Los Nietos School District

[illegible] SOUTH [illegible] AVENUE
WHITTIER, CALIFORNIA [illegible]
[illegible]

September 28, 1977

Honorable James H. Scheuer, Chairman
Subcommittee on Domestic and International
Scientific Planning, Analysis, and Cooperation
U.S. House of Representatives
Suite 2321, Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Scheuer:

Through fundings under the Emergency School Aid Act, Los Nietos School District is embarking on its third year of intensive use of computer assisted instruction to help our children achieve mastery of the basic skills of reading, language, and arithmetic.

With the inauguration of this program, a sixteen year decline of achievement test scores was dramatically reversed. Even though most of our children have been victims of intense racial isolation that has left many of them severely handicapped in the traditional teaching environment, the mean achievement level is rapidly approaching the national norm.

With their success in the basic skills, the morale of the children and parents has shown significant change. Absenteeism is down, vandalism is reduced, hostility and violence are no longer a problem, and the high school reports that children are experiencing new success as they begin higher cognitive learning.

Los Nietos School District has found computer assisted instruction to be a highly efficient and cost effective way to support the classroom teacher in today's integrated school setting.

Sincerely,

Martin C. Montaño, Ed.D.
District Superintendent

MCM:eb

AEOLIAN SCHOOL, [illegible] AEOLIAN ST, WHITTIER, [illegible]
LOS NIETOS SCHOOL, [illegible] RIVERA RD., WHITTIER, [illegible]
ADA S. NELSON SCHOOL, [illegible] VICKI DR., WHITTIER, [illegible]
RANCHO SANTA GERTRUDES SCHOOL, [illegible] CHARLESWORTH RD., SANTA FE SPRINGS, [illegible]
WALLJICE S. WIGGINS SCHOOL, [illegible] S. WEXFORD AVE., WHITTIER, [illegible]

AN ANALYSIS OF THE IMPACT OF COMPUTER ASSISTED INSTRUCTION ON A PROGRAM DESIGNED TO AMELIORATE THE EFFECTS OF RACIAL ISOLATION IN THE LOS NIETOS SCHOOL DISTRICT

Funded by the United States
Office of Education, DHEW

These data are submitted as part of the testimony presented to the House Committee on Domestic Applications of Science and Technology, October 6, 1977.

Nelson D. Crandall, Ed.D.
Project Director

Martin C. Montaño, Ed.D.
District Superintendent

CRANDALL, Nelson David, Ed.D

Business Address	LOS NIETOS SCHOOL DISTRICT 8324 South Westman Avenue Whittier, CA 90606
Residence Address	5603 East Seaside Walk Long Beach, CA 90803
Date of Birth	December 10, 1924

EDUCATIONAL TRAINING

Ed.D., Education Administration	U S C	1970
Administrative Specialist Degree	U S C	1968
Education Administration, M.A.	C S U L B	1955
Elementary Education, B.A.	C S U L B	1951

EMPLOYMENT EXPERIENCE

ESAA Director, Los Nietos School District	1974 -
Principal, Ada S. Nelson School Los Nietos School District	1972 - 1974
Director, Research and Teacher Education (RATE) Project, Los Nietos School District	1969 - 1972
Principal, Los Nietos School District	1958 - 1969
Principal - Superintendent, Newcastle School District Newcastle, California	1955 - 1958
Teacher, Sixth Grade Auburn, California	1953 - 1955
Teacher, Fourth Grade Long Beach, California	1951 - 1953

CONSULTANT

Montebello Unified School District	1970
Las Virgenes Unified School District	1971
Ventura Unified School District	1975
Pasadena Unified School District	1969-70-71
State Department of Education	1975-76

LECTURER

University of Southern California	1965 (Summer)
University of California at Los Angeles Extension	1970 (Summer)

PART TIME INSTRUCTOR

Pepperdine University	1974 - 1975
Rio Hondo College	1974 - 1975

PROFESSIONAL ORGANIZATIONS

Membership

Association of California School Administrators
National Association of Elementary School Principals
National Education Association
Phi Delta Kappa

Board Member

ACSA, Region 15

Chairmanship

ACSA Committee on Elementary Administration
USC-ACSA State-wide Conference
"The Computer and the Elementary School"

Membership
State Department of Education
State of California

State Task Force of Computer Assisted Instruction
State Advisory Committee on Educational Technology

PUBLICATIONS

"Teacher Aides Really Do Aid!"
California School Board, November 1970

"How Teacher Aides Help Teachers",
American Education, October, 1971 (Reprinted in Education Digest)

"The Role of Computer Assisted Instruction in the Education of Ethnic Minorities",
Journal for the Association for the Development of Computer Based Instructional Systems, Winter, 1976.

"CAI as a Tool for Building Internality in Traditionally Low Achieving Students",
Educational Technology (Accepted for Publication)

"CAI: Its Role in the Education of Ethnic Minorities"
The Journal: Technological Horizons in Education, December, 1976

TABLE OF CONTENTS

I. COMPUTER ASSISTED INSTRUCTION

"CAI: IT'S ROLE IN THE EDUCATION OF ETHNIC MINORITIES"
OF
Nelson D. Crandall, Ed.D.

About ten years ago, the federal government undertook a massive program to wipe out poverty in America. The thrust of the program was towards those ethnic minorities that comprised the bulk of the poor. Particular emphasis was placed on the American of Mexican descent, the Black American and the American Indian. Further references to minority groups in this paper shall pertain only to these groups as that is where the data has been collected.

A central hypothesis of this program was that poverty is closely linked to failure in school on the part of minority children. Massive amounts of money have been poured into the educational institutions of the nation to achieve this goal. In spite of the best efforts of our nation's educators and the good intentions of the programs, these efforts have failed according to the goals and objectives set by the program directors.

So massive was the failure that it has caused educators to engage in considerable soul searching and ask themselves, "Just what can the school accomplish? What is beyond the reach of the schools?"

In its comprehensive study, the Center for Educational Policy Research at Harvard University reported, "There is no evidence that school reform can substantially reduce the extent of cognitive inequality, as measured by tests of verbal fluency, reading comprehension, or mathematical skill. Eliminating qualitative differences between elementary schools would reduce the range of scores in sixth grade by less than three percent. Eliminating qualitative differences between high schools would hardly reduce the range of twelfth-grade scores at all and would reduce by only one percent the disparities in the amount of education people eventually get."

One of its gloomy conclusions, "Our research suggests that the character of a school's output depends largely on a single input, the characteristics of the entering child. Everything else - the school budget, its policies, the characteristics of the teachers - is either secondary or completely irrelevant, at least so long as the range of variation among schools is as narrow as it seems to be in America." (Jencks 1972.)

In the field of compensatory education, practitioners have been led by a succession of Messiahs who showed them the way. Each time the promised results did not materialize, yet the practices have lingered for want of something better.

As a result, educators have become increasingly skeptical of programs claiming success in raising achievement levels with children from a poverty background. To the uninitiated, proposing that achievement levels may be raised in children by having them sit in front of a computer terminal for fifteen minutes a day seems ludicrous. But, the facts are in. Standardized test scores have soared with children doing drill and practice on a daily basis using CAI. Those of us in elementary education who witnessed this phenomenon asked ourselves, "Why should CAI raise test scores when special reading teachers and teacher aides don't appear to be able to accomplish this? Why do reading scores go up when the child is taking arithmetic on CAI? Why do the slowest pupils make a significant jump in achievement when in other programs he continues to fall further behind?"

LOCUS OF CONTROL

The answers to these questions can be found when one examines children from homes with a heritage of poverty in the light of a concept called Locus of Control. This term refers to how the child perceives himself controlled. The internally controlled child perceives that he is in control of his own destiny, that his achievements are usually commensurate with his efforts, and that he can reach most goals that he sets for himself. The externally controlled child believes that his life is controlled by outside forces. He believes that what happens to him is the result of destiny, fate, luck, chance, the intervention of powerful others, or acts of God.

It is quickly evident that the child who perceives that there is no relationship between his own efforts and his achievements is under a tremendous handicap. Many of these children believe that there is no way they can help themselves succeed so they spend their time in trying to avoid failure. They do this by avoiding themselves either physically or psychologically from most learning situations.

The internal child, on the other hand, has learned to savor success. He spends his time putting himself in situations where he can succeed and once again know the pleasure that comes with success.

It appears that internality can be fostered by activities that can 1) allow the child to establish a cause-and-effect relationship with his own actions, and 2) relate these activities without the intervention of a "powerful other" (teacher, aide, parent).

There is good evidence that reinforcement to learning activities is not effective if the child does not perceive a causal relationship between his own actions and the feedback that occurs. Studies have shown that low achieving children and often minority children perceive themselves as not having much control over their own fate. They perceive what happens to them as a result of who their friends are, what color their skin is, how much money their folks have, luck, etc.

In constructing a social learning theory, J. B. Rotter (1966) stated: "When a reinforcement is perceived by the subject as following some action of his own but not being entirely contingent upon his action, then, in our culture, it is typically perceived as the result of luck, chance, fate, as under the control of powerful others, or as unpredictable because of the great complexity of the forces surrounding him. When the event is interpreted in this way by an individual, we have labled this a belief in external control. If the person perceives that the event is contingent on his own relatively permanent characteristics, we term this a belief in internal control".

The Coleman Report (1966) found that this belief in destiny was a major determinant in school achievement. They concluded that this pupil attitude factor had a stronger relationship in achievement than all other school factors together.

Computer Assisted Instruction has shown convincing evidence that it is an effective medium for building internal control in the child who believes that his life is controlled by external forces.

The child in question typically has poor tolerance to delayed gratification. He usually sees minimal relationship between his actions of today with success or failure as represented by marks on a report card. The computer terminal, with its one or two second response time, graphically shows the pupil immediate feedback to his input. He knows he is in control and can readily see the cause and effect relationship to his actions.

Vasquez (1974) sees the understanding of cause-effect relationship as essential to internal attribution of success or failure on the part of the child. This understanding has not been developed adequately in the mind of the external individual because of negative social experiences within a culturally biased classroom. The problem then is how to build understanding of cause-and-effect in the externally controlled child.

Vasquez suggests four criteria by which to evaluate activities to accomplish understanding of the cause-effect relationship:

1) See that the cause has sufficient power to produce the effect.

2) Students should comprehend that without the cause, the action or result would not have occurred.

3) Other equally likely causes must not be present if we are to identify a single cause.

4) The cause must precede the event in time.

When judged by the above criteria, Computer Assisted Instruction gets high marks. Let us examine each of the above as compared with CAI.

3

(A) Sufficient Power. It is difficult to conceive of any medium that would have more power. Whenever the pupil indicates he has finished his input to the computer, there is almost instantaneous response that is solely related to the input.

(B) Cause-effect relationship. On CAI, the child instantly recognizes the relationship of the output to his input.

(C) Other causes. The interaction between the child and the terminal is direct, without the intervening intermediary of the teacher or others. The child must take full responsibility or credit for the response whatever it is.

(D) Temporal relationship. The immediate feedback provided by the computer is unexcelled. The computer usually responds within one or two seconds to the pupil's input.

There is much research to be done to determine the extent that CAI modifies the locus of control of the minority child. Emperical evidence suggests that there is substantial change. Hard data shows that there is highly significant growth in reading and math as measured by standardized tests. For example, Bone (1974) reported an average growth of 1.1 years growth over an eight-month period in Chicago's inner city where the average growth had been close to .4 years growth in math for the period covered. Similar results have been reported from University of Akron, Stanford University, and from Montgomery County, Maryland.

Speculation as to why Computer Assisted Instruction gives evidence of increased internality has included the following points:

(1) Immediate feedback.

(2) Lack of external variables to which a student might attribute his success or failure.

(3) The very specific directions that the computer gives the learner, and the computer's low tolerance for deviation from the directions.

(4) The one-to-one relationship between the learner and the terminal.

