fifteen times as expensive as conventional instruction. The conclusion reached by the conference is that all programs are in an exploratory stage with plenty of enthusiasm but little firm evidence that computers can change the quality of instruction significantly. (BB)

NEW YORK STATE CONFERENCE

ON

INSTRUCTIONAL USES OF THE COMPUTER

A FINAL REPORT

YORKTOWN HEIGHTS, NEW YORK

1968

NEW YORK STATE CONFERENCE
ON
INSTRUCTIONAL USES OF THE COMPUTER

Walter Goodman,
Project Director
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A Summary of the Conference
Held October 3-5, 1968 at the
Sterling Forest Conference Center
Tuxedo Park, New York 10987

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A Project *Funded by*
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Yorktown Heights, New York 10598

YORKTOWN HEIGHTS, NEW YORK
1968

FOREWORD

This conference was planned as a first step in promoting cooperation among state CAI users. Ideas for advancing this cooperation and the possibility of future conferences were discussed.

The main purposes of the conference were:

1. To discuss and analyze new trends in CAI activities;
2. To acquaint participants with ongoing activities in New York State computer centers;
3. To introduce and discuss educational technological advances and their applications; and
4. To consider ways of coordinating and collaborating CAI efforts in New York State.

The conference was informal in tone and manner. Approximately 40 participants attended the entire conference. Because the participants who gave presentations were exceptionally prepared, and because all the participants were knowledgeable in CAI, many materials were shared and many discussions were enjoyed.

This final report is organized into three main sections.

SECTION ONE: A REPORT OF CAI ACTIVITIES IN NEW YORK STATE

SECTION TWO: SPECIAL PRESENTATIONS

SECTION THREE: SUMMARIES OF THE CONFERENCE

In general, all presentations contained in this report are edited versions of the original presentations and are based on the notes and recordings taken at the conference. In those instances where a complete copy of the presentation was given to the participants, the main section of it is printed here. The complete document can be obtained by writing directly to the author. Formal copies of presentations were given by Donald Bitzer, Perry Crawford, John Flanagan, Andrew Molnar, and Alexander Schure.

NEW YORK STATE CONFERENCE

ON

INSTRUCTIONAL USES OF THE COMPUTER

October 3-5, 1968

Sterling Forest Conference Center
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PROGRAM

October 3

Keynote Address: "Overview of CAI Practices in the U.S." - Albert Hickey, President, ENTELEK

REPORTING SESSION I

Mabel Techet, Rye Neck High School
Winifred Asprey, Vassar
Rex Lamb, SUNY at Plattsburgh

REPORTING SESSION II

Cornelius Butler, New York City Title III CAI Project
Robert Benenati, Brooklyn Polytechnical Institute

REPORTING SESSION III

Thomas Clayback, Erie County BOCES
Phyllis Gottfried, BOCES No. 2, Port Chester
Richard L. Wing, Walter Goodman, BOCES No. 1, Yorktown Heights

REPORTING SESSION IV

Alexander Schure, New York Institute of Technology
Ernest Stockwell, Rome Free Academy, Rome, New York

Panel Discussion "Industry's Outlook for CAI" -
Martin Maloney (IBM)
William R. Bush (RCA)
Heinz Pfieffer (GE)

October 4

Address: "Present and Future Capabilities of Computer Technology for CAI" - Donald Bitzer, University of Illinois

REPORTING SESSION V

Edward Lambe, SUNY at Stony Brook
Sylvia Wassertheil, SUNY at New Paltz
Bradley Bunker, Scarsdale Public Schools

REPORTING SESSION VI

Andrew Molnar (USOE), "Office of Education Plans for Development of CAI" and "NSF Computer Project Activities"

REPORTING SESSION VII

John C. Flanagan, American Institute for Research, Palo Alto; Project PLAN, Hicksville, New York 11803

Address: "Why CAI is Really a Late, Late Show!", Perry Crawford, IBM

October 5

Panel Discussion:	"SED Outlook Toward CAI" - Norman Kurland, Louis Di Lorenzo
Reaction Panel:	Al Hickey, Perry Crawford, Rex Lamb, Dick Wing, Cornelius Butler
Conference Summary:	Thomas Gould

AN OVERVIEW OF THE CONFERENCE

The information and ideas presented at the conference fell into three catagories.

1. Operational CAI Projects in New York State
2. Problems and issues of CAI
3. Recommendation for SED action

Fourteen CAI activities were described. The CAI activities ranged in size from the RCA-CAI project in New York City which has 192 terminals to the participation in time-sharing services with one terminal. These represented the CAI strategies of drill and practice, tutorial, instructional management, simulation-gaming, and problem solving.

With the exception of the time-sharing activities, all CAI projects were supported to some degree with federal or foundation funds. The CAI activities described gave strong indication that CAI is in the research and development stage and that it will continue to be in this stage for at least 3 years. Moreover, the initiation and continuance of these activities suggested that at this moment there is no coordinating agency of CAI activities for the State and there is no general State policy governing CAI development.

The following will serve as an outline of the operational CAI projects represented at the conference.

TYPE OF CAI	LOCATION OF PROJECT	DIRECTOR
Drill and Practice	New York City	Cornelius Butler
Tutorial	SUNY at Stony Brook SUNY at Plattsburgh SUNY at New Paltz	Edward Lambe Rex Lamb Sylvia Wassertheil
Simulation-Gaming	BOCES No. 1, Yorktown	Walter Goodman
CMI	Project Plan Hicksville, Long Island New York Institute of Technology, Old Westbury, Long Island	John Flanagan AIR, Palo Alto, Calif. Alex Schure
	Buffalo, Erie County BOCES	Judd Prentice
Problem Solving	Brooklyn Polytechnical Institute	Robert Benenati
	Vassar College, Poughkeepsie	Winifred Asprey
	Rome Public Schools	Ernest Stockwell
Programming: Time Sharing Service	Rye Neck Public Schools	Mrs. Mabel Techet
	Scarsdale High School	Bradley Bunker
	BOCES No. 2, Port Chester	Phyllis Gottfried

The problems and issues of CAI are indeed many. One of the largest problems exists in the development of CAI software. Not only is there a general lack of instructional software; but there is also no concrete evidence that instructional software will be available in the near future. The recent mergers of hardware manufacturers with publishing houses have not generated the production of CAI software. There is evidence that manufacturers, publishers and educators do not have the proper personnel resources to produce quantities of quality software.

The fact that hardware has advanced so rapidly presents a problem in itself. Because of this advance, hardware technology is 4-6 years ahead of the user's capability to take advantage of it. Moreover, the changeover to a more advanced machine demands many months of reprogramming. Because the basic hardware components were developed for data processing, the addition of graphic display terminals with audio capacity to the hardware configuration presents difficult problems.

Cost, of course, is the most practical problem that has to be faced. The cost estimates of CAI are varied and are based on research and development efforts. Given these limitations, the following general cost estimates were presented. Curriculum may take 40 to 200 hours to prepare for each hour of student time on the terminal. If the estimates of Booz Allen, and Hamilton are used, the cost per pupil per hour for CAI drill and practice (assuming a population of 10,000) would be approximately $2.27 per hour or $340,000 per year. For CAI tutorial the estimate would be $7.53 per hour or $1.130 per year. These estimates are based on the assumption that a student will spend one hour a day with CAI. Their figures can be compared with an average of $.56 or $564 per year per student spent in public schools during the last academic year for the total educational program. The cost of telephone communications is high, perhaps 20 to 30 percent of the CAI bill.

The following recommendations were presented at the conference to the State Education Department. These recommendations were not presented in a formal sense, but rather were indicated by several participants during their presentations.

1. The State should elicit the support of local school agencies in performing CAI research and development.
2. The State should become the systems manager of instructional uses of the computer.
3. The State should create a master plan for education as a whole so that technology can be properly integrated.

Norman Kurland summarized the policy implications received at the conference.

1. The SED should not fund for the next 2 to 3 years major hardware installations for CAI.
2. The SED should support efforts in learning about the types of instruction possible through CAI.
3. The SED should encourage the use of available equipment to acquaint pupils and teachers with computer technology.
4. The SED should support training programs in the use of the computer for education.
5. The SED should begin to design a system of education that is flexible enough to take advantage of technology.

SECTION ONE

REPORT OF CAI ACTIVITIES IN NEW YORK STATE

Mrs. Mabel Techet — Rye Neck High School
Teacher — Rye Neck, New York 10580

In the spring of 1967 the Board of Education approved a request made by the Mathematics Department Coordinator for $1,200 for the installation and use of an IBM Quiktran 2741 terminal. In the fall and again in the spring, a one semester course in Computer Mathematics was offered as an elective to 12th grade students who had completed Math 11a. The course was comprised of 10 weeks of intensive study in the mathematical aspects of programming. Studer designed a variety of programs related to matl ematical problem solving and in several instances they developed programs to assist them in advanced science courses. In the second 10 weeks they were utilizing the terminal whenever they had appropriate programs developed.

The terminal was also used during the spring to demonstrate the computer to junioı high school mathematics classes. A group of teachers from schools in southern Westchester met at Rye Neck High School under the auspices of BOCES second Supervisory District for a 10-week introductory inservice course in computer mathematics. The terminal was available to them after school for computer practice.

At Rye Neck, we want the computer to be a resource for all school personnel. At the present time, however, due to the high cost of computer activity, we are unable to finance any computer activity other than the computer math courses. The computer should be utilized in a variety of ways and should not be considered solely a mathematics department tool. This means we must educate all our teachers so that they realize the value of the computer as an educational tool. We must then train them in the basics of computer programming and we must make the computer available to them for use in a variety of ways.

Winifred Asprey — Vassar College
Chairman, Mathematics Dept. — Poughkeepsie, New York 12601

As a small, private, undergraduate college, Vassar is the proud owner of an IBM 360/30 computer. Because of our size, and because of economic factors, we use it for business and academic purposes. The academic use of the computer has the highest priority.

Presently, the computer is used as an aid to the credit courses of Numerical Analysis, Computer in the Humanities and Social Sciences, and Computer Calculus. My guess is that Vassar College, if it goes on in this field, will probably make its mark in humanistic research rather than scientific research.

We have four 1050 terminals located on campus in a trailer near the Poughkeepsie Day School. The terminals are connected to the computer in Yorktown Heights. We are most interested in learning and using the APL language because of its calculating ability. In all our efforts, IBM has been extremely cooperative in helping us set up the facilities, and even in teaching credit and noncredit courses in computer technology.

The Poughkeepsie Day School can also use the terminals. It is making use of the terminals in the following ways:

1. to familiarize students with the computer and to teach one language (APL), partly as an aid to learning algebra,
2. to work out or help work out other programmed material (such as the spelling course),
3. to study the learning process.

Work on our first aim has just been started this year so that there are no definite results to discuss as yet.

The second and third goals are becoming more of a reality as we begin to gather data on the spelling course and the students who have participated.

The spelling course, programmed in Coursewriter language, is usable for grades three and up. It covers vowel and consonant sounds, syllables, accents, certain types of spelling patterns, some demon spelling words and difficult homonyms.

Rex Lamb — State University of New York
Director, Computer Center — at Plattsburgh

The CAI program at Plattsburgh is currently using the following hardware: an IBM 1440, 16K; two disk drives; ten 1050 terminals; nine lines and one clock line. The terminals are located in dormitories 16 and 30 miles from the campus. Full-time personnel consist of one computer operator and the director of the computer center. The computer center is currently funded entirely with the New York State allocation to the college.

Presently, strong emphasis is being placed in the development of a new program for the freshmen political science course. Because this course uses the case study method, computer assisted instruction is being used as a factual disseminator and evaluator to develop background for the case studies. In addition, a locally developed software writing method is being evaluated and improved.

To develop CAI for the political science course, we have entered into the machine the logical sequence of the instructor's course objectives. The instructor then interspaces the text with questions. This enables the student to read through the work and be continually evaluated. Student progress is again checked in class by the case study method. This method could be done as readily with a textbook in the early stages. However, computer aided instruction gives the capability of branching upon partial understanding of concepts, and expanding this capability goes beyond the reasonable size of normal textbook or programmed text.

Cornelius Butler — New York City Public Schools
Director, Title III CAI Project

The New York City CAI project offers mathematics drill and practice exercises to 6,000 students in 16 schools in three boroughs of New York City. One hundred and ninety-two teletype terminals are connected to four line concentrators and telephone wires to the RCA central processor in midtown Manhattan. Twelve schools have the terminals grouped in clusters, four have them separately located throughout the school building.

The chief item in the implementation process has been the interaction of the project director with the Board of Education and RCA. This interaction has shown that more interest and help in CAI is being offered by outside agencies than school systems can effectively use. Although the school districts must approve the curriculum and accept the role of industry into their schools, no general antipathy by teachers and administrators has been experienced. To this date, when the goals of the project conflict with the goals of the administrator, the conflict has generally been solved without major difficulty.