(5) The programmed success that the pupil experiences on most CAI courseware.

Instructional Logistics

Accompanying racial integration in schools, there has been an ever-widening span of experiences, competencies, levels of achievement, and ability. In order to effectively teach such diverse groups, teachers have been told to individualize their instruction.

Seldom has there been a harder working group of teachers than those attempting to individualize their classrooms in schools such as we have described above. Despite these heroic efforts, they are unable to meet the goals that they have set for themselves despite special materials, paraprofessional help, subject matter specialists and parent volunteers. Teachers are being overwhelmed by the logistics of instructing such classes. Without special help, teachers are destined to direct the bulk of their instruction towards the mean achievement level of the group. In the past, such instruction has been satisfactory for homogeneous grouping. It is highly inadequate for a school in the process of racial integration as it results in pupil frustration and parent dissatisfaction. Needless to say, the teacher in such a setting is highly upset and can often be found in the personnel office filling out a transfer request.

At first glance, it appears perfectly feasible to individualize these subjects for thirty children. If we only did it with reading and arithmetic it would appear that at most the teacher would have sixty lessons in any one day. This is an illusion. Reading and arithmetic are nothing but names that we have given to a large assortment of complex skills. Should we break down these subjects into a minimal number of skill areas or "strands", we suddenly find that the teacher has about twenty-five areas to prepare for; and instead of a potential of sixty lessons, it has ballooned to seven hundred and fifty.

What has become an impossible task for the teacher is duck soup for the computer. Thousands of children throughout the nation are having their drill and practice lesson plans prepared for them daily in heterogeneously organized classrooms. They are highly successful. Teachers and parents are pleased at the results that are evident from the child's academic achievement and social adjustment.

Over a thousand terminals are now operating in classrooms of Los Angeles County alone.

In the Los Nietos School District, CAI is being implemented in five schools, grades four through eight. Teachers have remarked on the enthusiasm of the children towards the terminals and the change in attitudes that have accompanied the implementation of the program.

Teachers have reported that pupils who have been the most difficult to handle appear to be particularly attracted to the medium of CAI.

Evaluation of an innovation such as this is especially difficult to measure because of the number of uncontrolled variables involved. The following evidence has been observed and appears to have a relationship with CAI.

Scores on standardized test are sharply up.

Truancy and tardiness are down.

Children make intensive use of the computer terminals before and after school.

Vandalism of the school plants is down.

It appears that CAI is a valuable medium of instruction in school districts that are in the process of desegregation. One of the major obstacles has been the achievement of those children suffering the effects of racial isolation is often significantly lower than those children in the majority group. As CAI effectively brings up the achievement level of the lower quartile pupils, there is a reduction in the frustration level, the self-confidence of the pupil improves, and the general emotional climate of the institution is improved.

6

LOS NIETOS EDUCATION CENTER
COMPUTER CENTER

THE RELATIONSHIP BETWEEN CAI AND ACHIEVEMENT

All districts are cautious about claiming earned gains on standardized tests being attributable to certain programs. Los Nietos is no exception. However, the scores on the following pages do show highly significant gains made during a period when the only identifiable variable was the introduction of CAI. The district gains confidence in attributing these gains to CAI in that similar results have been found in Chicago, Montgomery County Maryland, Kansas City and the Los Angeles County program.

ACADEMIC GROWTH

The growth that children made in math and reading as measured by standardized tests has been dramatic and graphic. The tests were administered by the classroom teachers over a four year span beginning in October, 1974. The instrument used was the California Achievement Test of Basic Skills. The children marked their answers on "mark sense" data processing answer sheets. These were processed and tabulated by the Los Angeles County Superintendent of Schools Office.

The accompanying graphs and charts will atte·' to the significant growth that the children have made in the basic skills of reading and math. It can also be pointed out that these results were obtained while the percentage of minority population was growing. At the present time the school population is about eighty percent minority, principally Spanish surname.

II. DESCRIPTION OF PROGRAM

A REPORT OF AN ELEMENTARY INSTRUCTIONAL SYSTEM SUPPORTED WITH COMPUTER-ASSISTED INSTRUCTION IN DRILL AND PRACTICE IN THE BASIC SKILLS

The Los Nietos School District in Los Angeles County has the distinction of being the first school in the United States that has had their basic skills program supported through intensive use of computers.

This publication fulfills the obligation incurred upon receiving a grant under the Emergency School Aid Act; that of dissemination of successful practices for relieving ethnic segregation, and ameliorating the effects of racial isolation.

History of the Project

The Los Nietos ESAA Basic Program was the first program of computer assisted instructional program funded under Public Law 92-318, The Emergency School Aid Act. Approved for the school year 1974-75, the project became operational with the installation of an IBM 370 115 computer dedicated to computer assisted instruction, on January 5, 1975. The system initially supported seventeen 2741 typewriter-style terminals. Before the end of the year this number was increased to twenty-four. The system ran on Coursewriter III, an IBM instructional language, and supported the following courseware:

Arithmetic Proficiency Training Program (Gr. 2 - 9)
Elementary Reading Skills, CCC (Gr. 3 - 6)
WRITE, Poughkeepsie Schools, (Gr. 4 - 9)

Although the early results were excellent, the system was plagued by slow response time and software problems. The necessity to maintain our own software plus the inability of the system to support an adequate number of terminals resulted in the termination of the IBM lease in October, 1976 and a conversion to equipment and programs leased from the Computer Curriculum Corporation, Palo Alto.

We started the year with two CCC A16 computers supporting 32 CRT-type terminals running the following courseware:

Cont'd

Elementary Reading Skills (Gr. 3 - 6)
Elementary Arithmetic (Gr. 1 - 7)
Elementary Language Arts (Gr. 3 - 6)

In the evening hours, the system was used with adult reading, math, and language skills. This was administered under adult education programs.

HOW CAI IS USED TO SUPPORT TEACHERS IN DRILL AND PRACTICE

For the purpose of this subject, let us assume that we accept the following paradigm as the one being used to teach the basic skills:

Step 1. Teachers introduce concepts to children on the basis of their readiness for that particular concept and in a sequence that involves certain prerequisite skills.

Step 2. Upon the child achieving basic comprehension of a concept, the child is given drill and practice to achieve greater understanding and to gain mastery of the concept.

Step 3. Achieving mastery of the skill, the child is given contrived applications, direct purposeful applications, or utility of the skill to master more complex concepts.

Step 1. Traditionally we think of the teacher explaining the concept (such as contractions in grammar or division in math) with the aid of the blackboard, visuals, or printed matter.

Step 2. The dominant teaching aid for achieving mastery has been the liquid spirit duplicating machine. Teachers pass out exercises for the children to do that are hopefully at their level of achievement. Other aids have been workbooks, teacher made materials, games, and exercises taken from textbooks.

Cont'd

Step 3. The application level can be found in dramatic play of social studies, thought problems from math books, and contrived experiences in the classroom.

Computer Assisted Instruction takes over the function outlined in "Step 2". Computers are uniquely qualified to achieve the aims of drill and practice because they can store and recall vast amounts of information. The programs of Computer Curriculum Corporation, the most widely used software, tract the child in twenty-eight different skill strands simultaneously. When the child achieves ninty percent correct in any one strand, the program advances him. When the child achieves less than eighty percent correct, the pupil is given less demanding work. Thus in a class of thirty pupils, 840 skill strands are being tracked at the same time.

IT STARTS IN THE CLASSROOM The teacher introduces the concept. No computer can come close to the interaction that is necessary for that type of interaction needed for this type of teaching. Other media is usually employed to facilitate communica... at this point such as the blackboard, pictures, exhibits, etc.

The children become aware of the concept, gaining the basic knowledge involved, and then move to the level of comprehension.

Gaining comprehension, the children are then ready to begin the process of achieving mastery. Traditionally this is done in the classroom with ditto material, workbooks or copying exercises out of the textbooks.

This has always been a difficult area to individualize work for the child. In a fully integrated heterogenious classroom it becomes a logistical nightmare. Few teachers have the skills, the time, and the commitment to completely individualize in a diagnostic-prescriptive setting.

Where the teacher is highly skilled in communicating and perceiving feedback, the computer is highly skilled at remembering an infinite amount of data, storing this information, and recovering it quickly and accurately.

THE COMPUTER DOES ITS PART Working at grade by the teacher, the pupils do drills and prac that they comprehend from their classroom wo tracked in as many as twenty-eight skills st simultaneously.

This medium appears to have considerable cha Some of their comments:

"The terminal does what I tell it to do

"I know that I did the work myself."

"The computer never bawls me out."

"I get good scores on CAI."

"It's fun."

"Nobody but me knows what I am doing."

"I learn real good on the computer."

"You know that you do it."

"I like to beat the computer."

vel initially assigned
ce on those processes
The children are
ds by the computer

ma for the children.

children's actions reenforce their words. The terminals are y during lunch time, before school, after school and during ation periods.

ents of primary children often bring their children in after ular hours and sit with them at the terminals.

13

TEACHER FEEDBACK In addition to teacher observation of children at work with the terminals, the teacher can generate printed reports on demand. These reports show where the child is working in any of the subjects areas, expressed in grade level, e. g. Literal Comprehension 3.7.

The teacher may then refer to the teachers guide for that particular subject and see what concepts the child will need to understand to proceed further. If a teacher notices that a child is not progressing in a particular strand, this is a clue that the pupil lacks real comprehension of the concept.

Class reports are useful in grouping children for small group learning centers to meet common needs. Individual reports are often used to counsel the pupil and in parent conferences.

APPLICATION After the teacher has received evidence from the computer printouts that the child has achieved mastery of a given skill, it is incumbent on him to assign projects that permit the child to utilize these newly mastered skills so that they have meaning and value.

Newly mastered skills are also utilized as component parts for more highly organized skills that are in reality syntheses of subordinate skills. For example, evidence that the child has mastered vertical subtraction and horizontal multiplication indicates to the teacher that the child has the necessary skills to master division and can begin introduction of this concept.

The retention of any skill mastered is dependent upon review and application; use it or lose it.

WHY CAI IS SUCCESSFUL

Locus of Control

Educators scanning test results of children working with CAI for the first time are struck with an anomoly. They see children who have scored in the lowest quartile suddenly spurt forward. Two or three years growth in one year is the rule for these children rather than the exception.

This is against our past experience and leads us to ask why should they suddenly surge ahead when traditionally they have fallen further behind each year?

The answers to these questions can be found when one examines children from homes with a heritage of poverty in the light of a concept called Locus of Control. This term refers to how the child perceives himself controlled. The internally controlled child perceives that he is in control of his own destiny, that his achievements are usually commensurate with his effotts, and that he can reach most goals that he sets for himself. The externally controlled child believes that his life is controlled by outside forces. He believes that what happens to him is the result of destiny, fate, luck, chance, the intervention of powerful others, or acts of God.

It is quickly evident that the child who perceives that there is no relationship between his own efforts and his achievements is under a tremendous handicap. Many of these children believe that there is no way they can help themselves succeed so they spend their time in trying to avoid failure, thus, removing themselves either physically or psychologically from most learning situations.

The internal child, on the other hand, has learned to savor success. He spends his time putting himself in situations where he can succeed and once again know the pleasure that comes with success.

It appears that internality can be fostered by activities that can 1) allow the child to establish a cause-and-effect relationship with his own actions, and 2) relate these activities without the intervention of a "powerful other" (teacher, aide, parent.

There is good evidence that reinforcement to learning activities is not effective if the child does not perceive a causal relationship between his own actions and the feedback that occurs. Studies have shown that low achieving children and often minority children perceive themselves as not having much control over their own fate. They perceive what happens to them as a result of who their friends are, what color their skin is, how much money their folks have, luck, etc.

In constructing a social learning theory, J. B. Rotter (1966) stated: "When a reinforcement is perceived by the subject as following some action of his own, but not being entirely contingent upon his action, then, in our culture, it is typically perceived as the result of luck, chance, fate, as under the control of powerful others, or as unpredictable because of the great complexity of the forces surrounding him. When the event is interpreted in this way by an individual, we have labeled this a belief in external control. If the person perceives that the event is contingent on his own relatively permanent characteristics, we term this a belief in internal control".

The Coleman Report (1966) found that this belief in destiny was a major determinant in school achievement. They concluded that this pupil attitude factor had a stronger relationship in achievement than all other school factors together.

Computer Assisted Instruction has shown convincing evidence that it is an effective medium for building internal control in the child who believes that his life is controlled by external forces.

The child in question typically has poor tolerance to delayed gratification. He usually sees minimal relationship between his actions of today with success or failure as represented by marks on a report card. The computer terminal, with its one or two second response time, graphically shows the pupil immediate feedback to his input. He knows he is in control and can readily see the cause and effect relationship to his actions.

Vasquez (1974) sees the understanding of cause-effect relationship as essential to internal attribution of success or failure on the part of the child. This understanding has not been developed adequately in the mind of the external individual because of negative social experiences within a culturally biased classroom. The problem then is how to build understanding of cause-and-effect in the externally controlled child.

Vasquez suggests four criteria by which to evaluate activities to accomplish understanding of the <u>cause-effect relationship</u>:

1) See that the cause has sufficient power to produce the effect.
2) Students should comprehend that without the cause, the action or result would not have occurred.
3) Other equally likely causes must not be present if we are to identify a single cause.
4) The cause must precede the event in time.

When judged by the above criteria, Computer Assisted Instruction gets high marks. Let us examine each of the above as compared with CAI.

A) Sufficient Power. It is difficult to conceive of any medium that would have more power. Whenever the pupil indicates he has finished his input to the computer, there is almost instantaneous response that is solely related to the input.

B) Cause-effect relationship. On CAI, the child instantly recognizes the relationship of the output to his input.

C) Other causes. The interaction between the child and the terminal is direct, without the intervening intermediary of the teacher or others. The child must take full responsibility or credit for the response whatever it is.

D) Temporal relationship. The immediate feedback provided by the computer is unexcelled. The computer usually responds within one or two seconds to the pupil's input.

There is much research to be done to determine the extent that CAI modifies the locus of control of the minority child. Emperical evidence suggests that there is substantial change. Hard data shows that there is highly significant growth in reading and math as measured by standardized tests. For example, Bone (1974) reported an average growth of 1.1 years growth over an eight-minth period in Chicago's inner city where the average growth had been close to .4 years growth in math for the period covered. Similar results have been reported from University of Akron, Stanford University, and from Montgomery County, Maryland.

Speculation as to why Computer Assisted Instruction given evidence of increased internality has included the following points:

1) Immediate feedback
2) Lack of external variables to which a student might attribute his success or failure
3) The very specific directions that the computer gives the learner, the computer's low tolerance for deviation from the directions
4) The one-to-one relationship between the learner and the terminal
5) The programmed success that the pupil experiences on most CAI courseware.

Instructional Logistics

Accompanying racial integration in schools, there has been an everwidening span of experiences, competencies, levels of achievement, and ability. In order to effectively teach such diverse groups, teachers have been told to individualize their instruction.

Seldom has there been a harder working group of teachers than those attempting to individualize their classrooms in schools such as we have described above. Despite these heroic efforts, they are unable to meet the goals that they have set for themselves despite special materials, paraprofessional help, subject matter specialists and parent volunteers. Teachers are being overwhelmed by the logistics of instructing such classes. Without special help, teachers are destined to direct the bulk of their instruction towards the mean achievement level of the group. In the past, such instruction has been satisfactory for homogeneous grouping. It is highly inadequate for a school in the process of racial integration as it results in pupil frustration and parent dissatisfaction. Needless to say, the teacher in such a setting is highly upset and can often be found in the personnel office filling out a transfer request.

At first glance, it appears perfectly feasible to individualize these subjects for thirty children. If we only did it with reading and arithmetic it would appear that at most the teacher would have sixty lessons in any one day. This is an illusion. Reading and arithmetic are nothing but names that we have given to a large assortment of complex skills. Should we break down these subjects into a minimal number of skill areas or "strands", we suddenly find that the teacher has about twenty-five areas to prepare for; and instead of a potential of sixty lessons, it has ballooned to seven hundred and fifty.

What has become an impossible task for the teacher is duck soup for the computer. T ousands of children throughout the nation are having their drill and practice lesson plans prepared for them daily in heterogeneously organized classrooms. They are highly successful. Teachers and parents are pleased at the results that are evident from the child's academic achievement and social adjustment.

Over a thousand terminals are now operating in classrooms of Los Angeles County alone.

In the Los Nietos School District, CAI is being implemented in five schools, grades four through eight. Teachers have remarked on the enthusiasm of the children towards the terminals and the change in attitudes that have accompanied the implementation of the program.

Teachers have reported that pupils who have been the most difficult to handle appear to be particularly attracted to the medium of CAI.

Evaluation of an innovation such as this is especially difficult to measure because of the number of uncontrolled variables involved. The following evidence has been observed and appears to have a relationship with CAI.

Scores on standardized test are sharply up.
Truancy and tardiness are down.
Children make intensive use of the computer terminals before and after school.
Vandalism of the school plants is down.

It appears that CAI is a valuable medium of instruction in school districts that are in the process of desegregation. One of the major obstacles has been the achievement of those children suffering the effects of racial isolation is often significantly lower than those children in the majority group. As CAI effectively brings up the achievement level of the lower quartile pupils, there is a reduction in the frustration level, the self-confidence of the pupil improves, and the general emotional climate of the institution is improved.

III. RECOMMENDATIONS

RECOMMENDATIONS FOR THE COMMITTEE

1) As the emergence of electronic data processing has been very rapid, there is almost a vacuum of expertise in CAI and CMI in the teacher's colleges of the nation. Incentives are needed for professors of educational technology to become current in theory and practice of this field.

2) That federal aid to education through the various categorical fundings be diverted from less successful approaches into CAI.

3) That programs be initiated to change large population groups from an orientation of "external control" to a posture where they see themselves realistically; and to aid them in becoming self-actualizing individuals. Such groups, presently gripped in poverty and dependency, could then become contributing members of our society. Welfare roles, disease, crime, and poor personal performance could significantly be changed for the better with relatively modest cost.

IV. BIBLIOGRAPHY

BONE, Jan, "Turning on With CAI", American Education, November, 1974, P. 32, Vol. 10, eo. 9. United States Office of Education.

COLEMAN, J. S., CAMPBELL, E. Q., HOBSON, D. J., McFARLAND, J., MOOD, A. M., WEINFIELD, F. D., and YORK, R. T., EQUALITY OF EDUCATIONAL OPPORTUNITY. (Superintendent of Documents, Catalog No. FS5.238:38001) Washington, D. C.: United States Office of Education, 1966.

JENCKS, Christopher and Mary Jo Bane, "The Schools and Equal Opportunity, Saturday Review of Education, September 16, 1972, p. 37.

ROTTER, J. B., Generalized expectancies for internal versus external control of reinforcement. PSYCHOLOGICAL MONOGRAPHS, 1966, 80 (1, Whole No. 609).

VASQUEZ, James A., "Locus of Control Learning and Implications for Educators". An Unpublished Manuscript presented at the General Assistance Center, 1974 San Francisco, California 94103.

VASQUEZ, James, "Learning in Relation to [illegible]regated Classrooms", STRIDE, June, 1975, General Assistance Center, San Francisco, California.

23-082 O - 78 - 9

V. STATISTICAL DATA

NARRATIVE SUMMARY
OF
LONGITUDINAL AND CROSS SECTIONAL DATA

The longitudinal data show quite convincingly that students in the Los Nietos School District have made significant achievement gains over the past four years.

Students in the Fourth, Fifth and Sixth grades whose average achievement was between the 04%ile to 17%ile in Math four years ago are now achieving approximately 30%ile points higher. Similar, though not so dramatic gains have been achieved in Reading. Fourth, Fifth and Sixth grade students have risen from the 15%ile to the 38%ile. (See figures 27 to 36 .)

Another way of studying the longitudinal data is to look at the differences in achievement levels for a selected grade level over a period of years. This is generally referred to as cross-sectional data. For example, over the past three years, the math achievement of graduating 8th graders has risen from the 35%ile to the 47%ile. Significant gains have also occurred in the fourth through seventh grades. Again, similar yet less dramatic results have been achieved in reading. Reading achievement has risen from the 35%ile to the 40%ile for graduating 8th graders over the past three years. (See figures 37 to 48 .)

This year, an attempt is being made to implement a comprehensive evaluation project. This will lead to more specific statistical information regarding the extent to which CAI (and other programs) have contributed to the marked successes of students in the Los Nietos School District.

LOS NIETOS SCHOOL DISTRICT
LONGITUDINAL TEST DATA
CALIFORNIA TEST OF BASIC SKILLS (CTBS)

TOTAL READING MEAN PERCENTILE SCORES

8th Grade Class	1974-75	October 1973 - 14%ile	May 1975 - 35%ile
8th Grade Class	1975-76	October 1973 - 17%ile	May 1976 - 37%ile
8th Grade Class	1976-77	October 1973 - 15%ile	May 1977 - 40%ile
7th Grade Class	1976-77	October 1973 - 10%ile	May 1977 - 36%ile
6th Grade Class	1976-77	October 1974 - 16%ile	May 1977 - 37%ile