The key question facing public educators is whether to draw CAI programs into the control of the sponsoring school systems, or to leave the key responsibilities of CAI in the hands of universities or corporations. Control of CAI activities should be with the school system because of the CAI biases industry and the universities have. Until the schools have the resources and personnel to adequately accept control, however, an interim arrangement will have to be put into operation.

The effectiveness of this CAI project has not been demonstrated as yet because of the strike. However, teachers who have worked with students using this program intuitively feel that it will greatly enhance learning. An evaluation design has been constructed by the City University of New York under the direction of Max Weiner. The design calls for pre- and posttesting, observation of experimental and nonexperimental teachers, and a survey of parental attitudes.

Robert Benenati — Brooklyn Polytechnical Institute
Director, Computer Center — Brooklyn, New York 11201

In examining the educational needs of the institute, it was decided that using the computer as an electronic page turner, or as a vehicle for drill and practice had no value. Rather, the computers can assist learning by using them as computers. The computer is used at the institute to check the data which the chemical engineering students have read from various pieces of machinery and to perform the necessary calculations which these data warrant.

Having experienced the cost of participating in the GE and Dartmouth Time Sharing Services, the campus has purchased an IBM 360/50 computer. By means of NSF funding, a terminal has been placed in the major laboratory stations so that pupils can receive immediate feedback concerning the validity of their data, and so that pupils can perform the necessary calculations which would normally take hours to perform by hand.

In addition, 18 high schools presently receive time sharing service on the institute's computer through Call A Computer Company. The terminal in the classroom is used to assist pupils in their learning of physical principles by means of the Engineering Concepts Computer Program (ECCP). NSF has funded this activity. Moreover, with NSF funding, 10 Long Island school districts are participating in an experiment to apply the use of the computer, as demonstrated at the institute, to mathematics, physics, chemistry, and biology. The institute during the summer trained the teachers in programming, and assisted them in writing and debugging the programs intended for school use. A circuit rider supervises the operation in the 55 to 60 participating classes.

The institute would advise potential CAI experimentors not to underestimate telephone charges and the cost of teacher training. Experimentation in CAI is a worthy effort, however, because computers can facilitate experimentation in heretofore difficult areas, aid in algorithmic problem solving, and highly motivate the learners.

Thomas Clayback — Computer Based Resource Project
Director of Title III — Erie County BOCES

The BOCES have developed 28 computer-based resource units to help the teacher individualize instruction. The units are essentially developed for the teacher in his preplanning for classroom instruction. For each unit or theme there are many educational objectives to which the teacher may wish to address himself. The objectives are stated in student behavioral terms. For each objective curriculum content, activities, materials, and measuring devices are outlined. All these are stored in the computer and coded according to student variables; such as, interest levels, reading levels, and achievement levels.

A teacher who wishes to teach a theme for which a resource unit has been written obtains a list of learning objectives for that unit. From these objectives the teacher picks 10 or 12 which he judges to be relevant for his course of study and his particular class. For each child in the class he assigns several of the objectives. The computer then prints a resource guide for the teacher which suggests content, activities, and measuring devices relevant for each student. The teacher then judges which activities will be attempted by the entire class, and which will be attempted only by selected members of the class.

Over a 3-year period, 160 teachers and 4,000 pupils have participated. The present cost is $.75 per student per unit. Future plans call for a regionalization of planning and financing, and an extensive evaluation of units already produced.

Phyllis Gottfried — Westchester, BOCES No. 2
Coordinator of Time-Sharing Services — Portchester, New York

The BOCES at Port Chester has approached CAI by participating in time-sharing services. The main purpose of our time-sharing operation is to make computer facilities available to as many educators in southern Westchester as possible.

Time-sharing was chosen as our approach because the hardward is simple to operate, the programming language is in a conversational mode, and the cost is reasonable. We have four services available: Quiktran, Call 360-BASIC, Dartmouth, and the standard GE Service.

Our philosophy has been to educate the teachers and administrators in computer programming so that they may apply this knowledge in the classroom setting. The application of programming to the instructional setting has been made through the strategy of problem solving in the areas of mathematics and science.

Last summer a 2-week workshop was held for teachers to train them in the use of the time-sharing service and to relate this training to classroom practices. This year two workshops are in operation. One is a continuation of the summer workshop; the second is for teachers who are unfamiliar with computer technology. Presently, there are three terminals in operation within the BOCES district.

The terminals will not be used effectively unless the teachers are motivated and trained to use them. If the instructional staff becomes involved, so will the students. The Dartmouth report indicates that students' problem-solving work with a terminal may be the most significant independent work they will perform in their school career.

Walter Goodman — BOCES No. 1
Director, Title III — Yorktown Heights, New York
Richard Wing
Director, Curriculum Research

Philosophers of education agree that effort is needed to bring about individualized instruction, since the present educational system is constrained by factors which have produced instead relatively rigid, sterile, and insensitive procedures. Simulation is one method of organizing learning environments to provide for individualization in a broad sense. New technologies have been invented and, to a limited degree, explored for educational pupils.

The purpose of the experiment here reported was to produce and evaluate computer-based economics games as a method of individualizing instruction for sixth-grade pupils.

During the course of the project three games were developed: the Sumerian Game, the Sierra Leone Game, and the Free Enterprise Game.

The first two were used in a formal experiment and were programmed for a special IBM 7090 time-shared computer. The third game was completed after the experiment and was programmed in Autocoder for a 1401 computer.

In the Sumerian Game, the student takes the role of a priest-king in a Sumerian town about 3500 B.C. Through an introductory slide and tape presentation the pupil is given an orientation to the scene. Then, seated at the typewriter terminal of a computer system, he is presented with a series of economic problems, such as how much grain he should plant, store, or distribute to the population, how much manpower to assign to development of new crafts, whether to accept certain technological innovations, and how to cope with disasters which are introduced randomly throughout the game. Information is presented by means of printout, and the setting is illustrated with slides.

In the Sierra Leone game, the pupil plays the part of an AID officer in modern Sierra Leone. After taking a simulated tour of the country, he is assigned to each of the three provinces of Sierra Leone, one after another, and gives advice to the local administrators about their economic problems, such as land reclamation, price control, and even gross national product allocations. If he is successful in advising the country on these problems, he is promoted within AID.

The third game, Free Enterprise, puts the student in charge of a toy store and later a toy factory to give him simulated experience with economic problems which occur in these occupations.

The equipment used for the games originally was a time-shared IBM 7090 connected by telephone line to three 1050 terminals at our Center. Each terminal was equipped with an experimental slide or film strip projector. At the present time, the Sumerian and Free Enterprise games have been reprogrammed in Autocoder and Coursewriter III, and are running at our Center from a BOCES 1401 computer and a 360 at IBM, Poughkeepsie. The instructional versions of the games were written by teachers and then the games were programmed in FORTRAN Assembly Program by IBM. The computer programs for these games are quite complex and differ in essential ways from linear or simple branching programs.

Experimental Procedures. In order to assess the results of the games, an experiment was set up along these lines. From October 1965 to March 1966, 26 sixth-grade students from the Mohansic School in Yorktown Heights played two games, the Sumerian Game and the Sierra Leone Game, on three terminals at the Center for Educational Services and Research of BOCES. Meanwhile, a control class of equal ability studied about the economics of life in Sumer and Sierra Leone under the direction of a talented teacher using ingenious but "conventional" methods.

The effectiveness of the whole experiment was measured by several different techniques. One was to observe the students carefully and interview them after they finished playing the games. Another was to compare their pre- and posttest scores on specially prepared tests of economic understandings, and a third was a depth interview technique designed to probe for understanding of economic concepts on the part of selected pupils.

Before and after the experimental use of the terminals, all students in both control and experimental classes were pretested with the "Test of Economic Principles Based on Ancient Sumer" and the "Test of Economic Principles Based on Sierra Leone" prepared for the project.

Conclusions

1. It is technically feasible for sixth-grade students to play economics games on a computer system. In the case of the Sumerian and Sierra Leone games, the students experienced no real problems except for two students with very low reading ability.
2. The computer-based economics games were at least as effective in teaching principles of economics as the classroom method with which the experimental technique was compared. On one game the experimentals gained significantly more from pretest to posttest then the controls. On the other game the controls gained slightly but not significantly more than the experimentals.
3. The control group showed more understanding of economic principles several months after the instruction than did the experimentals.
4. The game appears to have been superior in teaching interpretation of graphs and diagrams but not as effective in teaching facts.
5. The experimental group spent less time at the computer than the controls did in the classroom in the process of learning approximately the same materials.
6. The more intelligent students gained more while playing the game than the less intelligent students.
7. Students who read well gained more from the game than those who read less well.
8. The students who spent the least time at the computer made the greatest gains.
9. The students who did poorly on the pretest gained more from pretest to posttest.
10. There is only a very slight connection between intelligence and the time which pupils in the experimental class needed to complete the game.
11. Students who had otherwise been ranked low in terms of intelligence or speed of performance did well in the game situation.
12. The students enjoyed playing the economics games for the entire 15-hour period.
13. The computer games provided theoretical variability in six out of nine specified categories of individualization.
14. The Sumerian and Sierra Leone games may be played **in other locations.**

Suggestions for Future Research

The experience with Project 2841 indicates that fruitful research might take these directions in the future.

1. Experimentation with computer-based games should be pursued.

   As the result of listening to consultants and reflecting on our own, we have decided that a number of improvements should be made in the games. Some of the changes contemplated are to make use of the random access tape recorder in order to provide oral instruction, to exploit the increased capabilities of advanced systems, to make the slides contribute more to the understanding of economic principles, to recognize other objectives besides economic ones, to increase the realism of the simulated situations, to create a greater variety of instruction routines, to provide opportunities for conscious transfer of understandings from one situation to another, to experiment with a technique which might be called pseudodocumentation, to build in better diagnosis of student understandings, and to improve the measurement of understanding by the exploitation of a depth interview procedure.
2. New topics should be explored to see what other kinds of simulation are possible.

3. New configurations of the simulated learning environment style should be developed.
4. Different technological instruments should be utilized, such as the random access sound drum and the light pencil.
5. New styles of teaching logics should be invented and tried out, in addition to linear, branching, and simulated environment styles.
6. Further exploration should be made of the use of auditory and visual cues to prompt constructed answers.
7. Further study should be made of the possibilities of using computer logic and storage capabilities to analyze and compare student responses.
8. Experiments of some length should be completed in order to test the long-term effects of automated instruction.
9. The computer industry should be encouraged to search for an improved technology which would include devices capable of voice recognition, language interpretation, olfactory simulation, tactile simulation, storage of moving picture sequences, and others.
10. Improvement should be sought in the methods of communication among persons engaged in simulation and computer-assisted instruction.
11. More study should be made of the diagnostic and evaluative aspects of automated instruction.
12. Systematic programs should be devised in which many different computer applications are combined.

Alexander Schure New York Institute of Technology
President Old Westbury, New York 11568

A SYSTEM FOR INDIVIDUALIZING AND OPTIMIZING LEARNING THROUGH COMPUTER MANAGEMENT OF THE EDUCATIONAL PROCESS

The Project

One problem facing today's educational leadership is to design a system that will facilitate the relevant utilization and management of the new resources and techniques. The educational community has long realized the potential to improve the education process through a meaningful use of these new technologies and organization. To accomplish an operant management system, as the outgrowth of an actual experimental program in typical living educational environments, is the essence of the project now underway at New York Institute of Technology.

Objectives of the Project

A. To organize, develop, and refine, by a systems engineering approach, a model computer-based system for the management of the educational process, operationally and economically feasible, and capable of:
   1. replication at alternate educational levels;
   2. self-improvement, through continuous rapid feedback of hard data, recorded, interpreted, analyzed and presented for decision by computer;
   3. individualization and improvement of the learning of each student in a heterogeneous population in specified curriculums and subject sequences;
   4. management, toward optimization, of instructional programs having applicability to general and occupational education (the curriculums involved will have relevance to the grade level continuum from year 9 through year 14);
   5. establishment of parameters for guidance, counselling and screening of students in such programs;
   6. proof of definition of goals, course content, prescriptions, and instructional strategies (acceptable to senior advisory boards consisting of representative educational, management and industrial experts), related to the selected curriculum areas.

B. To implement, test, revise, restructure and optimize the system in selected courses (mathematics, electronic technology, physics, computer sciences), in a selected environment, at New York Institute of Technology.

C. To demonstrate replicability and viability of the system for one course (the articulated physics program) at the branch faculty of New York Institute of Technology and at least one other environment typical of the Nassau County Secondary School System.

D. Concurrently, to train those members of the community operationally involved with the educational process (the learners, the teachers, the guidance counselors, the department chairmen, the administrators, the school board members, the trustees, and such other members of the social, industrial and political communities as can provide additional opinions or expertise in the development and implementation of a superior learning system) at both the secondary and collegiate levels, so as to ensure effective operation of the system.

E. To disseminate to interested segments of the educational and social communities the findings and conclusions of this study.

Procedures

In order to accomplish the objectives of the project an "action research" program has been prepared, which will, when successfully implemented, achieve the specific goals previously set forth. Procedurally, the "action research" program may be considered to encompass several interrelated categories of activities.