---

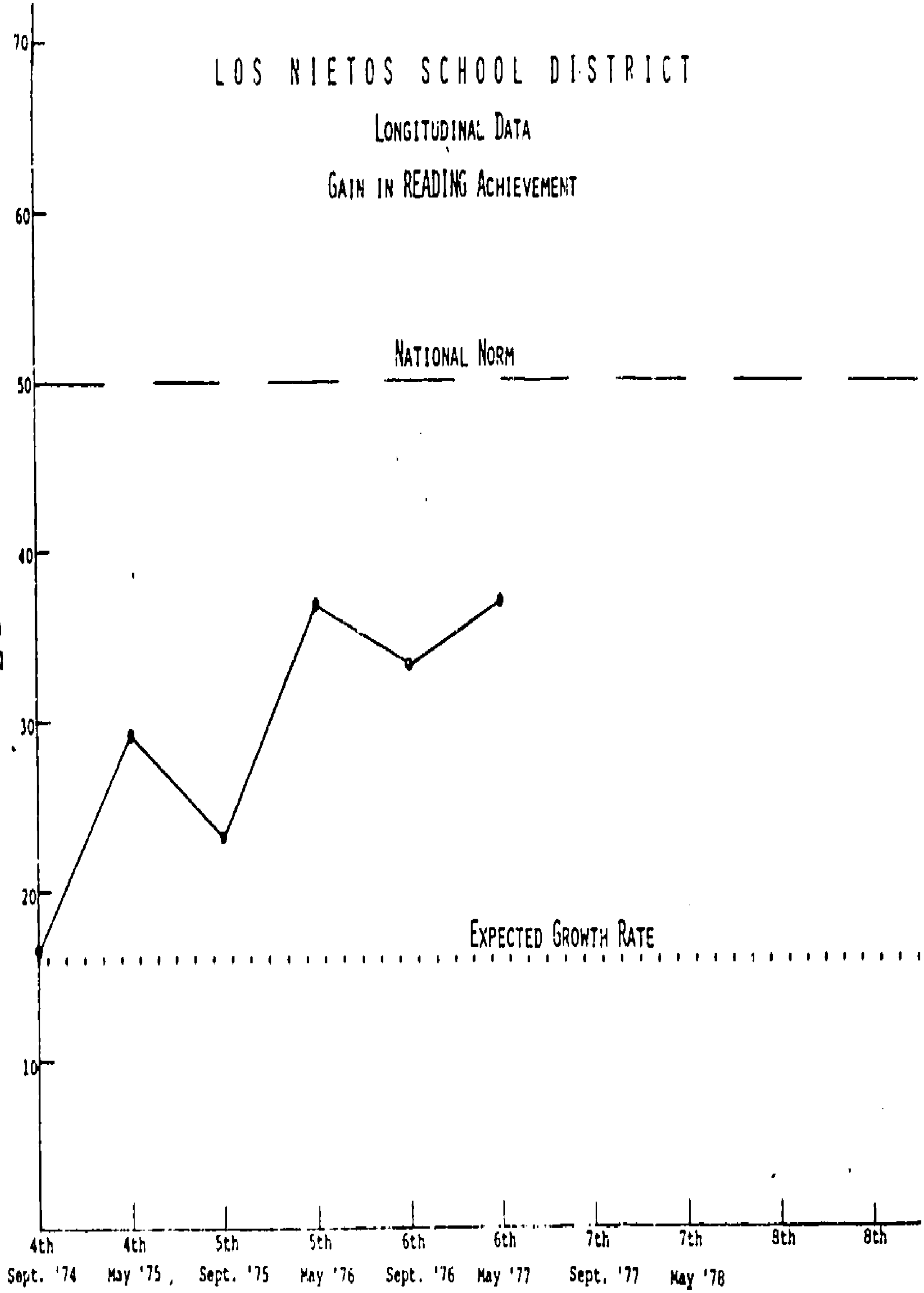
TOTAL MATH MEAN PERCENTILE SCORES

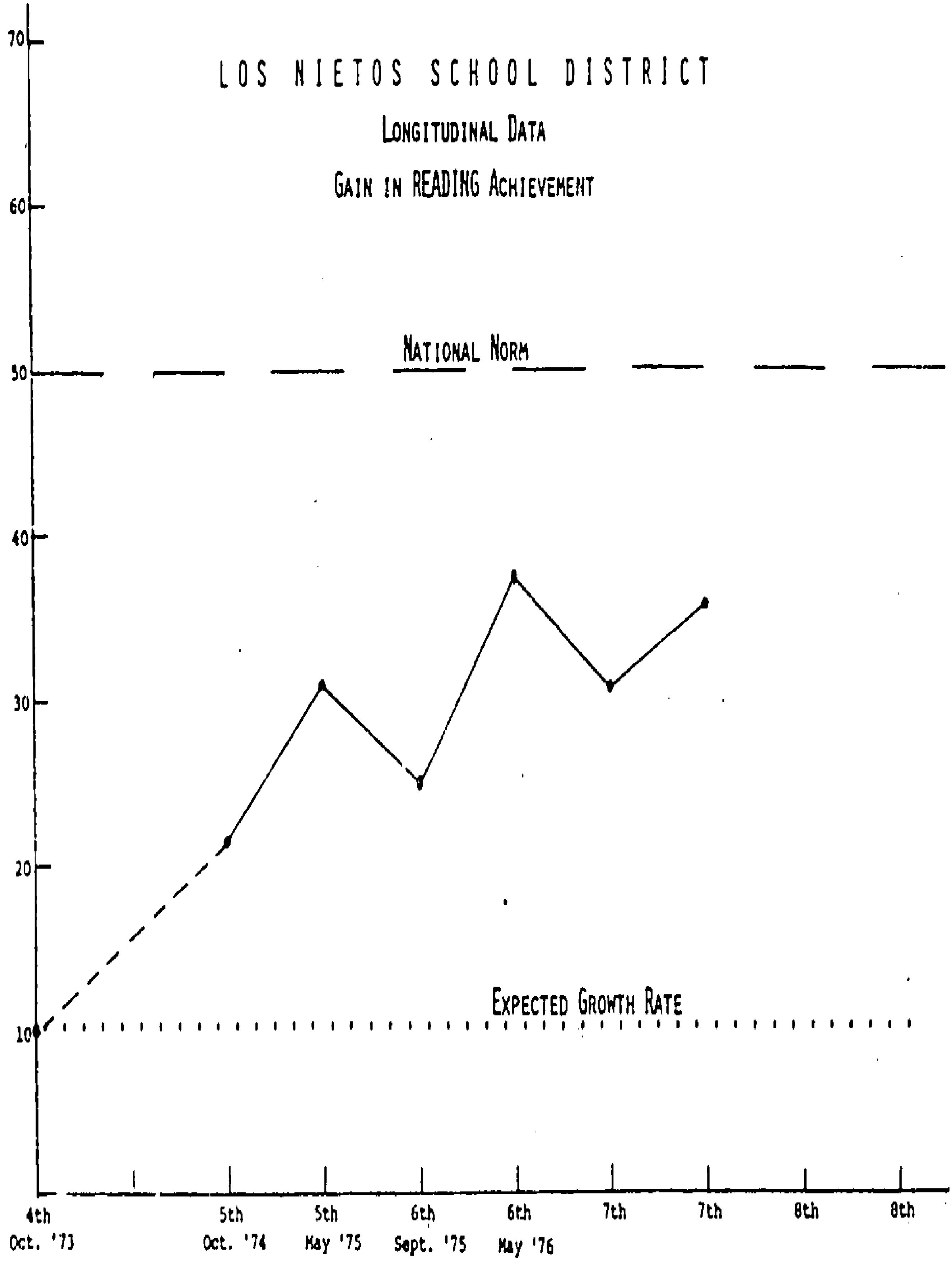
8th Grade Class	1974-75	October 1973 - 11%ile	May 1975 - 35%ile
8th Grade Class	1975-76	October 1973 - 15%ile	May 1976 - 42%ile
8th Grade Class	1976-77	October 1973 - 09%ile	May 1977 - 47%ile
7th Grade Class	1976-77	October 1973 - 04%ile	May 1977 - 47%ile
6th Grade Class	1976-77	October 1974 - 16%ile	Oct.1977 - 39%ile

CTBS MEAN SCORE
SPRING OF YEAR

LOS NIETOS SCHOOL DISTRICT

Grade Level Equivalents Longitudinal Group	READING				LANGUAGE				MATHEMATICS					TOTAL BATTERY
	Vocab	Comp	G.E. Total	% ile	Mech	Express	Spell	Total	Comput	Concepts	Appl	G.E. Total	% ile	
1st Grade 1974	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA		NA
2nd Grade 1975	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA		NA
3rd Grade 1976	3.1	3.1	3.3	38	2.9	3.1	2.9	2.9	3.5	3.0	3.1	3.4	38	3.1
4th Grade 1977	3.9	3.8	3.8	32	4.0	3.9	3.4	3.7	4.5	4.0	4.0	3.8	33	3.9
2nd Grade 1974	NA	NA	1.6		NA	NA	NA	1.9	NA	NA	NA	1.9		1.8
3rd Grade 1975	NA	NA	2.9	29	NA	NA	NA	2.5	NA	NA	NA	2.8	23	2.3
4th Grade 1976	4.0	3.9	3.8	32	4.2	3.9	3.8	4.0	4.6	4.0	3.9	3.9	34	4.1
5th Grade 1977	4.9	4.8	5.0	37	5.2	4.9	4.8	4.9	5.2	5.0	5.1	5.3	40	5.0
3rd Grade 1974	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA		NA
4th Grade 1975	3.9	4.0	3.6	29	4.1	4.0	3.9	3.9	4.5	4.1	4.2	4.0	36	4.0
5th Grade 1976	4.8	4.7	5.0	37	4.7	4.9	4.8	4.8	5.4	4.8	5.0	5.3	40	4.9
6th Grade 1977	5.6	5.6	5.7	37	7.0	6.2	5.4	5.8	6.4	6.0	6.0	5.9	39	5.9
4th Grade 1974	NA	NA	3.0		NA	NA	NA	3.2	NA	NA	NA	3.4		3.1
5th Grade 1975	4.7	4.9	4.5	31	5.0	4.8	4.6	4.7	5.4	5.2	5.0	5.1	36	4.9
6th Grade 1976	5.7	5.7	4.7	38	5.5	6.2	5.3	5.5	6.4	6.0	6.1	5.9	39	5.8
7th Grade 1977	6.4	5.8	6.3	36	6.5	5.9	5.9	5.9	7.7	6.8	7.0	7.4	47	6.6
5th Grade 1974	NA	NA	3.5		NA	NA	NA	3.2	NA	NA	NA	3.4		3.4
6th Grade 1975	5.6	5.7	5.2	32	6.0	5.7	5.7	5.7	6.1	5.9	5.8	5.8	39	5.7
7th Grade 1976	6.6	6.3	6.8	41	6.5	6.1	6.5	6.1	7.0	6.4	6.7	6.7	41	6.6
8th Grade 1977	7.8	8.0	7.8	40	7.6	7.5	7.5	7.5	8.5	8.1	7.9	8.4	47	7.9

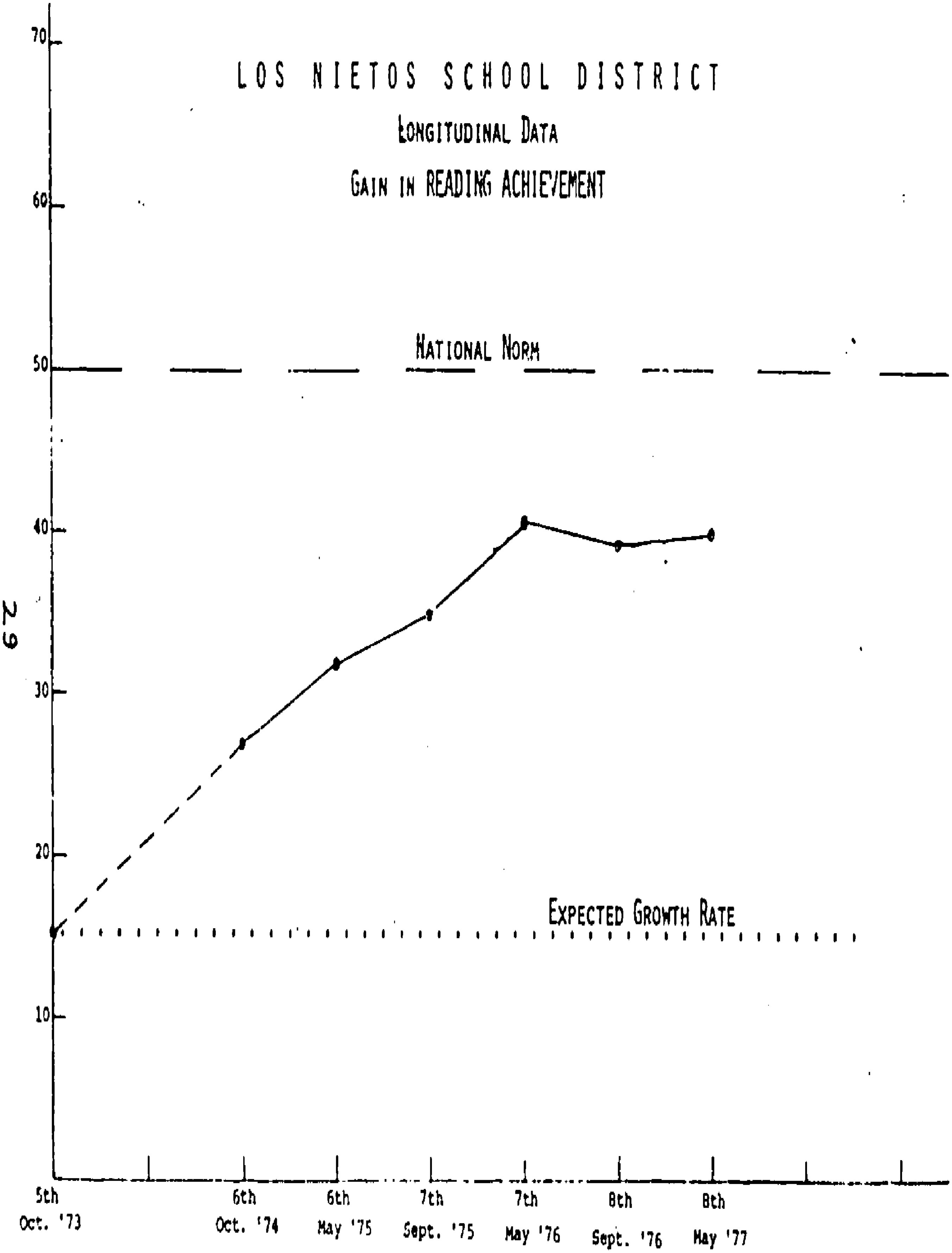

LOS NIETOS SCHOOL DISTRICT
LONGITUDINAL DATA
GAIN IN READING ACHIEVEMENT
NATIONAL NORM
EXPECTED GROWTH RATE
70
60
50
40
30
20
10
4th Sept. '74
4th May '75
5th Sept. '75
5th May '76
6th Sept. '76
6th May '77
7th Sept. '77
7th May '78
8th
8th



LOS NIETOS SCHOOL DISTRICT
LONGITUDINAL DATA
GAIN IN READING ACHIEVEMENT
NATIONAL NORM
EXPECTED GROWTH RATE
70
60
50
40
30
20
10
4th
Oct. '73
5th
Oct. '74
5th
May '75
6th
Sept. '75
6th
May '76
7th
7th
8th
8th

28

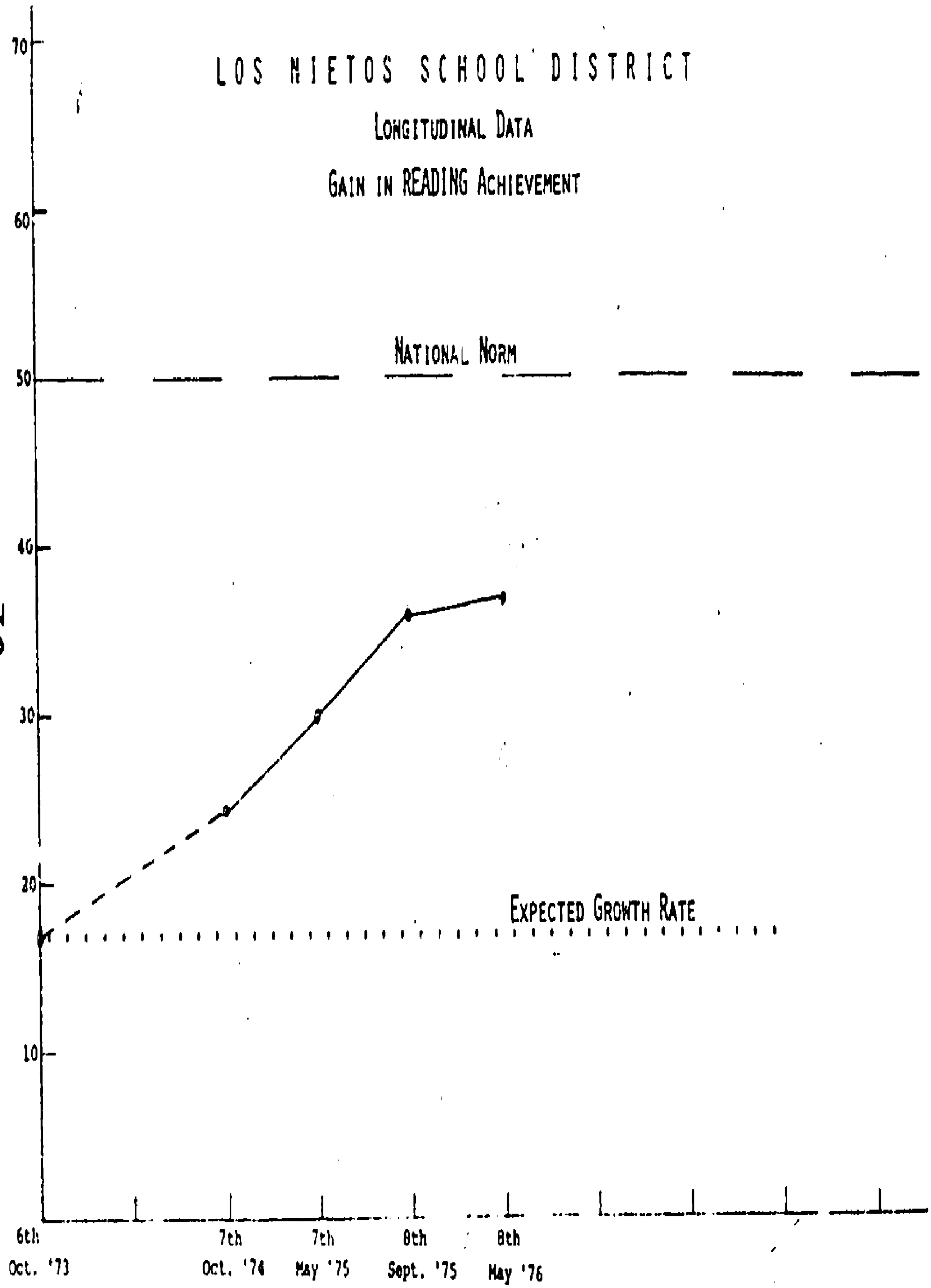
131



LOS NIETOS SCHOOL DISTRICT
LONGITUDINAL DATA
GAIN IN READING ACHIEVEMENT
NATIONAL NORM
EXPECTED GROWTH RATE
70
60
50
40
30
20
10
5th Oct. '73
6th Oct. '74
6th May '75
7th Sept. '75
7th May '76
8th Sept. '76
8th May '77