An initial and continuing category of activities covers the design and development of the computer-based management system itself, through which the assessment, revision, restructure, optimization and validation of the instructional system is to be accomplished. Since the system is self-generating and self-correcting, these activities involve empirical implementation and observation under actual living school conditions, and testing, modification and retesting in such a viable situation.

Therefore, a concurrent category of activities addresses itself to the development of subject matter courses, with all appropriate support material, and their testing, revision, restructure and ultimate optimization and validation. These activities are governed within the instructional management area of the system. The method of attack, the step-by-step procedure whereby the courses are behaviorally defined, structured, refined and validated, evolves directly from the system design, and is controlled and directed by the computer-based management system.

A third category covers the tasks involved in the replication of the management system and the teaching of the sample courses in the selected other environment, and the training of that personnel concerned at the Institute and among the cooperating school systems.

Finally, there is the dissemination of the findings of the study for broad application throughout the educational community.

These major categories of activities go on, to a certain extent, concurrently, and one cannot proceed to culmination without the other.

The course development activity, particularly as it reaches the implementation and assessment stage, depends entirely upon the management system, with its immediate feedback and analysis. The management system, conversely, requires the course development activity as its "test bed" upon which it bases its own growth and shape. Final validation of both the course and the management system depends upon the experiences of the replication experiment.

Critical to the success of the computer management is the Automated Adaptive Feedback Subsystem (AAF) developed as part of the management system. In essence, AAF is a self-adaptive system embodying prediction, evaluation, recordkeeping, and feedback mechanisms. The objective of AAF is to provide a logical basis for simultaneously improving curriculum and optimizing instructional decision processes for increasing individual student performance.

Perhaps the single most important design characteristic of the proposed subsystem is the continual improvement property. This allows for continual testing of new ideas in course presentation and content. In addition, the system continually improves its prediction capabilities relating to individual student instructional strategies.

Desired Outcomes

The demonstration of the effectiveness of "A System for Individualizing and Optimizing Learning Through Computer Management of the Educational Process" will have pertinence beyond the limits of mathematics, physics, electronics, and computer programming at college level. The system will have applicability to a wide range of grade levels and broad spectrum of subject areas. It should be understood that *it is the primary purpose of this project to study the viability of such a management system,* the development of the specific course content and format is secondary, although the products thereof will be substantial and capable of replication in other learning situations.

The experience gained in introducing change in school systems will be helpful to other innovators.

The program is aimed at arriving at a better learning system than is presently in operation either at New York Institute of Technology or in the cooperating school systems. The program should result in better organized, accurate hard data relating to the materials, equipment and systems that will be used in actual instructional operations. It will certainly provide for testing and assessing the various instructional methodologies employed, as well as verifying the content and the performance of the software and strategies used to obtain any particular learning point. It will also provide a frame of reference and assessment data relating to a set of strategies, a set of instructional materials, and a set of hardware suited to the four subject areas under consideration, and relevant to the needs of particular students undergoing these learning experiences.

The professional teams concerned with this program will have integrated into the instructional process an extensive range of media, selected from among all the texts, films, television tapes, audiotapes, transparencies, slides and filmstrips, workbooks, the behavioral games available today, and any other materials that are necessary to attain the educational aims of the courses, and to design new aids and devices when needed.

Computer Assisted Instruction as a technique will have received due attention. It is intended to experiment with CAI as a prime resource in the computer sciences program. The objective here is to provide experience in the use of CAI (and to evaluate its effectiveness) for the teachers and students in the Institute and in the cooperating secondary school system.

The computer-based analysis and evaluation of the results of the use of this range of relevant material should enable a teacher to move from the old pattern of selecting from a variety of uncoordinated materials to a coordinated system, integrated, capable of easy updating and based upon a store of specific experience about particular learning materials, equipment and software demonstrated pertinent to the subject matter areas treated experimentally in this program.

To summarize, among the desired outcomes of this proposed research program will be the development of a model computer-based educational management system that will have improved individual student learning; will have been demonstrated operationally feasible and capable of replication in other educational environments; and will have yielded data serving to demonstrate the validity and cost-effectiveness of such a system. Courses in four subject areas, optimized as a result of data feedback and analysis, will have been developed, and training of teachers and other participating specialists, at New York Institute of Technology and the secondary school educational environment in which the system will have been replicated, will have been accomplished.

Ernest Stockwell — Rome Free Academy
Mathematics Chairman — Rome Public Schools

Beginning in September 1965, Rome Public Schools, particularly Rome Free Academy, have used the computer for instructional purposes. Presently, an IBM 360/30 is operating for both administrative and instructional purposes. The computer is used for scoring system-wide tests, and for instructing pupils in data processing and computer orientated mathematics. The cost of this operation has been born chiefly by the school district, although some support has come from providing administrative services to area districts and from some small grants for special services.

Perhaps the outstanding achievement has been the degree to which the use of the computer has been developed without the addition of instructional personnel. The chairmen of the Business Education and Mathematics Departments have given leadership for curriculum development and inservice training. Had more time and money been available for the development of instructional material, even more progress could have been made. The frequent change of computer systems has been both a bane and a blessing.

One central conclusion can be drawn from our work. It is that there is a place for the computer in secondary education and that there is enthusiasm and talent to develop the use of the computer in a variety of ways. There is no doubt that it will be used effectively at the elementary level, through CAI especially.

Mrs. Sylvia Wassertheil — State University of New York
Director, New Paltz CAI Project — at New Paltz

During the 1967-68 academic year, New Paltz participated in the SUNY-CUNY Institute for Research in Learning and Instruction. Six 1051-1052 teletype terminals, two of them with audiovisual capacity, were connected by direct lines to an IBM 7010 computer at the Thomas J. Watson Research Center in Yorktown Heights, New York.

The College contributed $25,000 as its share of the expenses of the Institute's network. In turn, the network provided computer time, terminals, and the salary for the Facilities Supervisor as well as some support for faculty efforts. The college is financially responsible for the six telephone lines connecting the terminals to the computer. College funds for telephone lines, student personnel, and supplies were provided through New Paltz Instructional Resources by John Price, Director.

Faculty members of the college have generated program modules (concept units) in physics, biology, economics, mathematics, and philosophy. Approximately 1,000 pupils are using these programs. While the coding or programming of material was done by CAI staff members and student author assistants, the authors had a general idea of the programming strategy.

The CAI project has a full-time director and a full-time facilities supervisor. In addition, three student author assistants, with the aid and training of the supervisor, work in close association with their assigned faculty authors during the generation of the text. Four student proctors are in attendance when students are on the terminals.

During the 1968-69 academic year, the teletype and audiovisual terminals will be connected to an IBM 360/40. A modern mathematics program is planned for use in conjunction with the General Education Math videotape series. Its programming strategy will be modular to insure the possibility of selection of material within the program, and will be independent of the video tapes.

Bradley Bunker — Scarsdale High School
Chairman, Mathematics Dept. — Scarsdale Public Schools

Interest in computer programming and the instructional uses of the computer has been operating in Scarsdale since 1962. Beginning with lectures and courses in computer programming and technology given to both students and teachers, Scarsdale now participates in the Quiktran Time-Sharing System. An Olivetti-Underwood Programma 101 desk-top calculator computer was introduced last year to encourage underclassmen, in particular, to try programming on their own, since the cost of learning time on the Quiktran System would be prohibitive.

At the moment, an Advanced Placement mathematics teacher, having one less class assignment than the normal load has the responsibility of overseeing the Time-Sharing Quiktran program. A full-time aide in the mathematics center also has supervisory control of the seminar-laboratory and its equipment. In addition to using the equipment in class (Math 12H), several teachers refer individual students to the laboratory for work during study hall time or after school.

Scarsdale has found the computer to be a great motivational tool. The more mathematically interested and mature student has been able to do far more on his own than could possibly be done in a structured classroom.

Edward Lambe
Director,
Institute for Research on
Learning and Instruction
State University of New York
at Stony Brook, New York 11790

My experience in CAI has been at the college level with the CAI activities operating by means of a terminal.

There are two projects with which I have been associated at Stony Brook. The first is the CUNY-SUNY Project which last year consisted of a 32 terminal network operating out of the 7010 research computer at Yorktown Heights. Terminals were located at the State Universities of Buffalo, Binghamton, Albany and Stony Brook, at the City Colleges of Brooklyn and Queens; and at the Community College of Nassau. The subject areas of the CAI program were German, French and statistics. The results of this project are presently being organized and are too detailed for presentation here.

In addition, Stony Brook has an IBM 1500 System which operated with 20 terminals last year and is presently operating with 32. An IBM 1500 System has also been planned for Brooklyn College.

Instruction has not yielded readily to the promised improvements of technology. Books, blackboards, and talk still bear the main burden of instruction. One reason for this is that technology often presents data faster than the learner can digest it. Moreover, the simplicity of the traditional means of instruction are more attractive to the educator than the complexities of technological methods. Finally, needless to say, the cost of technology is very high.

I would like to restrict my attention to the question of pedagogical software which computer systems might in principle use. Great problems in software development exist; however, the solution to these problems can generally be worked out in the absence of any further advances in hardware development.

In the area of instructional software six areas deserve our consideration.

1. The nature of useful processing of student experience
2. The nature of useful control of student experience
3. The difficulty of programming
4. The acceptability of software
5. The improvement of materials
6. The effectiveness of materials

The first three areas are grouped together because they are specifically related to the computer. The last three are common to any development of curriculum materials.

The process and control of student experiences must be closely examined if one is to believe that the computer can individualize instruction. Individualization, if it exists at all, is learning something from the student response and doing something with it that will optimize his own learning process.

The processing of student experiences is very difficult. When a question is asked, there is usually a target answer. There is no difficulty when the target answer is given. The difficulty arises when the target answer is not given. The question could be repeated again and again, but this repetitive paradigm is not very attractive in human terms. How far away from the correct answer was the student's answer? How should the student be routed to the correct answer? These questions must be answered for each specific case. If individualized instruction is to take place, the computer needs to know the patterns of each route and the appropriate algorithms to use. Because we do not know that much about the instructional process, and because we do not possess many algorithms to help us, areas of process and control of student responses is one that demands our immediate attention. These areas can be worked on outside of hardware development.

The difficulties of programming will tend to disappear when we know what the appropriate algorithms are. Some of our present difficulties arise from our practice of attempting to program branching techniques for each student response. The worth of this practice is debatable.

The last three areas outlined have always been issues in all efforts to develop curriculum materials. In regard to effectiveness, the cry of ETV is appropriate; that is, everyone is an exporter, no one is an importer. In other words, everyone's instructional method except one's own, is poison. There must be developed procedures to assure acceptability of curriculum on a broad scale. In regard to the improvement of curriculum materials, the traditional method has been to develop one draft and then ask three other experts for improvements. Generally, the result is three different approaches. This procedure is often repeated. This is not exactly a convergent process. Finally, the type of criteria to judge effectiveness has to be examined. One criterion that is not often mentioned is that a student should make maximum amount of progress in a minimum amount of time. Attempts to define and measure progress must be made.

I would like to briefly comment on the experiments in German language instruction at Stony Brook in relation to the six areas of concern. The student's experience is processed in the following manner. The student is asked to write a phrase or sentence of approximately one hundred symbols. The student's response is then compared to the target phrase. The output is an edited version of the student's response so that wherever the student departed from the target a blank appears. This process appears to useful. We cannot at this time report on control. We are just beginning to control on certain responses.

The difficulty of programming has been eliminated. Acceptability of this approach appears to be widespread among our faculty.

With the help of consultants the target sentences have been improved. Presently the CAI students show improvement in reading and writing when compared to the audiolingual control group. In listening and speaking little difference is noted.

It is extremely important that the SED participated in some way in a vigorous research effort in CAI. The SED should now support efforts to research the instructional process and to arrive at appropriate control paradigms. To the extent that the SED can draw to itself the resources necessary to initiate such efforts, it is the most qualified agency to coordinate CAI activities for the State.

John Flanagan — American Institutes for Research
Director — Palo Alto, California 94301

PROJECT PLAN

Individualizing Education Using the Knowledge Available

The needs for research and development to plan and carry out an effective program for individualizing education are somewhat staggering. Certainly the things we do not know seem to very greatly exceed those that we do know. However, it does appear that we do know how to assist students to learn better than the programs exemplified by current practice in the schools. Therefore, a number of psychologists and educators have joined with a learning corporation and a number of school districts in a developmental program to attempt to move one step up the ladder toward the type of individualized educational program that appears possible.

This program, known as Project PLAN (Program for Learning in Accordance with Needs), was tried out in three grades, 1, 5, and 9, with the assistance of 14 cooperating school districts during the past academic year with 2,000 students. This year 4,000 students in grades 1, 2, 5, 6, 9, and 10 will be participating in Project PLAN. It may be useful to review briefly the preliminary decisions made in establishing this program. As an introduction to these points, the major strategy in initiating the program will be summarized. First, we chose to work within the school setting and closely with school personnel. Second, a comprehensive, rather than a piece-meal approach to the problem was selected. Third, only those school districts who were sufficiently interested and committed to make a substantial contribution in time and funds were included. Fourth, a team of behavioral scientists with long experience in the application of research and development to practical problems was assembled. Fifth, plans for the program from the outset included the evaluation of each aspect of the program in terms of the assessment of the results with the students. And sixth, the developmental program was scheduled over a several year period with a clear indication at the outset that initial progress could be expected to be slow and difficult.