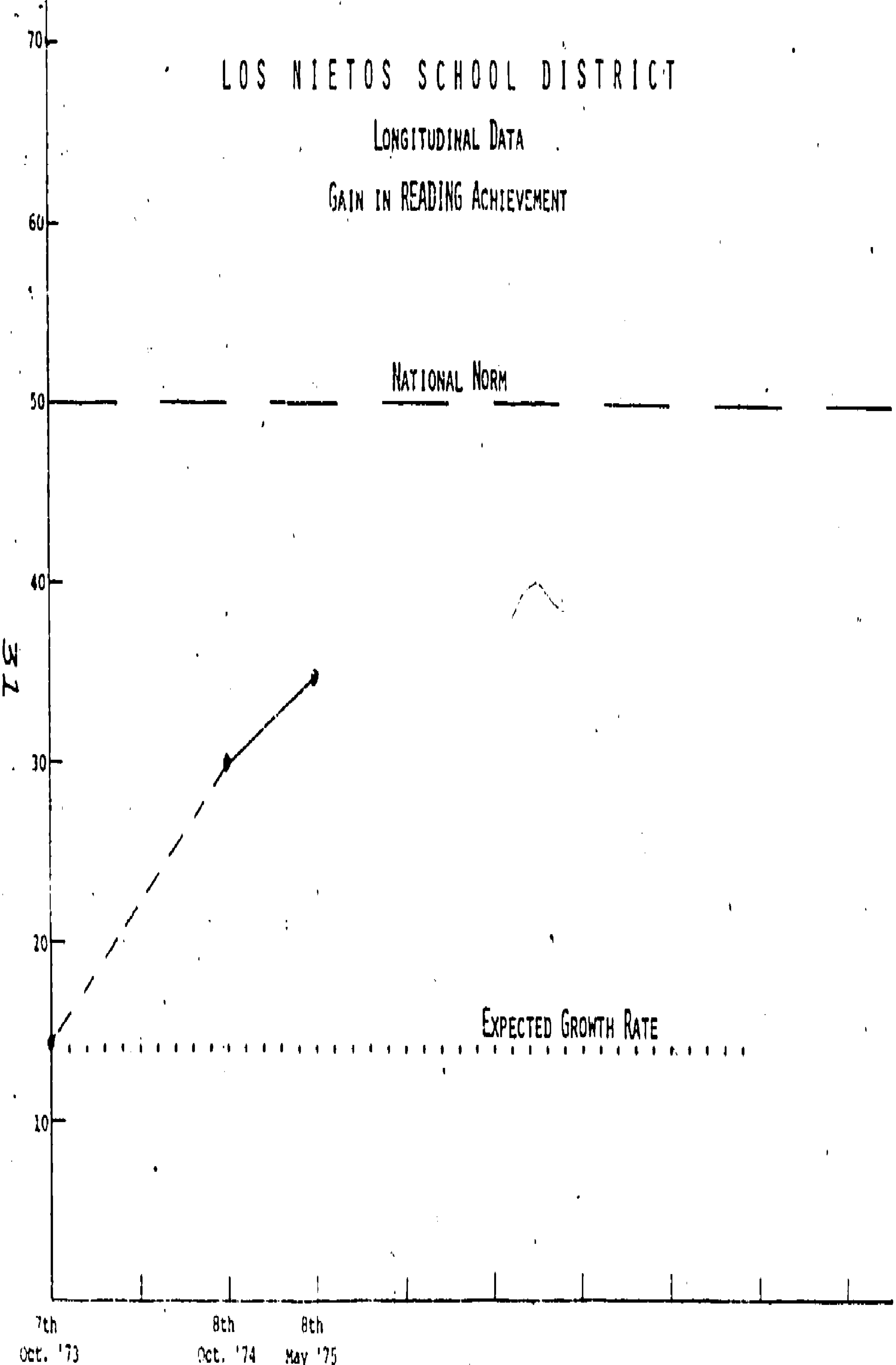
29

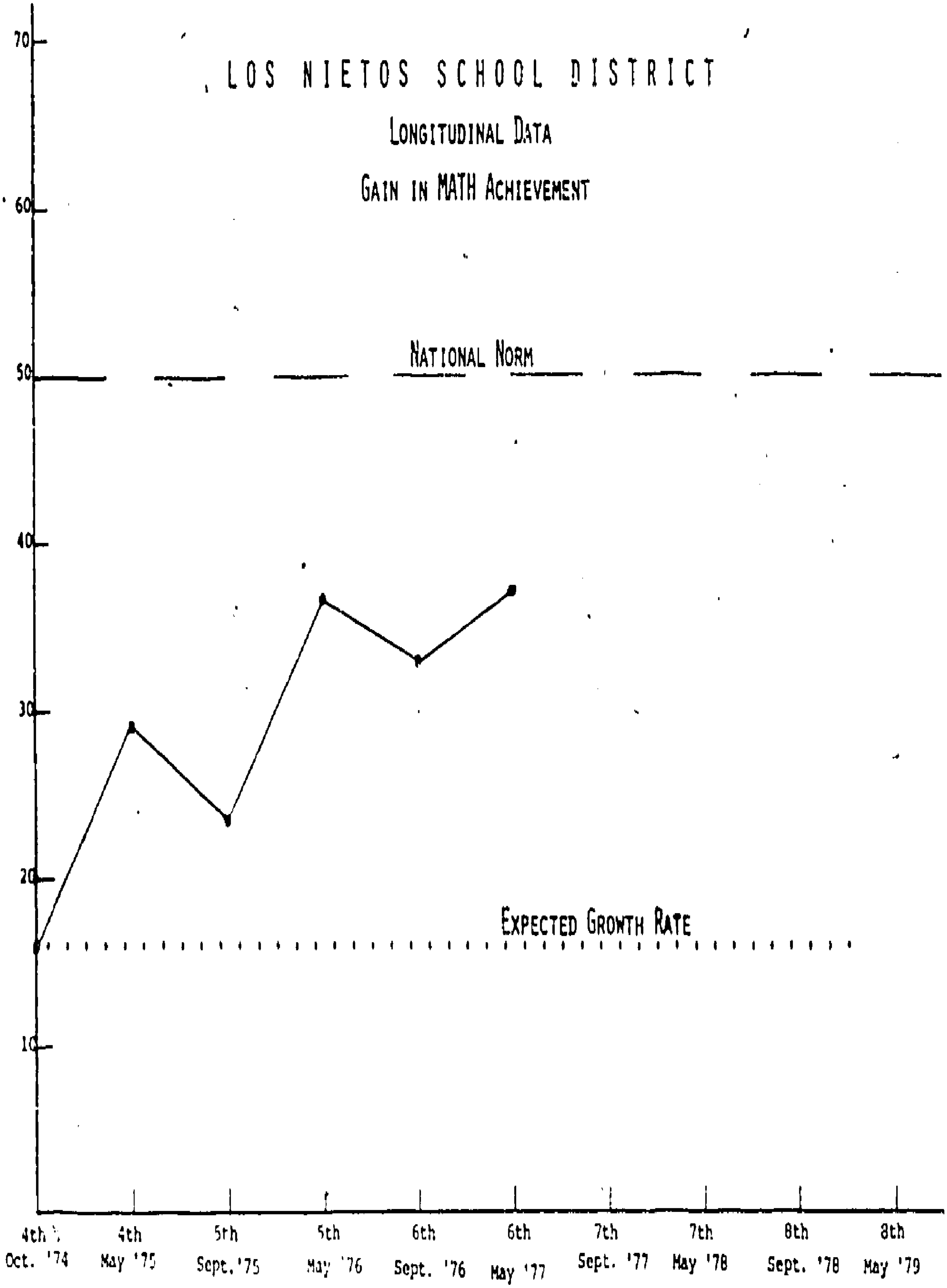
132

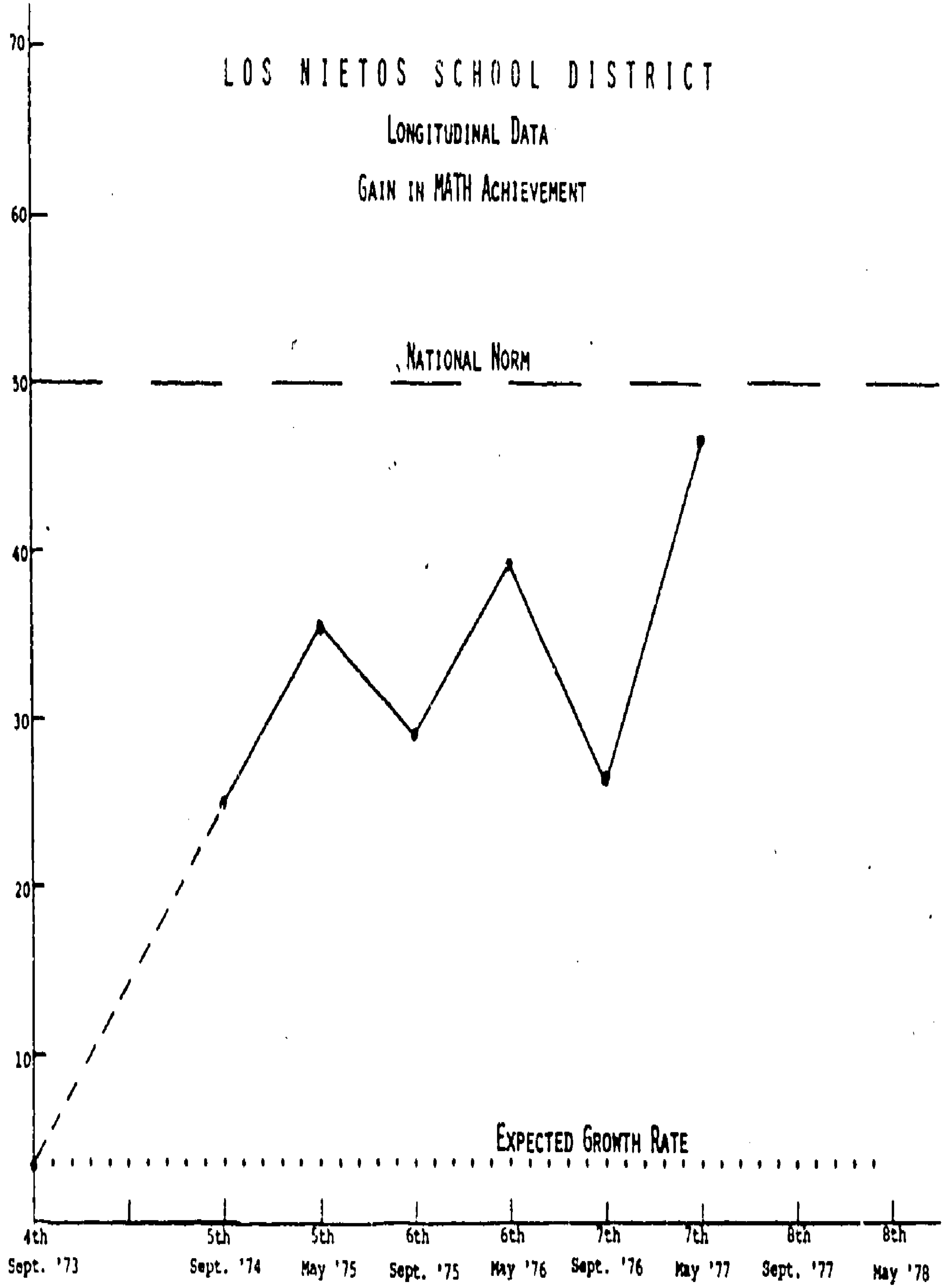

LOS NIETOS SCHOOL DISTRICT
LONGITUDINAL DATA
GAIN IN READING ACHIEVEMENT
NATIONAL NORM
EXPECTED GROWTH RATE
70
60
50
40
30
20
10
6th Oct. '73
7th Oct. '74
7th May '75
8th Sept. '75
8th May '76

30

133

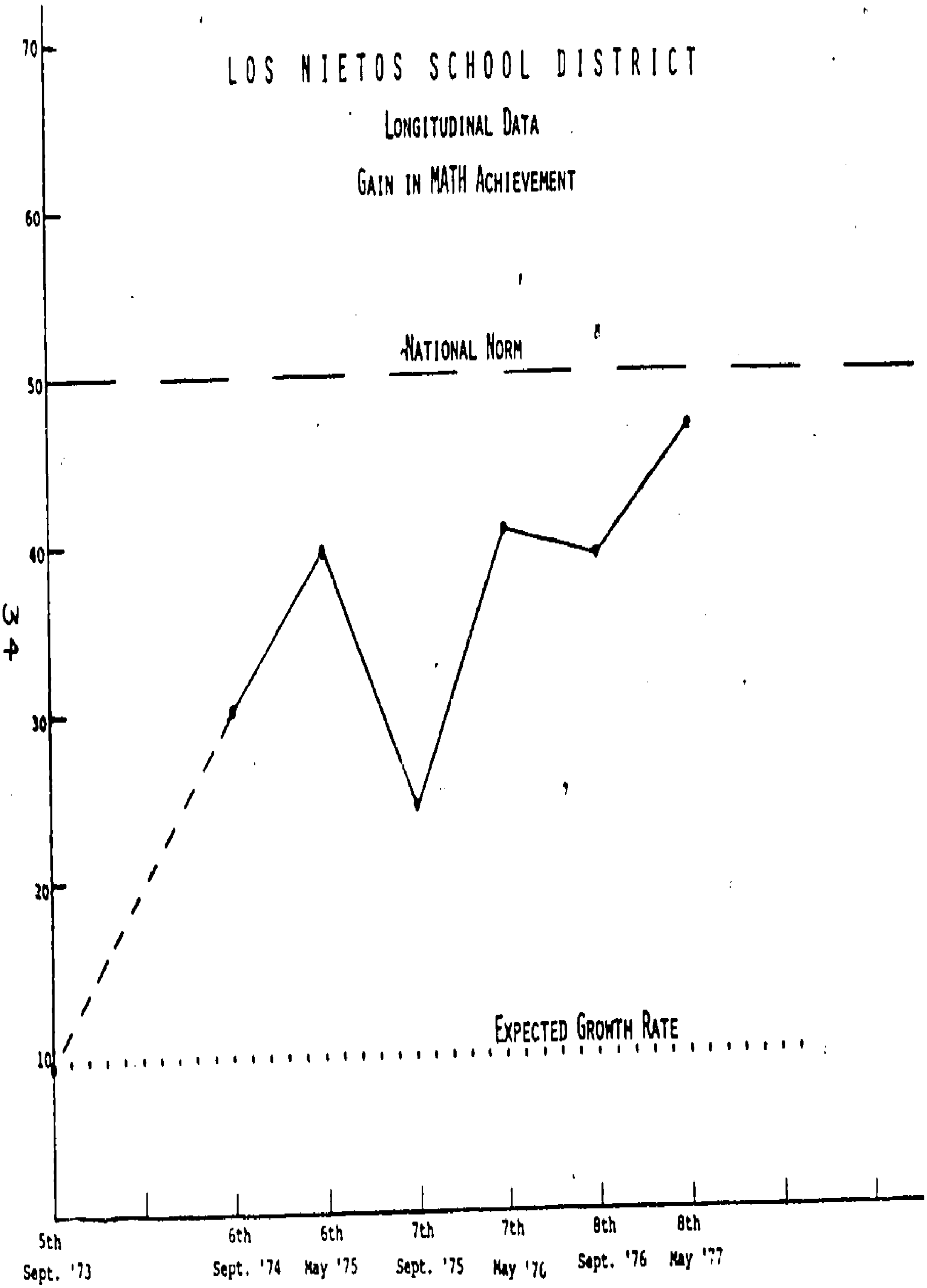

LOS NIETOS SCHOOL DISTRICT
LONGITUDINAL DATA
GAIN IN READING ACHIEVEMENT
NATIONAL NORM
EXPECTED GROWTH RATE
70
60
50
40
30
20
10
7th
Oct. '73
8th
Oct. '74
8th
May '75

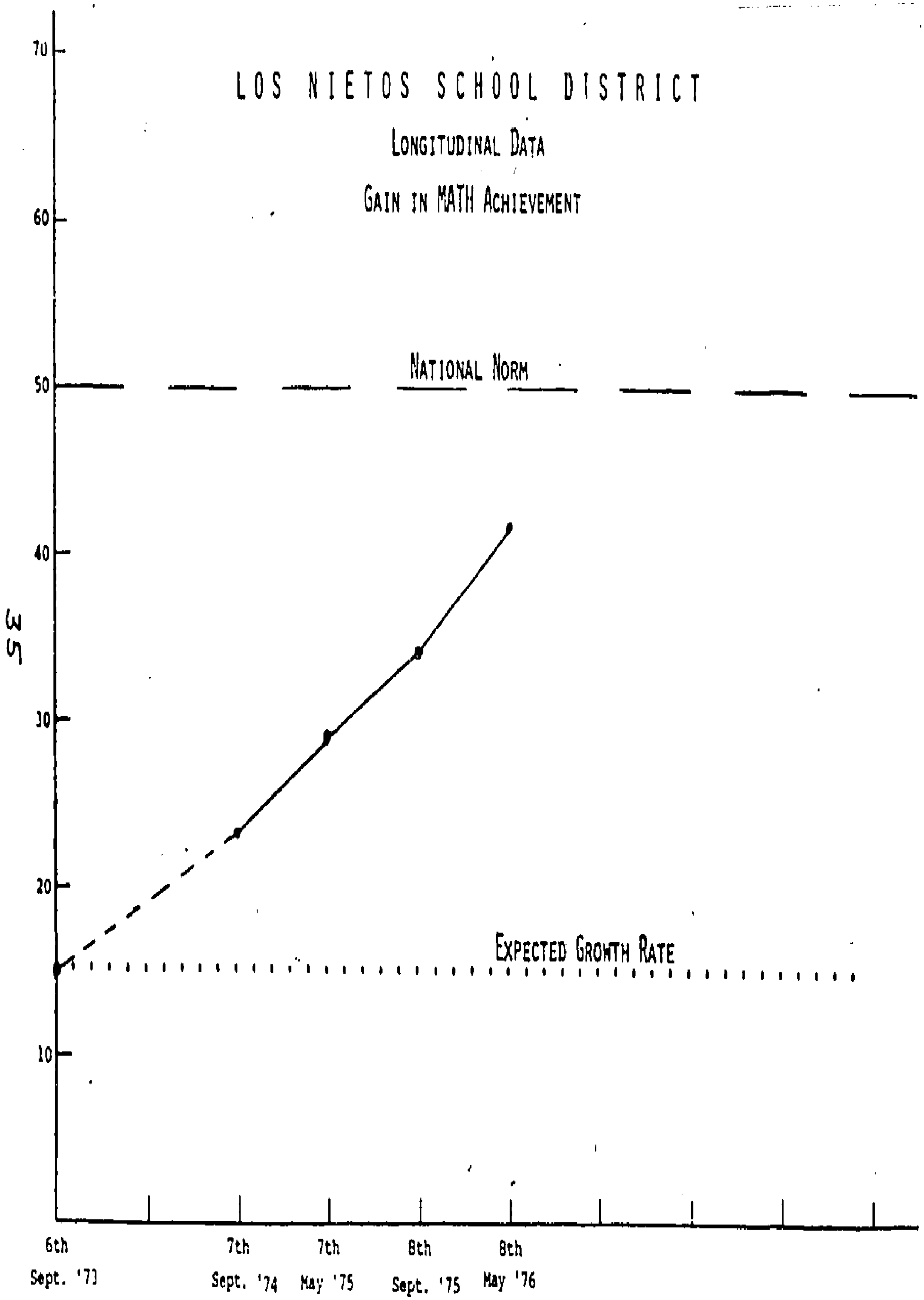

LOS NIETOS SCHOOL DISTRICT
LONGITUDINAL DATA
GAIN IN MATH ACHIEVEMENT
70
60
50
40
30
20
10
NATIONAL NORM
EXPECTED GROWTH RATE
4th Oct. '74
4th May '75
5th Sept. '75
5th May '76
6th Sept. '76
6th May '77
7th Sept. '77
7th May '78
8th Sept. '78
8th May '79

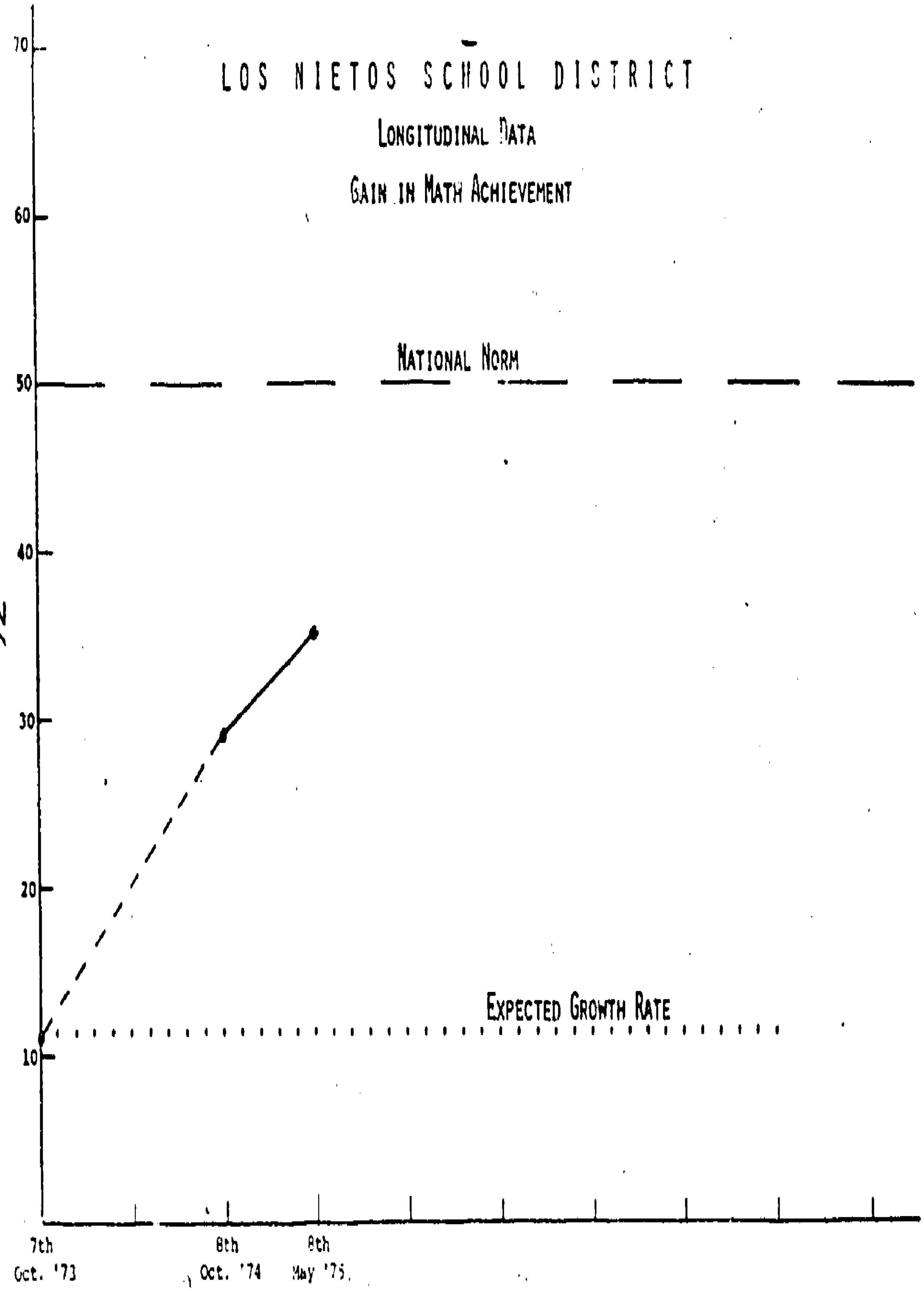

LOS NIETOS SCHOOL DISTRICT
LONGITUDINAL DATA
GAIN IN MATH ACHIEVEMENT
NATIONAL NORM
EXPECTED GROWTH RATE
70
60
50
40
30
20
10
4th Sept. '73
5th Sept. '74
5th May '75
6th Sept. '75
6th May '76
7th Sept. '76
7th May '77
8th Sept. '77
8th May '78

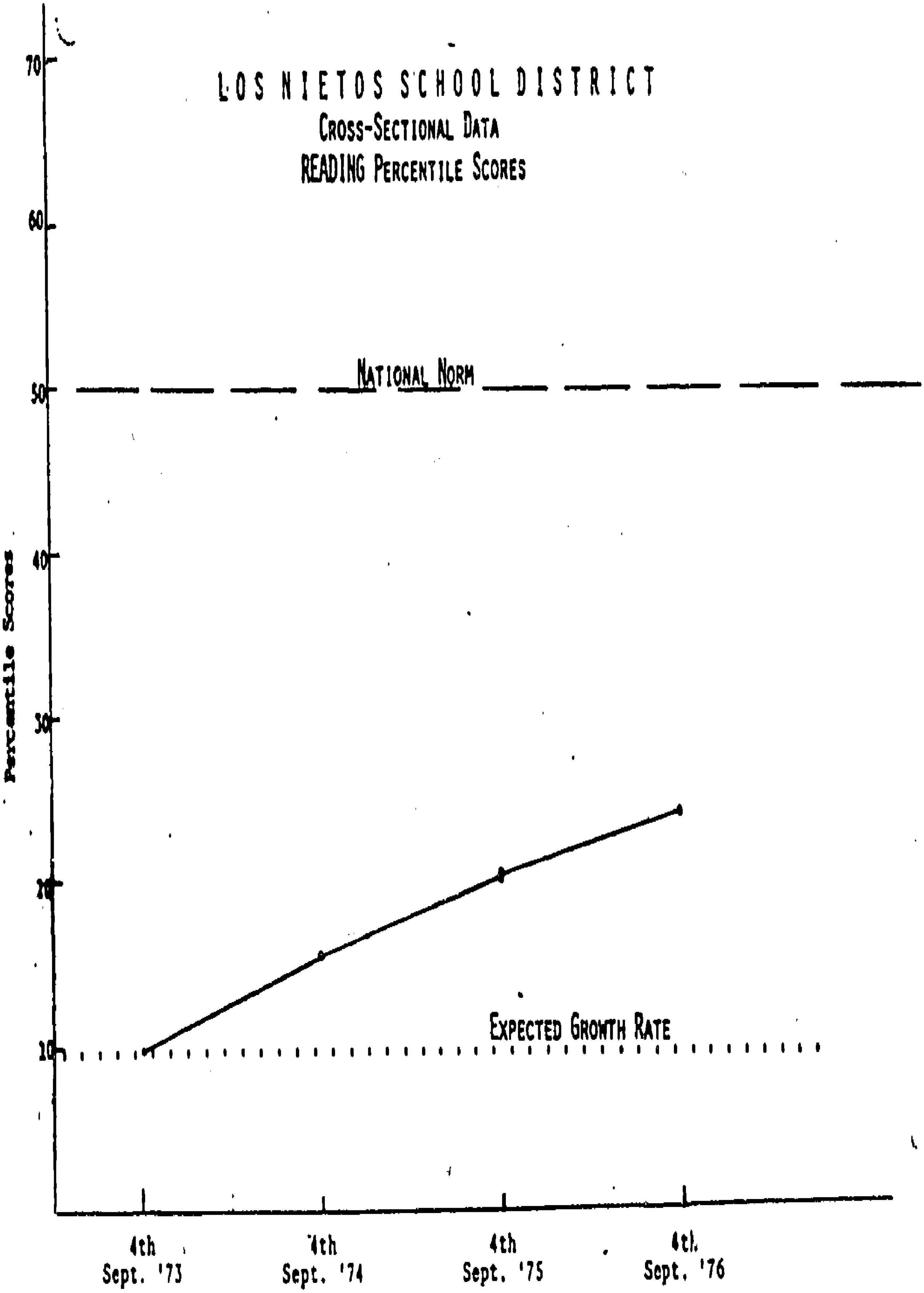
33

136


LOS NIETOS SCHOOL DISTRICT
LONGITUDINAL DATA
GAIN IN MATH ACHIEVEMENT
NATIONAL NORM
EXPECTED GROWTH RATE
70
60
50
40
30
20
10
5th Sept. '73
6th Sept. '74
6th May '75
7th Sept. '75
7th May '76
8th Sept. '76
8th May '77