The major decisions made with respect to educational objectives, learning methods and materials, evaluation, guidance and individual planning, and teacher development are reported briefly below.

1. *Educational Objectives.* With respect to educational objectives, Project PLAN has developed comprehensive lists for grades 1 through 12 which reflect current thought and practice. These lists have been prepared in the four subject matter areas of language arts, social studies, science, and mathematics. They are based on the reports of various committees which have been studying the curriculum in connection with new government sponsored developmental programs in these areas and on the available instructional materials.

It is intended that each Project PLAN student select his own educational objectives with the help of his teacher. For the present these are restricted to objectives for which instructional materials are available. It is expected that as better information becomes available about the educational objectives of most value to students with specific ambitions in terms of life goals and activities, it will be possible to develop new instructional materials to permit the student to achieve these objectives efficiently.

In Project PLAN about five objectives are grouped together in a module. Each of the objectives is intended to require 2 to 3 hours to achieve, and thus the module is intended as approximately a 2 week segment of instruction.

2. *Learning Methods and Materials.* As indicated above, it was decided that Project PLAN should begin with available instructional materials and media. To provide the necessary flexibility for individualizing education, several teaching-learning units are provided for each module. A teaching-learning unit is a four page guide which lists each objective along with the materials to be used by the student

in attaining this objective. An effort has been made to provide for individual differences in terms of interests and learning styles by presenting several alternate routes to achieve the same objectives. The various teaching-learning units make varying use of audiovisual media and capitalize on such differences as there are in the instructional methods used by different authors and publishers.

An important aspect of this program is the evaluation of the effectiveness of the various instructional methods and materials in terms of learners with known characteristics. By dividing the instructional program into manageable segments of these types, it is possible to vary the time spent on objectives. A person might complete as few as 12 modules, or as many as 24 modules in a year in a particular subject. Also, the procedure makes possible at least a limited adaption of the individual's learning style to an available instructional program. Finally, the modules permit tailoring the curriculum for each student to his short-range objectives and requirements.

3. *Evaluation.* The program of monitoring and evaluating Project PLAN is accomplished with two main types of assessment materials. The first type includes specific test questions focused on the achievement of the objectives in a particular module. These questions, or alternate forms of them, are also used in placement and survey tests. They are intended to indicate mastery of the stated objective.

The second type of assessment procedure is designed to measure a long-term objective. An example of one of the most important objectives of this type is reading comprehension. Other objectives of this type would include attitudes, appreciations, originality, and other important skills and abilities which require more than 2 weeks to develop.

Procedures other than pencil and paper tests are used, particularly to assess some of the long-term objectives of the program.

4. *Guidance and Individual Planning.* The guidance and individual planning program of Project PLAN represents a major developmental effort in this educational system. Two factors have led to this emphasis: first, the conviction that individual planning must be a central function in a program for individualizing education; and, second. the newly available data from Project TALENT students given a comprehensive set of tests and followed up 5 years after they had completed their high school courses. These data provide a solid foundation on which to build a career planning program. The Project PLAN program is focused on assisting each student to formulate his goals in terms of adult opportunities, roles, and activities; to take responsibility for and plan a developmental program to achieve these goals; and to learn to manage his own developmental program to carry out these plans.

The Project PLAN guidance and individual planning program consists of four major components. The first two are primarily related to imformation and concepts and their interpretation. And the second two are more specific skills and abilities for planning and carrying out the individual's development based on the knowledge presented in the first two components.

(a) The first component is a program for acquainting each individual with the status of his development with respect to abilities, interests, physical and social characteristics and values in the areas of education, vocations, social behaviors, citizenship, and the use of leisure time. This program should include developing an understanding of individual differences during childhood, adolescence, and maturity, and the basic principles of learning. In this program it is proposed to substitute for the concepts of intelligence and aptitudes, the slightly different concept of developed abilities. The concepts of aptitude and intelligence connote abilities which are too fixed and unchangeable. The concept of developed abilities is given a much more controllable quality. The individual would be informed of the level of development of his abilities in statements having direct meaning such as the number of words he understands from among those listed in ***Webster's*** *Collegiate Dictionary*. Or, his ability to read might be reported in terms of the types of materials he can read with a defined level of comprehension, for example, the type of textbook, or newspaper, or news magazine which he understands.

In interpreting the student's score on reading comprehension the student would be told that the average gain in reading comprehension on this particular test of developed ability in reading comprehension was six points. It could be pointed out that his chances of being admitted to an engineering program in a university and completing this program would be less than 10 in 100 if his gain during the next 3 years was only six points. On the other hand, if he were able to increase this gain to 12 points, his chances of success would be increased to 50 in 100. Information could also be supplied to the student on the frequency with which gains of this size have occured. This type of interpretation will be discussed in terms of planning and decision-making skills.

(b) The second component consists of a program to familiarize the student with the variety of opportunities, roles, and activities in the world of work, in social and civic relations, and in cultural, recreational, and other leisure time pursuits. This information includes the educational requirements for various occupations, the competencies in terms of developed abilities required for admission and success in these occupations, and the conditions and importance of each of the various roles. Similar types of information would be provided with respect to the other types of adult activities for which the student might wish to prepare himself.

(c) The third component is a program to assist each student to formulate his long-term goals, to take the responsibility for and plan a developmental program to achieve these goals. Each individual would be assisted in relating his personal potentials for developing abilities, his interests, and his values with opportunities likely to be available to him. The program would include substantial training in decision making and problem solving. One procedure which will be used extensively is to give the student practice in making decisions and plans for other students on the basis of their Project TALENT information. The decisions and plans made for the student would then be compared with the experience of this student in real life. This training is being formalized in a career game which would ask the student to make a series of decisions for a specific person with known characteristics. These decisions would cover a period of 10 or 15 years in the life of the hypothetical person whose career was being planned, but would be made on the basis of periodic feedback in just a few weeks by the person being trained in planning and decision making. Feedback would be provided based on Project TALENT data in the same way as in the usual simulation and business games. Only after the individual has shown considerable competence in making plans for these other students which are appropriate and in accordance with their goals and abilities would he be asked to make decisions having to do with his own development.

(d) The last component in the guidance program is a set of procedures designed to assist the student in learning to manage his own development. This development would be defined in terms of his goals and plans. It is proposed that one of the inputs to this program would be the record of critical incidents observed by the teacher which defines certain areas needing improvement in behavior. It is anticipated that at least some students will be able to learn to carry out a program of reinforcement of desirable behaviors which will correct their behavioral patterns in those areas in which improvement is needed. Other students will require more direct assistance from teachers, counselors, and parents in managing their development programs.

5. *Teacher Development.* The teacher development program of Project PLAN consists of two parts. The first part is a 3 day individualized program which uses modules, teaching-learning units, objectives, and tests. To achieve these objectives, extensive use is made of motion pictures and video tapes. In using the motion pictures and video tapes, there is considerable emphasis on modeling for the teacher and actual practice by the teacher of the skills found to be most important in individualizing education along the lines of Project PLAN. This practice is recorded on video tape and critiqued to improve the teacher's performance. The second phase of the teacher development program is the inservice training program. This consists of the identification of problems, the discussion and development of solutions, and the additional use of modeling and practice techniques to develop effective behavior patterns during the school year.

6. *Conclusion.* In concluding this discussion, it seems appropriate to mention that we do use a computer in Project PLAN. The function of the computer is simply to perform clerical and statistical activities of a teacher-support nature. These activities include test scoring, preparing records, filing, matching characteristics, and estimating probabilities. The program could function without a PLAN system is an adaptive system in the sense that the response of the system is modified by the nature of the input. In Project PLAN, in any given subject, inputs and adaptive responses occur at only 2 week intervals in any subject. It is the belief of the group working on Project PLAN that an adaptive system is essential, but that modification of the instructional program at 2 week intervals probably provides sufficient external monitoring. The teacher and student, of course, are expected to be responsive in an adaptive way to student behavior in the interim period.

Comparing the modest objectives of Project PLAN with the enormous task facing psychologists in improving education on the basis of valid research evidence, it seems like a small beginning. To succeed in the major task will require the active participation of many hundreds of psychological researchers. It is hoped that both the trained psychologists and the required support can be found to make the needed rapid progress on this very important problem in the next few years.

SECTION TWO
SPECIAL PRESENTATIONS

Albert Hickey
President

ENTELEK Incorporated
Newburyport, Massachusetts 01950

An Overview of CAI Practices in the United States

ENTELEK is interested in the exchange of information among users of computers for instructional purposes. ENTELEK was formed in 1965 with the support of the Office of Naval Research.

There are two important reasons why CAI should be seriously developed. The first pertains to the ratio of students to teachers. As David Sarnoff has remarked, if we were to maintain the present ratio of students to teachers, by 1973 one out of every three persons graduating from college would have to enter the teaching profession. Therefore, it is necessary to develop a different type of instructional system. The second pertains to the nature of CAI. Of all the media now used in education, none are truly capable of individualized education except the computer.

The present state of CAI is like the Wright Brothers flight at Kitty Hawk. It is hardly of practical significance, but the development of such a technique can hardly be ignored.

Harold Mitzel of Pennsylvania State University maintains that CAI lacks credibility at this moment because of cost, shortage of CAI course content, and the lack of a detailed plan for using CAI in a continuing educational program. To remedy these problems Mitzel suggested the following:

1. move hardware from the category of current operational expense to that of capital outlay
2. organize CAI user groups
3. try CAI on a limited basis where possible.

Other problems also exist. There is the difficulty of evaluating the complexity of the new education system which CAI would make possible. Moreover private industry may look to the federal government as its main partner in CAI activities and not to local governmental and educational agencies. Finally, the existing copyright laws may not be sufficient to protect the publisher and the user of CAI programs.

Many people are asking where will the money come from. At this moment the federal government is the prime source of funds. In the fiscal year of 1967, $40 billion was allotted to education of which 4 billion went to the Office of Education. Of this 4 billion, approximately 8 million was allocated to CAI projects. Sixty computer related projects were funded to some degree by the USOE.

23 CAI projects
6 Projects for programming for specialized data development and analysis
5 Projects for computer models and simulation
4 Projects for data banks and information retrieval systems
9 Projects for the use of the computer for administrative purposes
13 Projects for curriculum development and training for computer applications.

More recently the NSF has formed the Office of Computing Activities to establish a program for the development of CAI. Also, the Department of Health, Education and Welfare has instituted a Commission on Instructional Technology. These represent other potential sources of CAI funding.

There has been some debate on the current status of CAI and the prospects of its future. The debate essentially revolves around the views of Patrick Suppes and A. Ottinger. Suppes maintains the CAI is a reality now; Ottinger claims that CAI will not be feasible for some years to come. In a sense both are correct. CAI does exist now, but whether it is economically feasible for general use remains an unanswered question.

The following universities are considered the leaders in CAI research and development.

University of Alberta	University of Southern California
University of California	Stanford University
Florida State University	University of Texas
Harvard University	University of Wisconsin
University of Illinois	U.S. Military Academy
Pennsylvania State University	U.S. Naval Academy
University of Pittsburgh	

Interest and activity in CAI are not confined to the borders of the United States. The Russians are extremely interested in Cybernetics. The United Kingdom, although 2 years behind the U.S.A. in hardware development, is experimenting and researching the variables of CAI. In general, foreign lands are not as interested in numbers as we are; but rather, they are interested in the systematic research of critical CAI variables.

We can identify the following instructional strategies for CAI.

1. Linear
2. Branching
3. Adaptive. The program requires the computer to make many successive decisions regarding instructional alternatives based on the student behavior during and before he entered the program.
4. Socratic. The program allows the student to assert an answer or solution at any point in the interaction, or to ask for data.
5. Learner-Controlled. This strategy combines the qualities of information retrieval and programmed sequences into a series of maps. Using the maps the student can chart his own path through the course of

study. The student can decide what concepts he wishes to study next.

6. Simulation. The program duplicates in the learning situation the format and sequence of stimulus events in the real world. The student manipulates the simulated environment much as he would the real one.
7. Testing. The computer may be used to assemble tests, mathematical models, and computer-assisted counseling.

We should not just limit ourselves to applying the computer to instructional purposes. The computer must be used for information retrieval, vocational guidance, and classroom management. Without the classroom management system, we are not going to see much success in the application of computers to education.

The problem of estimating the cost of developing CAI software remains unsolved. In general, the ratio of man hours to 1 hour of CAI ranges from 70 to 200 hours. The copyright problem also remains unsolved, although there are some indications that this may not be a problem in the near future. Moreover, as long as ATT does not discriminate between CAI users and personal telephone users, the cost of communication will remain extremely high. Finally, the problem of professional communications regarding CAI is beginning to be solved because of efforts that result in a conference of this type. Many other states are planning similar efforts.

INDUSTRY'S OUTLOOK FOR CAI

Discussants:

Martin Maloney	Heinz Pfeiffer, Manager
Director of Educ. Systems	Educ. Technology Program
IBM	GE

William Bush, Manager
Research and Development
RCA

Martin Maloney:

I would like to offer one personal comment regarding CAI. There appears to be a large amount of impatience regarding CAI on the part of both industry and education. The recent mergers probably account for this. The fact is that CAI is in the research and development stage and therefore, patience is extremely necessary.

The computer can be applied to education in four areas.

1. Administration
2. Research
3. CAI
4. CMI or CBI

Within CAI the following strategies are being developed. 1. Drill and practice, 2. Simulation, 3. Testing, 4. Tutorial, 5. Problem solving.

We define CAI as the process whereby the student receives instruction through interaction with the computer. CMI allows the student to receive prescriptions, but the student has no direct contact with the computer.

At present, it doesn't seem economically feasible to have the more complex uses of the computer in the public schools. However, industry and the military do find it economically feasible and educationally valuable to have full tutorial programs.

We often ask the government how we can advance CAI. They usually ask us to lobby in a sense to obtain funds. The highway type of funding – the 90/10 ratio of federal to state funds – is necessary for the adequate development of CAI.

In general, the computer will not replace the teachers. However, their role in the classroom will change. Also, CAI should be developed in such a way as not to impinge upon the autonomy of the local school system.

Heinz Pfeiffer:

General Electric Company is working in the CAI area of problem solving through the Dartmouth and Altoona Projects. From the studies relating to CAI drill and practice, it is found that the low ability experimental groups gained significantly and that the high ability experimental groups did not. It is often suggested that the gain can be attributed to the patience of the computer.

In the area of simulation-gaming the computer can play the role of nature. Perhaps the computer should not give immediate feedback. Moreover, ways should be found whereby groups of students can play against each other by means of a terminal. In our experience with the development of tutorial programs with educators, we find that the educator wants the computer to be an aid, and the industrial staff want it to be more of a total approach.

A close examination of data collection and evaluation techniques is necessary. The two basic questions remain: what data are we to collect, and how are we to handle and communicate these data? From answering these questions, perhaps the student's permanent record folder will contain more pertinent information than that which is now contained in a sentence or two.

William Bush:

The generation of appropriate and useful curriculum material is a major issue with CAI. In this regard, industry has the responsibility not only for the development of hardware systems, but also for the presentation of techniques, procedures and methodologies whereby the materials for the systems can be validated.

Industry has to offer data processing systems that are multipurpose in nature. We cannot understand how the educator can use the hardware for CAI alone. This is an inefficient use of the computer. Again, it is the responsibility of industry to design systems that can effectively handle administrative, research, CMI, and CAI services.

By research, we have to ascertain what types of terminals are appropriate for what educational purposes. We have found that students working with terminals with audiovisual capability often loose the sense of rhythm that is natural with the teletype terminal. More research must be performed to ascertain the type of equipment that is appropriate for a given CAI activity.

From the question and answer period that followed, these comments deserve note.

1. The cost of CAI cannot be judged from the R and D activities now operating. Also, it is not appropriate to compare CAI R and D cost with EDP operational costs.
2. In some CAI activities an immediate feedback can be changed to a 24 hour turn around.
3. The state of the art has not progressed far enough to justify massive funding for CAI implementation. By 1973-75, we can take a step away from pure research. In the meantime we should continue the research and development of hardware and software systems.
4. The only way to obtain vendor support is to have collective need.

Andrew R. Molnar, Acting Director
Division of Higher Education Research
Bureau of Research
Office of Education

THE FRONTIERS OF COMPUTERS IN SOCIETY

Future of Computers in Education

It is clear that the computer industry is as much a basic industry as steel. Computer concepts and applications are permeating all levels of education. The President's Science Advisory Committee in their report "Computers in Higher Education" stated that an education without adequate computing experience is a deficient education just as any education without adequate library facilities would be a deficient education.

Unfortunately many of today's uses of computers are inappropriate. We still insist on adapting the computer to the old curriculum and it is possible to find students using a sophisticated computer to add two and two. In the future, educators will recognize the new degrees of freedom available to them and develop new curricula.

In the Higher Education Amendments of 1968, a request has been made for the establishment of "knowledge networks." This is to provide for inter-institutional arrangements for the use of such facilities as library networks, closed-curcuit television networks (CCTV) and computer networks.

In addition to this, a commission has been set up under the provisions of Title III of the Public Broadcasting Act of 1967 to study instructional television and telecommunications in education. The role of the computer and computer networks will in all likelihood be a major concern of this Commission.

The Bureau of Research of U.S.O.E. has initiated several studies on the feasibility of a computer utility. Our objective was to determine what computer services could be installed in a centralized facility which would serve 100,000 students within a 100 mile radius at a minimal cost and to evaluate the worth of these services. Interestingly enough, independent studies snowed that it would be possible to provide the administrative computer services for the schools, junior colleges, and universities within this area during the post-school hours while providing terminals for students for problem solving, computer concept and vocation training during the school day – all of this for less than 1 percent of the school's operating budget. Currently the Bureau of Research is initiating a project to develop and demonstrate this concept. It is also contemplated that student guidance, computer managed instruction and library functions will also be ultimately added to the system.

What do these developments mean for the future of education? It means that the organization, planning, administration, and curriculum of tomorrow will be significantly different from what we commonly imagine as education.

At the higher education level there is a trend toward the "multiversity" with television and computer networks. In all probability, the education of the future will be less formalized, more field oriented with users being located at remote terminals. What will be tne organizational configurations, the curricula, and the effects and consequents of such an education is one of the major concerns of higher education research.

Social Problems

Roy Buck of Pennsylvania State University has noted that necessity was once thought to be the mother of invention; today invention has become the mother of necessity. Technology is the bellweather of social change, pushing ahead while social institutions follow. Mr. Buck also observes that social institutions and technology are seldom in harmony. When technology advances there is stress on social systems which will have traditional norms and values based upon obsolete, and erroneous information.

There seems to be a pattern to all of this. First, we argue that the old institutions and the old ways are best. Then we somehow try to apply the new technology to the old methods and produce minimal improvements. Finally, we recognize the problem and eventually society accepts the new ways for what they are and retains the best of the old for what it can do. And so we progress. So it is, and so it has been.

Today, in education we can identify many areas where the new technology offers the potential for educational advances, but the norms and values of our social institutions are in conflict. We in education strongly believe in local autonomy; on the other hand, cost trend to make modern technology most economical on a regional or national basis. Consequently our 23,000 school districts and 2,200 colleges and universities tend to do without. Today, it would be much easier to put up 25,200 communication satellites, one for each autonomous school district, college and university, than it would be to put up one for all of them.

In one educational computer project the communications line costs amount to 45 percent of the entire project. The reason for this is that the Federal Communications Commission has a nondiscriminatory policy toward education. That is, education pays the same rates as do commercial enterprises. Commercial firms can, however, get discount rates because they can use the services for many more hours per day than does education. This is but one case in which we find society's commercial values in conflict with social needs.

The efficient use of the computer as a data bank, library information storage and retrieval system and a computer-assisted instruction device conflict with present copyright laws. If we are to follow existing custom and practice, it becomes quickly apparent that the cost of black boxes which are required to keep record of useage for royalties become the major costs of the system.

What is required to bring technology and social institutions into equilibrium is a reevaluation of our social assumptions. It has been claimed that a negative income tax could accomplish what our welfare programs are doing without the undesirable side-effects; that if we paid all automobile accident claims without processing or taking cases to court that the insurance rates could be maintained or reduced; and that if we did away with the time-and-distance formula for long distance calls and had a direct-dialing system our unit costs would not increase significantly.

I cite these, not as answers, but as significant attempts to reevaluate our social concerns and policies in the light of technological advances.

So what of the future? Will education solve man's problems? There is a story of an old Indian who watched the building of a new lighthouse. Sometime later a heavy fog began to roll in. The Indian said, "Light shine, bell ring, horn blow, fog still comes in." The moral to this story is that like the light educational technology will not stop the fog from rolling in, but it is capable of guiding many ships safely along their course to their ultimate destination.

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PRESENT AND FUTURE CAPABILITIES OF COMPUTER TECHNOLOGY FOR CAI

The University of Illinois has been experimenting with a computer-based educational system (PLATO) for the past 8 years. This system has evolved from a single terminal connected to the ILLIAC I (a medium-speed 1954 vintage computer) to a computer classroom of 20 graphic-pictorial terminals connected to a Control Data Corporation 1604 computer. Some of the areas in which studies have been conducted are electrical engineering, geometry, biology, nursing, library science, algebra, math drill, computer programming, and foreign languages. This material has been presented by use of a variety of teaching strategies, ranging from drill and practice to student-directed inquiry. This talk describes the PLATO system which has evolved over the past 8 years, illustrates some of the pedagogical methods we have used, and most important, describes the development of an economically viable system. Some of our guidelines for developing the system's software and hardware are:

1. normally the computer should only be used when it is the best method of presentation. Less expensive methods such as program texts, films, slides, tape recorders, etc., should be used when appropriate.
2. the computer should be used as much as possible to simulate results in models built by the students rather than simply turning pages.
3. the system must be flexible and adaptable. It must be able to teach many subjects and present the lesson material by a variety of teaching strategies. The system must change to meet the needs of the students and teachers, and not be limited to off-the-shelf items presently available.
4. the system design must consider its method of integration into the educational system. For example, a school should be able to start with a single terminal for the incremental terminal cost instead of having to invest large sums of money just to determine if they want or need CBE.
5. the cost of computer-based education should be comparable with the cost of teaching at the elementary grade school level. Cost effectiveness should be determined by an hour-to-hour cost comparison (25 cents per hour of terminal use for the computer and terminal).

A present student terminal consists of a keyset and a television monitor. Information viewed on the television monitor is composed of a slide selected by the computer (random access time less than 1 millionth of a second) and a superimposed image of graphs, diagrams, and alphanumeric characters drawn by the computer in a point-by-point fashion. The student uses the keyset for constructing answers, questions and for setting up simulated or real experiments as well as for controlling his progress through the lesson material. The computer responds to the student's requests within one tenth of a second.

The computer also controls other devices, such as movie projectors, lights, etc. The students at the terminals can interact with each other through the computer, thus permitting games to be played which require communication between the players.

In addition to keeping detailed records of the student's performance, the computer can provide individualized instruction, immediate feedback, and remedial training by the use of complex internal branching and the alteration of presentation or type of material based on the student's past performance. These unique features seem to make the computer an ideal instructional device for developing cognitive skills.

To encourage development of critical thinking skills, the author presents the student with questions or problems commonly encountered and sets up the teaching strategy so the student must think about what information he needs about possible solutions to the problem or sources of information, interpret the data gathered, and test his solution. The computer immediately provides appropriate feedback to open-ended questions, thus reinforcing a correct approach, or in the case of an incorrect response, encouraging the student to a new approach.

The computational use of the computer appears in several ways. First, experiments are simulated by the computer, immediately providing the student with results he uniquely requested. These same results might require hours or even days to calculate by hand. Second, a large amount of computation is involved in processing student responses. The more flexibility provided for the student to answer a question, the more feedback is needed to inform him of the correctness of his response. When only multiple-choice responses are required, the processing is relatively simple. But when the student is permitted to construct long alphanumeric and graphic responses, the computer must analyze his answer to see if it is equivalent to a correct response, check for spelling and completeness of the answer, as well as inform him which part of an incorrect answer is unacceptable. To illustrate how the computer interacts with the student we will describe some sequences taken from lessons in geometry, electrical engineering, and maternity nursing.

A user's computer language consisting of English directives was used to write a series of 15 lessons in informal geometry. These lessons were to give 7th and 8th grade students an understanding of geometric concepts. A grid is provided on which the student draws and manipulates geometric figures. The computer is used to determine the correctness of the figure, independent of its size, location, and orientation on the grid. The student must select points of the grid to be used as the vertices of his figure. To do this, eight keys on his keyset have been defined which move a bright spot around on the grid. Once a student has decided on a point, he communicates his selection to the computer by pressing the MARK key. He presses the CLOSE key to close the figure (connect the first point to the last point). To judge the figure the student presses NEXT and the computer either okays the figure or indicates the student's error.

In the following sequence, the student is asked to draw quadrilaterals with a single line of symmetry. The student is instructed to draw a quadrilateral with one line of symmetry: the two possibilities are an isosceles trapezoid and a kite. He selects the points he wishes to use for his figure and marks them. The student partially constructs a trapezoid. When four points have been marked the student closes his figure and asks the computer to judge it. The completed figure is judged and the computer points out to the student that the symmetry line for an isosceles trapezoid does not go through the vertices.

The student then moves to the next page of the lesson and is asked to draw a quadrilateral with a single line of symmetry that does go through the vertices. The student, however, reconstructs the trapezoid. The computer, when judging the figure, recognizes the duplication and tells the student that he has drawn the same figure as he drew before. The student then draws a kite which has a single line of symmetry through vertices and the figure is judged OK.

For our second case we use a sequence taken from a circuit analysis course in electrical engineering. The student has just analyzed a circuit containing a battery, a switch, an inductor, and a resistor, all connected in series. His task is to determine the value of the inductor and resistor that causes the current waveform to pass through the points marked on the graph after the switch is closed. He is instructed to make the resistor value small and notice the effect of the inductor on the initial slope of the current waveform and then vary the resistor and notice the effect on the final value of the current. By manipulating these values, the student gains an intuitive feeling for the effects of the inductance and resistance, and he can proceed in an orderly way to determine their correct values.

The third example is taken from a maternity nursing lesson where the student is presented with a question which asks her to list two cardiovascular compensations which occur as a result of the increased blood volume during pregnancy.

The student, needing information to answer this question, presses the button on her keyset labeled INVEST. She is then presented with a slide where she indicates that she wishes to investigate "Anatomic and Physiological Changes of Pregnancy."

After choosing her area of investigation, she is presented with a slide which requests further specification. Here the student indicates that she wishes information concerning changes which occur in the circulatory system during the third trimester of pregnancy. Having done this, she presses the ANSWER button and the computer generated information tells her there is an "increase in blood volume, a 50 percent increase in cardiac workload, left ventricular hypertrophy, and vasodilation produced by an increase in progesterone." Deciding that increased workload is one compensation, she considers left ventricular hypertrophy, but needs to further clarify the word hypertrophy. By pressing the button labeled "DICTIONARY," she is presented with a list of terms used in the lesson. The student types the word "hypertrophy" and the computer supplies the definition "increase in size of an organ or structure."

By pressing the button labeled AHA, the student is returned to the question on which she was working. Here she types the answer "hypertrophy of the left ventricle" and the computer judges it OK. However, the answer "the left ventricle" is judged NC, that is, correct but not complete. Next, the response "the left ventricle decreases in size" is entered. The computer responds NO and XX's out the word "decreases." Rewording the correct answer, the student types "the left ventricle enlarges" and the computer responds OK. However, when the student presses the CONTINUE button to advance to the next page, the computer prints out "Duplicate Answer." Before the student can continue, she must change one of her responses to a correct answer which differs from the first.

Records of each student's request (his identity, the key pushed, and the time to the nearest sixtieth of a second) is stored on magnetic tape. A complete rerun can be initiated by playing the record tape into the computer. These data are processed by the same computer that is used for teaching. Approximately fifty million student requests have been stored for processing. We have used these records for improving course content, designing better teaching strategies, as well as in planning new, economically viable computer-based education systems.

On the basis of CERL's experience with early PLATO systems, certain design philosophies for the proposed system have been formulated. First, each student terminal requires a keyset and a display, both connected to an inexpensive data transmission system which can also drive optional equipment such as random-access audio devices, reward mechanisms, movie films, lights, and so forth. Second, each student terminal must be capable of superimposing randomly-accessed color slide images and computer-generated graphics. Third, the system should be controlled by a large-scale, centrally-located computer rather than many small computers located at the classroom sites. This decision is based upon social and administrative factors as well as on system economics. Semiconductor large-scale integration techniques may some day make the use of small computers as effective as large ones, but the added human expense of operating a computer center does not promise to scale as effectively. It is our opinion that the initial low cost of a single terminal will permit tightly-budgeted public school systems to economically incorporate computer-based teaching into their programs. The number of terminals could be increased or decreased as the needs of the school system dictate. Fourth, the cost per student contact hour for the proposed system must be competitive with equivalent costs of traditional teaching methods at grade schools, high schools and colleges.

Computer Evaluation

Statistical records of over 5×10^7 requests on PLATO indicate that the average request rate per student is approximately one request every 4 seconds. These records also show that average computer execution time per request for the CDC 1604 is less than 20 milliseconds, equivalent to executing approximately 1,000 instructions. The request rate probability density function versus computer execution time is approximately an exponential curve, therefore, student requests requiring the least amount of computer time occur most frequently. For example, the simple and rapidly-processed task of storing a student's key-push in the computer and writing the character on his screen represents 70 percent of the requests. On the other hand, the lengthy process of judging a student's completed answer for correctness, completeness, spelling, etc., occurs only 7 percent of the time.

Several existing large-scale computers can perform about 4×10^6 instructions per second. Even if we double the number of instructions needed to 2,000 per student request, it is seen that these large-scale computers require an average processing time of only 500 microseconds per request. Allowing a safety factor of two to insure excellent system response time, the system can accept an average of 1,000 requests per second. This safety factor implies that the computer will be idle approximately 50 percent of the time. However, the computer time not utilized in processing the student requests can be effectively used for other purposes. Since the average student request is 1/4 of a request per second, the system can handle up to 4,000 students simultaneously allowing one millisecond to process a request. Assume that the student input arrival time is Poisson distributed (a reasonable assumption for 4,000 independent student stations), and that the request rate probability density function versus computer execution time is approximately exponential (PLATO statistical records substantiate this). For an average computer execution time of 500 microseconds and an average request rate for 4,000 students of 1,000 requests per second, it is determined from queuing theory that the expected waiting time that elapses before the computer will accept a given student's request is approximately 500 microseconds. The probability that the student must wait for as long as a tenth of a second is negligible. Hence, the probability of a student's request queue becoming long, or of the student experiencing a noticeable delay is very small.

Each student needs to be assigned approximately 300 words of extended core memory to be treated individually. The maximum used in any teaching strategy has been 600 words per student. Let us allow on the average 500 words (fifty bit) for each student for a total of 2×10^6 words for 4,000 student terminals. Our data shows that 20 percent of the computer instructions refer to these words individually assigned to the students. Therefore, the system must be capable of rapidly transferring data between the slower extended core storage and the high-speed core memory. Some existing computers are capable of transferring data at 10^7 words per second, requiring only 50 microseconds to transfer the data each way between the memory units. This transfer time is acceptable.

The peak data rate from the computer to each student station is limited to 1,200 bits per second to permit data transmission over low-grade telephone circuits, a system feature made possible by the use of the plasma display panel discussed later. For 4,000 stations the worst case data rate would be about 4.8×10^6 bits per second, well within the present state of the art for buffering data out of a computer.

Summarizing the computer requirements, therefore, the central computer requires about 2×10^6 words of extended core memory capable of high-speed transfer rates to the main computer memory, it must have an execution time of at least 4 instructions per microsecond and be capable of transmitting data at a rate of 4.8×10^6 bits per second. There should be a sufficiently large memory (64k to 128k words) in the central processing unit for storing lessons (1k to 2k words per lesson) and for the various teaching strategies. Several existing computers meet these requirements.

Cost Analysis

The main frame cost of a computer meeting the above requirements is approximately $\$2.5 \times 10^6$. The additional cost for two million words of memory and other input-output equipment is approximately $\$2 \times 10^6$. An estimate for the system software, including some course development programming, is another $\$1.5 \times 10^6$. The total of $\$6 \times 10^6$ amortized over the generally-accepted period of 5 years yields $\$1.2 \times 10^6$ per year.

Assuming that the 4,000-terminal system will be in use 8 hours a day for 300 days a year, there are approximately 10^7 student contact hours per year. The system costs, excluding the terminals, is thus 12 cents per student contact hour. In order for the cost to be comparable to a conventional elementary school classroom cost of approximately 27 cents per student contact hour, the terminal costs must be limited to 15 cents per student contact hour, or to a total cost of about $\$7.5 \times 10^6$ over a 5 year period. The cost for each of the 4,000 terminals, which include a digitally-addressed graphical display device and its driver, a keyset, and a slide selector must therefore be a maximum of approximately $1,900. Present indications are that this cost can be met.

Using newly-developed technological devices it is economically and technically feasible to develop large-scale computer-controlled teaching systems for handling 4,000 teaching stations which are competitive with the cost of teaching in elementary schools. The teaching versatility of a large-scale computer is nearly limitless. Even while simultaneously teaching 4,000 students, the computer can take advantage of the 50 percent idle time to perform data processing at half its normal speed. In addition, 16 hours per day of computer time is available for normal computer use. The approximate computer cost of 12 cents per student contact hour pays completely for the computer even though it utilizes only 1/6 of its computational capacity. The remaining 5/6 capacity is available at no cost.

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WHY CAI IS REALLY A LATE, LATE SHOW

THE COMING OF AGE OF THE COMPUTER

All that follows is based on the presupposition that the growth of the computer is going to parallel the growth of other technologies that have been born and have grown to maturity in this century and the last. According to this presupposition, then, the computer is entering adolescence now and will reach maturity in the coming 10 year period. The first point to be made concerning these technologies is that, in each case, we can see an abrupt transition from a period of groping attempts to develop and exploit the new technology to a period of successful exploitation of the technology, a period in which services based on the new technology became an essential part of the workings of society. The second point to be made is that, in almost every case, the transition of the technology to maturity began when the technology was one generation old—33 years. The third point is that about 10 years was all the time that was needed for the technology to reach maturity and become the basis of an established industry.

If 1937 is accepted as the birth year of the computer, signs of the adolescence of the computer should be visible now, and the computer should be expected to pass through adolescence between now and 1977. The chief signs of pending maturity of the technologies are signs that the technology is moving from a specialist role where one had to be an expert in the workings of the technology to use it to a role where anyone could use the technology.

In the earlier days of the computer, to avail oneself of the services of the computer, one had to make the computer and write the programs that would make it work. Today, one still has to write programs that require technical knowledge of the internal workings of the computer. But, if the computer develops in the way the other technologies have developed, tomorrow one will be able to avail oneself of the services of the computer by specifying a service or result desired; the service will then be furnished without any knowledge on the part of the person requesting the service about what went on in the computer to provide the service.

A central development will be what is the counterpart in the realm of the computer of movie making in the motion picture technology, highways and airways in transportation, and broadcasting in radio and TV. This counterpart is the production of bodies of "data," held in networks of computers, that can be consulted and used by anyone on a demand basis. The production and maintenance of the bodies of data—they are coming to be called "data bases" will constitute a new form of publishing. In time, the range of subjects "published" in the form of computer data bases will be the same as the range of subjects covered in conventional publishing, and from the libraries the role of developing and maintaining the human record.

A broad range of data services will develop as the computers mature, that will become a new foundation of intellectual work and, accordingly, for society and life generally. A service that will occupy a central role is simulation. As a technical term, "simulation" refers to using one process to represent another process. Rehearsing, practicing, and some forms of game playing can be counted as instances of simulation; but, these days, "simulation" refers to using computing processes to represent other processes.

THE COMING OF AGE OF THE NEW VIEWS

That the computer will be growing to maturity and attaining wholly new powers during the coming decade is, for me, a presupposition on which everything that I have to say about education is based. Another presupposition on which everything I say about education is based is that new modes of perception and understanding will also grow to maturity during the coming decade. In fact, these presuppositions are one; that is, the consistent application of the new modes of perception to the computer itself that brings forth the new modes of functioning and new powers of the computer; and that it is the computer functioning in new modes that brings the new modes of perception to each individual and to maturity. The way that is easiest for me to set forth what I see to be the essential features of the new modes of perception or new views is to set forth ideas of people that I identify with the established views and with the emerging views.

The modes of perception and the views of the world that stand as the established modes and views of the Western World, and that stand as presupposition behind every word written in the textbooks of our schools were given definitive formulation by Descartes and by Newton. Descartes divided the world into material things and into knowing minds and established the doctrine that what merits knowing can be known in terms of quantity. Descartes' proposals were given triumphant affirmation by Newton's theory of universal gravitation which gave to phenomena as diverse as the fall of an apple and the movement of celestial bodies a simple and elegant quantitative formulation.

Slowly but surely, however, the doctrines established so firmly by Descartes and Newton are giving way; the evidence is by now widespread that the years immediately ahead will bring the final removal of these doctrines from their central position and their assimilation into the more general doctrines.

A generation ago, Whitehead was completing a formulation of views that he called an organic philosophy. Central in this philosophy was the view of phenomena as process and as system of processes; no matter how far one's analysis of phenomena might be carried, nothing could be encountered that was not itself a process and system of processes. Central also was the view that mental processes were not set apart but were integral with other processes in nature.

Beginning a generation ago, Whyte undertook development of a doctrine in which a process view of phenomena and a unified view of mental functioning and other functioning in nature were central. Central also was the proposition that a new, humane science was in the making that would bring a solution of the problem of form and restore to form and aesthetic sense their earlier role as basis of intellectual processes.

McLuhan sees one of the greatest changes in the history of man taking place as electric technology replaces print technology as the primary extension of mans' nervous functioning. McLuhan proposes that, with electricity, the primacy of process is restored, the interrelatedness of all processes is reaffirmed, and the transformation of the functioning of man by his technologies is made evident.

Fuller sees the possibility of a fundamental advance in the condition of man through developed capacities for design and planning. Fuller sees the use of the computer, especially the use of the computer as a simulator as a crucial factor in the new capacity to make the world work.

A generation ago, Korzybski was advancing doctrines that may be counted as the principal precursor of doctrines that are now coming to the fore. Korzybski was proposing a new orientation in which the process character of nature was fundamental, human nervous functioning was continous with other functioning in nature, and in which the adequate use of man's unique symbol making capacity was fundamental for both "Science" and for "Sanity."

Spengler advanced and treated at length propositions concerning "styles of knowing" and the interrelatedness of expression means and symbols of all kinds with styles of knowing. Spengler undertook to identify different styles of knowing with each grouping of individuals, but most particularly, with those groupings that he identified as the major cultures. Spengler emphasized that we tend to presuppose that the progress of man is a concomitant of the accumulation over the millenia of a growing stock of eternally valid knowledge of the world; in actuality, however, the knowledge of the world accepted by a group of people is just one of an indefinitely large number of possible ways of representing the world.

Dewey may be considered to bring to our roster the ideas of an American line philosophic advance including those of James and Pierce. For Dewey, the discovery in the individual sciences that it is not "fixity" but "process" that is universal is the most revolutionary discovery yet made.

Once this discovery moves out of the realm of science and philosophy, the social consequences will be far reaching. In "pragmatism," Dewey, James, Pierce, and others were advancing views that were a precursor of the systems views that are now coming to the fore, which call for primacy to be given in one's view of anything to the effects secured by the thing in its environment.

Goethe was the founder of "Morphology," a science of form, the maturing of which Whyte sees, and perhaps, McLuhan and Fuller see as the foundation of the new science. Goethe's view of the world was an organic view, and, by the standards of the mathematics of his time, an unmathematical view. For Goethe, it was the evolving pattern and form in any situation that was the key to understanding and to vision, Goethe stood in fundamental opposition to the doctrines of Descartes and Newton that were ascendant in his time, even in his own country.

One generation after Descartes and during the lifetime of Newton, Leibniz was not simply declaring his fundamental opposition to the doctrines of Descartes and Newton, he was advancing alternative doctrines that come close to constituting the doctrines that are coming to the fore today. An inventory of the central points of Leibniz's doctrine constitutes an inventory of the central points that have emerged from our consideration of the maturing of the new views.

Leibniz is to be counted as the originator of the modern organic philosophies. For Leibniz, there was only process or activity and systems of processes and activities. There was no lower limit in the analysis of the processes of nature that was not itself a process and system of processes. There was no "matter" in "space", there was only systems of processes everywhere potentially interrelated with all other systems of processes. Any division of the processes is a division of all of nature into two interrelated parts. Our knowledge of our environment is not to be understood in terms of a "stock of knowledge" that is built up, recorded, and "taught," it is to be understood in terms of the development by each individual of representations of his environment.

Notational systems for expressing or setting forth our representations constitute a technology that is capable of being improved fundamentally in effectiveness and efficiency and of giving men fundamentally improved capacities to express and convey understanding. It is of very special significance in connection with our topic that Leibniz is the only man in all history to experiment systematically over the greater part of a lifetime with mathematical notations. It is not merely fortuitous, accordingly that Leibniz's contributions to our mathematical notation are greater than those of any other individual. Leibniz's experimentation was part, however, of a project that occupied Leibniz from the age of 18 to the end of his life, to construct an expression means that would have the power noted above to enhance fundamentally to capabilities of men to understand and convey understanding. Liebniz called his expression means his "Characteristic" or his "Universal Characteristic." He saw his Characteristic as making possible a "Universal Science," and, accordingly, a "Universal Encyclopedia" in which all of man's thoughts could be held in ordered array.

The task that is presented to us now as the computer enters adolescence and the New Views approach maturity is the task that Leibniz set for himself nine generations ago. The prospective accomplishment of this task is viewed with foreboding by many; but to characterize this task the words used, by one of the greatest geniuses the world has known and the man who considered the task longer and more carefully than anyone else may offer encouragement:

> **I dare say that this is the last effort of the human mind, and, when this project shall have been carried out, all that men will have to do will be to be happy, since they will have an instrument that will serve to exalt the intellect not less than the telescope serves to perfect their vision.**

FUSION OF THE MEDIA

By the new views, everything in nature including man, consists, in effect, of its system of connections with its environment. In the case of man, the system of connections includes the instrumentalities and technologies by which man has perfected, first his physical capacities, then his sensory capacities, and, more recently, his intellectual capacities. These instrumentalities and technologies literally constitute intermediaries of media between the raw functioning of the individual and the environment of the individual. The history of man, thus far, is very largely, a history of the development and of the workings of these media.

The coming of age of new views and, accordingly, of the computer constitutes, in effect, the coming of age of the whole system of media that connect man and his environment. As the media comes of age, they become transformed.

Up to now, the media have perhaps not constituted a system but a collection, a collection that has grown by accretion and that has emphasized mechanism and the perfection of man's physical capacities. Now, however, the media are coming together into a system that is not mechanical but organic. The new system of media will literally constitute an organic system of connections between each individual and his environment which includes, of course, each other individual. The new system of media becomes capable of a high and growing degree of self-development; parts of the system of media can make other parts of the system and place them in operation. operation.

In recent generations, a component of the written record has grown that already manifests the transition of the media from mechanical to organic. This is the growth of the scientific record as the foundation of exact knowledge and communication; a record that is created and maintained in strict accordance with canons of the scientific communities and that may subsequently, any time, give birth to ideas or aid development of ideas and actions that will then be duly recorded in the scientific record. Accompanying the growth in recent generations of the scientific record is the growth of media that speed measurement and experimentation, and speed and extend by enormous factors communication, computation and control. In recent generations, there have been enormous extensions also in the order media, the vehicles, weapons, and tools.

As the computer comes of age and the fusion of the media takes place in the years ahead, man is literally catapulted onto a new plane of existence. None of the features of his existence on the plane that he has occupied during the historical period up to this day will remain unchanged. The central task that is presented is nothing less than providing a wholly new education for the new generations, and an entire reeducation for the generations now alive.

THE NEW EDUCATION

Our present educational approaches were designed in and for the industrial age that is now passing; they must be replaced by approaches designed to meet the needs of the new age that is before us.

Our present educational approaches were established originally to meet the need for each individual to be literate – to have some mastery of the forms of written expression which were the foundation of the industrial age. The approaches were extended to meet the need for each citizen in a democratic society to be knowledgeable about his society; they were extended again to meet the need for citizens who could perform the established tasks of an industrial society.

But the established forms of written expression are being supplemented by new media with new powers that are evolving into a unified system of media the need is presented for the children to have some mastery of the full range of media; and the capacity to acquire mastery of new media as they evolve.

The rate of progress toward the new era and wholly new conditions of life means that no fixed stock of knowledge acquired in school will prepare a person for life; it means that each person must have the capacity to acquire the knowledge needed to perform intelligently as an adult. They mean also that the acquisition of an established skill in school must be replaced with the capacity to acquire skills as they are needed.

The new educational approaches must aim at developing the capacity of each individual to use and to avail himself fully of the powers of the new media; they must aim at developing the capacity of each individual to perform and accomplish new tasks. In short, the task of new education is to develop the full range of the capacities of each individual to the limit of each individual's potential and to strengthen the desire of each individual to use his developed capacities constructively.

Each individual community is called upon to establish new educational programs to accomplish the new task of education as effectively as it can be accomplished with the resources available to the community.

To establish the new educational program, those who assume the responsibility in each community are called upon first to identify and define in terms that are meaningful to them and to the members of the community those human capacities the development of which is to be established at one part of the educational task; they are called upon, too, to define the constructive use of developed capacities.

Those responsible for education are called upon next to identify and define as many things as possible that could be made a part of the educational program, and which would, if made a part, contribute to developing capacities and desires for constructive use.

Those responsible for education are called upon as a third major step to determine how the means that are available can be brought together so that the task is accomplished as effectively as possible with the resources that the community can secure and make available.

The third step also constitutes the design of a new educational system. In accomplishing this design, there must be no assumption that any features of the existing systems are to be retained in the new system. The working out of the most sensible transition from the existing system to the new system is the task of a subsequent step.

The three steps together and the subsequent working out of a transition program constitute the application to education of the New Views considered in Section 2. The consistent and comprehensive application of the New Views to education can give us the new education needed for the new age and will secure the coming of age of education.

No one has yet carried out fully the design of a new education system, but such design programs are in progress, and results secured portend success.

On the basis of results secured, one may say with confidence that there is virtually no connection between the kind of system determined to best accomplish the new task and existing educational systems. One may say also that a very large part of what goes on in the existing system is not simply less effective than it might be in accomplishing the new task, it works against the accomplishment of the task and toward the destruction of the capacities of the children.

The design of a new educational system is in progress at Furnace Woods. A first inventory and definition of the capacities of each child that it is the task of the educational program to develop has been produced.

Based on the inventories of capacities and means for developing capacities, proposals have been made concerning the principal design features of a new system for accomplishing the educational task and concerning the implications of these design features for the physical environment to be created for the new education program.

As work proceeds on inventorying the means by which each of the capacities can be developed, it soon becomes clear that means that are crucially important for every capacity are exposing children to instances of already well-developed capacities, and providing opportunity for successful exercise of capacities.

To say this is in one sense to expound the obvious; to say it is to say that most schools do not use the two most important educational resources that are available, and it is to say that systems designed to make full use of these resources are radically different from the existing systems.

In a system in which children are exposed to instances of already developed capacities, the older children work systematically with the younger children, capable people in the community work systematically with the children and the staff, and the whole school is turned into things going on that exemplify capable people in action.

In a system that provides opportunity for successful exercise of capacities, the ability to perform and the evidence of actual and meaningful accomplishment - no matter how modest - becomes the basis of evaluation and the guide to action by the staff.

It becomes clear also in designing an educational system to accomplish the new educational task that learning through direct observation and experience, providing opportunity for utilizing all the senses, reducing dependence on language, and maintaining balance between the concrete and the abstract are crucially important considerations.

A central design feature that is proposed for the new educational system is that there be systematic progression in all that is done from the concrete modes of representation to the abstract modes and back again. In as much as possible that is done. Experiencing and observing are to precede the abstract symbolizing of experience. As far as possible, as Holt has proposed when abstract methods are taken up they must appear to a child as a better way of dealing with something that he can already deal with in more concrete ways.

In the nursery schools and kindergartens, and sometimes into the primary grades, the children do work at connecting themselves directly to their environment by experiencing and observing things directly and with the aid of enactive and ironic representations - by mimicking and play acting and by models and pictures. In their play acting, they also translate imaginative ideas into ironic and enactive representations: they create new environments and live in them for extended periods.

In this work the children are physically as well as mentally active; they use and develop the full range of their mental, sensory, and other capacities. They continually accomplish things and are delighted and motivated by their accomplishments.

In the first grade, however, things change. The first task of the schools, the development of capacities to make sense out of the marks on surfaces that man has devised to record linguistic expression, takes command. For most of the children who trail the leaders in making sense out of marks, there isn't time for much else. For the leaders, the approbation of the adults around is earned by assimilating more and more of the markings.

What has happened is that the children have been catapulted from the level of direct experience and observation and enactive representation to the level of symbolic representation - to description and to theorizing. Thereafter, they are held at this level - held to the books and to lecturing and teaching that often could come directly out of a book.

When account is taken of the limitations of symbolic representation, there is movement toward the less abstract levels. "Audiovisual Aids" are brought into supplement written material and verbal discourse. These include projections of multi-layer transparencies, movies, models and a growing range of other ingenious devices.

There is further movement toward experiment in the sciences and to nature walks, toward field trips, toward the creation of habitats - the environments of other times and places. But these are all means of "enriching" a program that has, at bottom, the task of securing reasonable mastery of particular technical means of constructing symbolic representations. Their use at all, or their value, if used, is dependent on the ingenuity and energy of the individual teacher.

The way out of the situation that has developed is not, of course, through improved operation of the present educational system; it is to recognize that a wholly new situation is developing in which a wholly new educational system is needed and can be provided. The new computers and the unification of the media and the means of representation that the computer makes possible creates both the need for the new educational system and the means for satisfying the need.

There have been gaps in the means of representation that have made systematic progression back and forth across levels of abstraction very difficult, and there have been difficulties in securing an awareness of the workings and the relationships of language and other means of representation that we are only now beginning to be able to overcome. But, simulation, the new key function of the computer, fills the main gap that has existed between the changing processes of nature and the static collections of marks on surfaces that have undertaken to provide representations of these processes, and the new languages or notational systems that are, in effect, the computer itself can give new awareness and understanding of the workings of language and the interrelations of the forms of representation.

Up to the present time, the new computers have, of course, been performing the tasks of the old education that, with the computer are no longer required. In performing accounting tasks for education, the computer is performing tasks that it performs effectively for every kind of enterprise, but in performing scheduling, testing, and grading task, the computer is performing tasks made obsolete by the computer itself. In undertaking to perform or assist in tasks of teaching or instruction, the computer is assisting or performing a task that is obsolete. It is in this sense that CAI is a late, late show.

The computer and the unified media made possible by the computer become a new foundation of intellectual functioning of all forms including the forms that we call education and including the education of the young. The capacity of the young to avail themselves fully of the new media, and, through the new unified media, to strengthen their connections with their environment are to be developed as are other capacities through successful use of the new media.

We are to establish as a schedule for the development and introduction of the new media and for the introduction of the new education the schedule of the growth of the children that have been born in 1967. If we set ourselves the task, we can see that when they are 2 and 3 years old, they can be served by educational approaches that have been known for two generations to be effective, but which have not been used; when they are 5 and 6 years olds, they can be served by new educational approaches that take the new computers fully into account and by the new computers themselves.

If we set ourselves the task, they can continue to be served by the new education in ways that do develop the full range of their capacities and strengthen their commitment to constructive use of their capacities through their graduation from high school as the class of 1984 to and beyond their emergence in 2000 as the older generation that takes over the running of the world.

SECTION THREE

SUMMARIES OF THE CONFERENCE

SED OUTLOOK TOWARD CAI

Norman Kurland
Director, Center on
Innovation in Education
New York State Education Department

In general, all of the programs reported at this conference are in an early exploratory stage in which there is plenty of enthusiasm for the potential of computers but little firm evidence that they can change the quality of instruction significantly.

The conclusions reached are equally applicable to the entire field of educational technology. The major conclusion was that a large, carefully coordinated research and development effort must be undertaken if the potential of the technology is to be realized.

The conference heard that no systematic planning was now occuring at the Federal level; although reference was made to the possibility the Commission on Educational Technology might do something of this kind. If no national action is forthcoming, the conferees urged that the planning and coordination be undertaken by the State. The feeling was strongly expressed that unplanned, uncoordinated efforts must be avoided. Not only is this terribly wasteful, but a few unproductive or negative projects, particularly in a field where project costs run high, could kill all interest and support for years to come.

It was generally felt, therefore, that a major effort must be undertaken both to discover how to use computers effectively to improve education and to produce evidence of the relative value of the new technology in comparison with alternative approaches.

To do this it was recommended that the research and development effort in the field be much more carefully planned than it has been to date. Up to now there has been little systematic planning for development. Projects are undertaken with little or no relation to one another and the findings, if any, of one project are seldom used or followed up in others. To help prevent this situation it was felt that some agency in the Federal government or the State should workout a research and development plan to guide the funding of projects and to provide all concerned with a common reference.

One possible planning approach is the following:

1. Identify all significant "alternative futures" - that is, possible ways in which the technology may someday be utilized in education.

2. Obtain estimates of the probable dates when each "future" may become reality and judgments on the desirability of each possible future.

3. Determine the activities that must be undertaken to arrive at the most desired futures including how much effort is likely to be required, what the cost will be, and in what sequence the activities should best be undertaken.

4. Assess the current status of research and development with respect to each activity and the agencies or individuals most competent to carry forward on next steps.

5. Estimate the costs of arriving at each desired future in specified time periods. This will provide an indication of the level of investment that will be required to arrive at a desired goal by any given date in the future.

6. For varied levels of expenditure during each of the next 5 years, determine what mixes of activities are possible and how much each "mix" will contribute to the movement toward desired futures. This will give a reasonable basis for determining how best to use limited funds.

7. On the basis of all of the preceding information, establish long- and short-range development goals and specify the sequence of activities that must be undertaken to achieve those goals.

8. In each funding period, support projects that fit the development plan.

9. Assess progress annually and revise the plan as experience dictates.

These steps would be applicable not just to the development of computer applications but might even be more meaningful if done for the total area of automated or technological aids to instruction.

Some other conference conclusions that are relevant are the following:

1. The major problem in CAI development at the present is not equipment but the lack of adequate theories of instruction or readily applicable validated experience. Therefore, extensive research and careful development should be undertaken. Application of computers to instruction without such a foundation is not going to produce measurable results to support the advantage of computers over traditional methods.

2. The successful application of computers (or any other technology) to education requires total system redesign - another reason why careful planning and a large investment of money and time will be required.

3. The proper question is, not how can computers (or any other device) be used in education, but how can computers help improve the quality of education. One

implication of this formulation is that computers should be utilized in ways that take maximum advantage of their unique capabilities, leaving to other devices and to people functions that they can perform better.

4 For the next few years Federal or State funds should not be used for direct "hands-on" experience for students or teachers. If schools or colleges wish to provide such experience with their own funds encourage them to use relatively inexpensive available equipment such as computers being used for administrative purposes, time-sharing terminals, calculators, or very low cost simple computers.

5. Encourage development of both computer monitored instruction (CMI) where there is no direct student access to computers and computer assisted instruction (CAI) where there is interaction with the computer.

6. While some attention should be given to the application of computers to present curricular goals and methods of instruction, the main emphasis should be on the changing goals and methods that will be more appropriate for education in the computer age.

7. A major developmental objective should be increasing compatibility among computer systems so that instructional programming may be more readily exchanged among users.

8. Begin developing plans now for the utilization of computer systems that will in a few years make available very low cost services using languages and procedures that will require no specialized training. These plans should include familiarizing both laymen and professionals with the profound changes these developments will bring about.

9. One of the major obstacles to the development of CAI identified by many conferees is the high cost of telephone communication from computers to remote terminals. These costs reduce the potential use of large systems and thus may make overall costs prohibitive. It was strongly urged that efforts be made to obtain changes in the FCC tariffs for live usage or that alternative arrangements, such as communication satellites, be quickly developed.

Louis Di Lorenzo
Director, Office of Research
Training and Special Studies
New York State Education Department

Louis Di Lorenzo summarized the major themes of the conference with some references to the Title IV proposal which he initiated, and entitled, Planning for ITALICS: Individualized Teaching and Learning in Computer Systems.

Louis Di Lorenzo suggested that the Department's Title IV planning proposal's first objective of describing a CAI model for 1980 be revised to include the notion of many models. The model approach to planning CAI was chosen because it would serve as a check that all the parameters of CAI had been accounted for and as a norm to which the development and progress of CAI may be compared. Eight broad areas of educational specifications for CAI would have to be described in the model.

I. Software
   1. Subject areas
   2. Course objectives
   3. Instructional theory
   4. Applicability to individual differences
   5. Flexibility in terms of curriculum change
   6. Use of conventional text materials
   7. Evaluative procedures

II. Student Participation
   1. Use of terminals
   2. Responsibility for rate of learning
   3. Choice of objectives

III. Professional Staff
   1. Role of administrator
   2. Teacher role
   3. Preservice and inservice training

IV. Hardware
   1. Function
   2. Flexibility; use with other programs
   3. Capacity
   4. Staffing

V. Research and Evaluation

VI. Regional Operations
   1. Size
   2. Location
   3. Cooperation with EDP centers

VII. Role of Department and Other Educational Agencies
   1. Financing
   2. State
   3. Local

VIII. Financing
   1. Federal
   2. State
   3. Local

The proposal also indicated a network approach to the development of CAI within the State. The network approach to CAI suggests a coordination of cooperative CAI efforts by a multitude of educational agencies for the research, development and implementation of CAI.

Mr. Di Lorenzo presented six ideas which he felt the conference participants were in general agreement.

1. Both CAI and CMI are potent avenues of individualized instruction. Unless they are mated, we will not see progress in these areas.
2. Cost effectiveness studies show varied results. Therefore, avoid any cost effective analysis while CAI is in the R & D stage.
3. CAI development reflects more from theories of instruction than from theories of learning.
4. CAI should be a total pedagogical approach.
5. Educators must use the computer as a computer; only where it is most educationally sound.
6. There is a need for behaviorally stated objectives when planning CAI program development.

REACTION PANEL

Panelists:

Rex Lamb – Cornelius Butler – Albert Hickey – Perry Crawford – Richard Wing

The purpose of the reaction panel was to receive opinions on the various important themes brought to the floor at the conference. The opinions of each panelist are presented in outline form.

Rex Lamb:

1. The general public needs more education regarding the role of the computer in today's society. The general public as well as the public school population desires this education.
2. Suggestion: The SED should train 10 teachers every Saturday for 10 Saturdays; install terminals in each of the teacher's schools; the teachers could use the programs at Plattsburgh or at another State University. By a repetition of this process a network approach to CAI could be developed.

Cornelius Butler:

1. Should the SED assume a leading or catalytic role in the area of computers in Education? Definitely yes. There are several reasons for this answer.
   a. The Federal government is not going to be helpful in the near future in funding CAI projects.
   b. The states have asked and received more control of Federal funds; the opportunity now exists for the states to use these funds for a significant cause.
   c. The application of the resources and talent of the NYSED to the area of CAI development will serve as a model to other state education departments.
   d. The SED can be more effective than the Federal government in eliciting the cooperation of industry.
2. Should the SED assume a leadership role now, or a few years from now? Definitely now. There are two basic reasons for this position.
   a. Educational breakthroughs should not wait for technological breakthroughs.
   b. We can do many things as economically with first and second generation computers as can be done on third generation computers.
3. The conference has very adequately delineated the different species of CAI. In the future, a conference of this type should not occur again; that is, it should not be dedicated to a discussion of the whole area of computer applications in education. In the future, our attention should be focused on a few key areas within CAI.
4. State money should not be used for familiarizing pupils with computer technology. This is the role of industry. State money should be going into projects, not workshops.
5. CMI projects are promising. However, CMI and CAI should not be mated except in the general sense of utilization of computer capability. But in the education program, it is too much of a burden on the complex fields of CAI and CMI. To intermingle these two would obfuscate them to the point that we would learn very little about either one of them.
6. The changes in school organization and curriculum which CAI will initiate can be accomplished within the present educational structures.
7. Network approach to CAI is a good one because it will generate a wide participation in CAI and help elicit the support of political resources so necessary in CAI implementation. However, the State should not resort to a per capita type of thinking in its work to set up a network.

Albert Hickey:

1. The conference has been extremely timely. Many states are following New York State's lead in this regard.
2. The State is the logical unit to become the systems manager of the instructional uses of the computer. The alternative is to have industry become the systems manager. Industry appears to be waiting to see if the state is going to draw up the specifications for CAI development.

3. Any programs for CAI development must take into consideration the fact that 500 high schools will be participating in time-sharing systems this year in order to improve their mathematics and science programs.
4. A meeting of this type in the future should focus its efforts into some of the following activities:
   a. Ascertaining the educational level to which CAI should be addressed.
   b. Finding the algorithm by which the State can come to a reasonable answer to the economic questions of CAI.
   c. Seeking solutions or alternate methods to the practices and regulations of ATT and the FCC.
   d. Determining the methods by which CAI can be integrated with existing curricula.
   e. Maintaining the development of CAI languages that represent various types of instructional strategies. (We don't want to standardize CAI languages because author languages imply an instructional strategy. Thus, to adopt one language as standard, would commit the curriculum to a limited instructional strategy.)
   f. Ascertaining the instructional uses of small computers and table top computers.
   g. Reporting and interpreting the results of CAI activities.

Richard Wing:

1. In regard to the New York State Title IV proposal; Planning for ITALICS: Individualized Teaching and Learning in Computer Systems:
   a. There should be greater emphasis on research objectives because we are at the point of exploration, not of service.
   b. The State should create a mechanism to encourage CAI research and programming.
   c. The term "network" should be changed to "web" or "pipeline." Network implies a rigid structure.
   d. Greater effort should be made to ascertain what education will be like 20 years from now. Long range as well as short range planning must be done.
   e. Provisions must be made to facilitate the continuous examination of ways by which the capability of the computer can be addressed to the more complex areas and methods of teaching.
   f. Other sources of funding should be examined; such as, Title III and NSF.
2. The SED should get out and help local districts and regional agencies submit CAI proposals of merit.

Perry Crawford:

1. Instruction itself is a late show. Instruction is adequate to impart a skill to one whose capacity is reasonably well developed. But this is not an educational program. An educational program is one which *draws forth, fosters growth and development.* Because instruction means to inject, it can only be an adjunct to an educational program.
2. The computer itself, as we know it today, is a late show. Well before 1980 the terminal and computer will reexpress knowledge. It will not just perform more efficiently what can be manually done.
3. Education itself is a late show. Not only must the SED move ahead in particular areas of CAI (simulation, problem solving, etc.), more importantly it must create a master plan for education as a whole so that technology can be properly integrated. This master plan can be developed by answering these five questions. In taking pains to answer these, a new educational system will develop that will be different from those now existing.
   a. Given our present societal and educational setting, what are the critical factors that must be taken into account when performing long- range planning of an educational system?
   b. In the situation that is in prospect, what is the educational system called upon to accomplish?
   c. By what means can these objectives be accomplished?
   d. How can these means be brought together and most effectively be applied?
   e. How do we develop the operational system?

This is the only way to move ahead. Our only choice is radical reform or self-destruction. The focus must always be on providing for children born in the late 60's, an educational system that develops their capabilities. The children born in 1967 constitute the class of 1984.

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