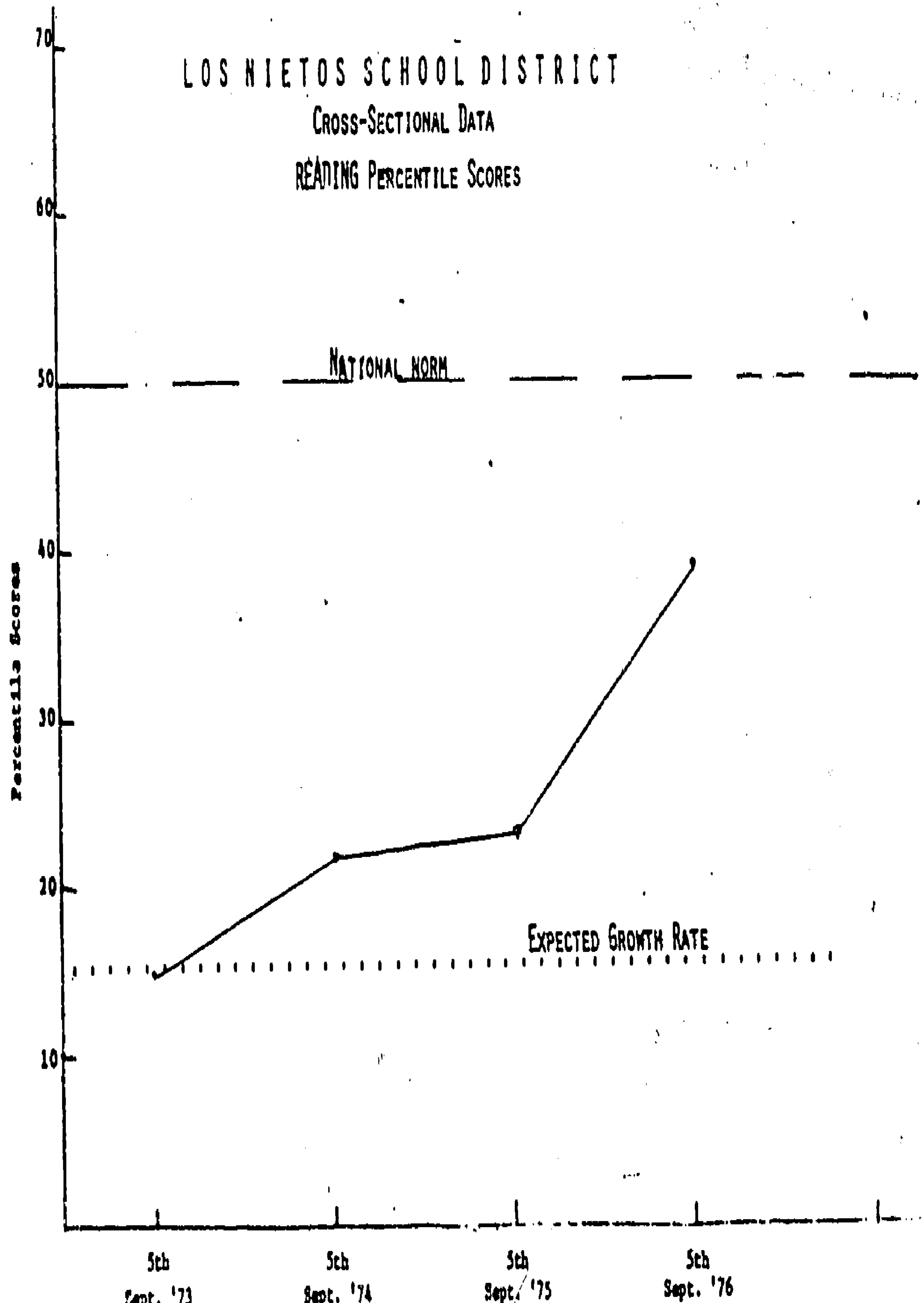

LOS NIETOS SCHOOL DISTRICT
Longitudinal Data
Gain in MATH Achievement
National Norm
Expected Growth Rate
70
60
50
40
30
20
10
6th
Sept. '73
7th
Sept. '74
7th
May '75
8th
Sept. '75
8th
May '76


LOS NIETOS SCHOOL DISTRICT
LONGITUDINAL DATA
GAIN IN MATH ACHIEVEMENT
NATIONAL NORM
EXPECTED GROWTH RATE
70
60
50
40
30
20
10
7th Oct. '73
8th Oct. '74
8th May '75


LOS NIETOS SCHOOL DISTRICT
CROSS-SECTIONAL DATA
READING PERCENTILE SCORES
NATIONAL NORM
EXPECTED GROWTH RATE
Percentile Scores
70
60
50
40
30
20
10
4th Sept. '73
4th Sept. '74
4th Sept. '75
4th Sept. '76

- 37 -

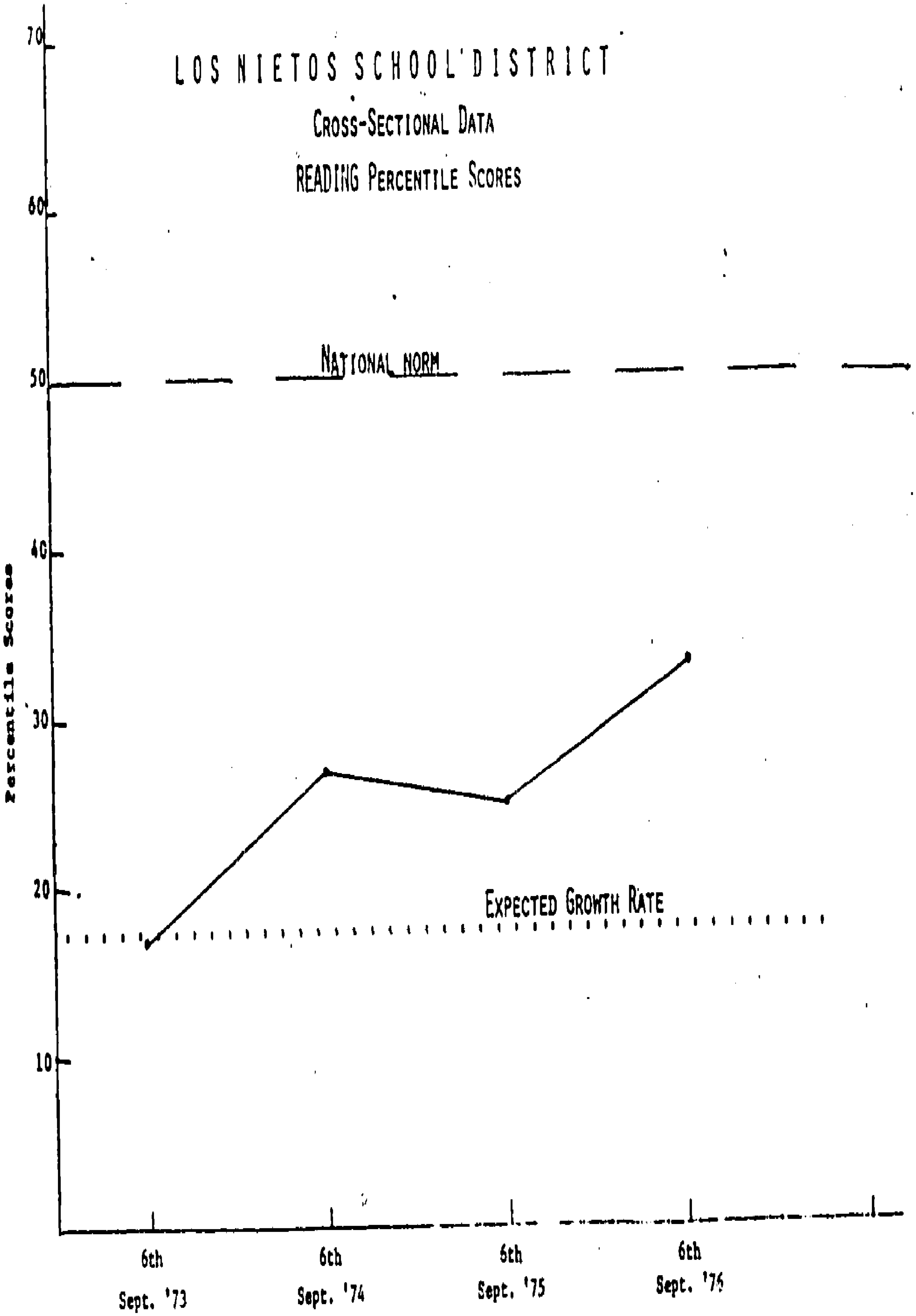
140

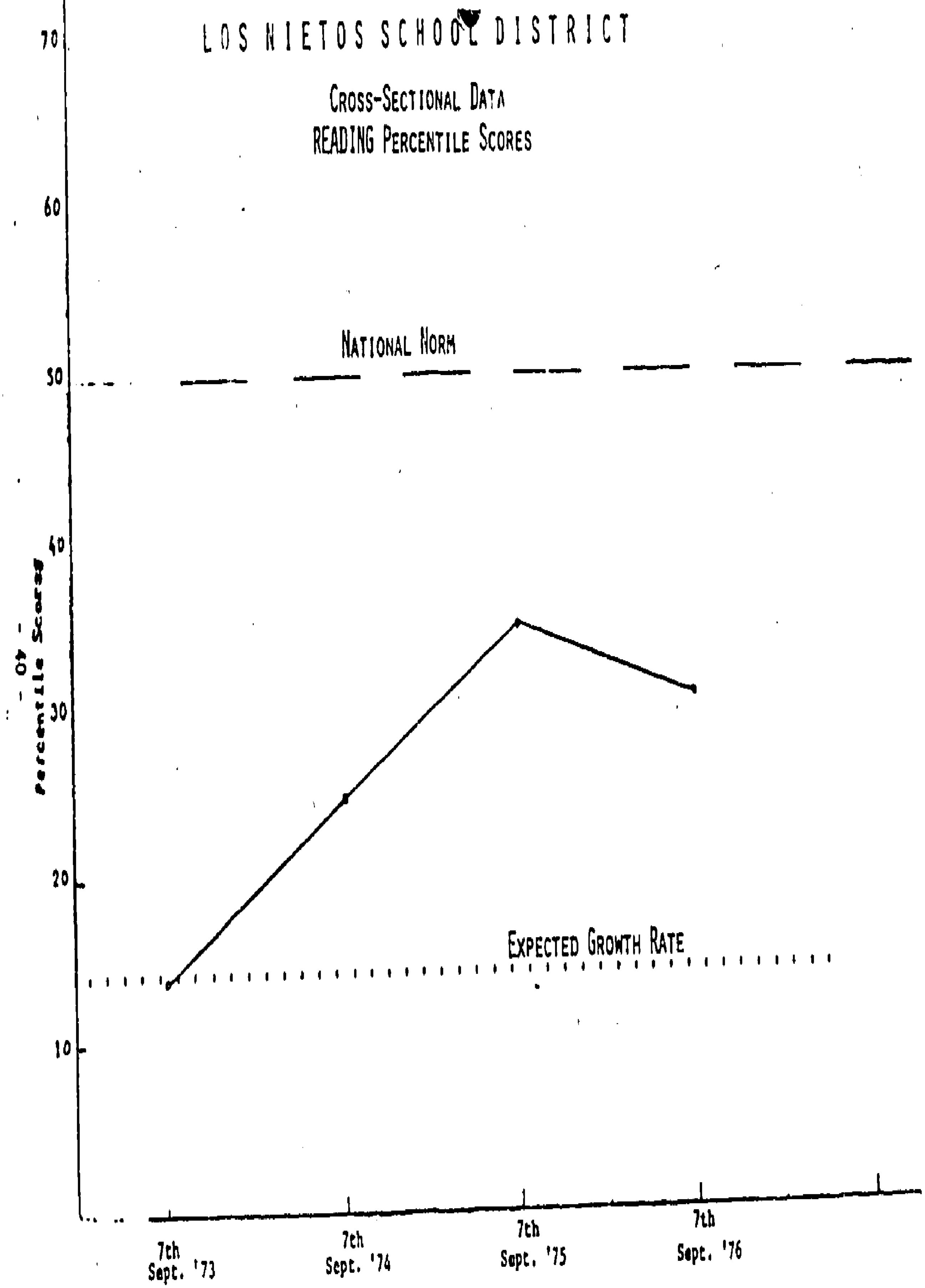


LOS NIETOS SCHOOL DISTRICT
CROSS-SECTIONAL DATA
READING PERCENTILE SCORES
70
60
50
40
30
20
10
NATIONAL NORM
EXPECTED GROWTH RATE
Percentile Scores
5th
Sept. '73
5th
Sept. '74
5th
Sept. '75
5th
Sept. '76

- 38 -

141

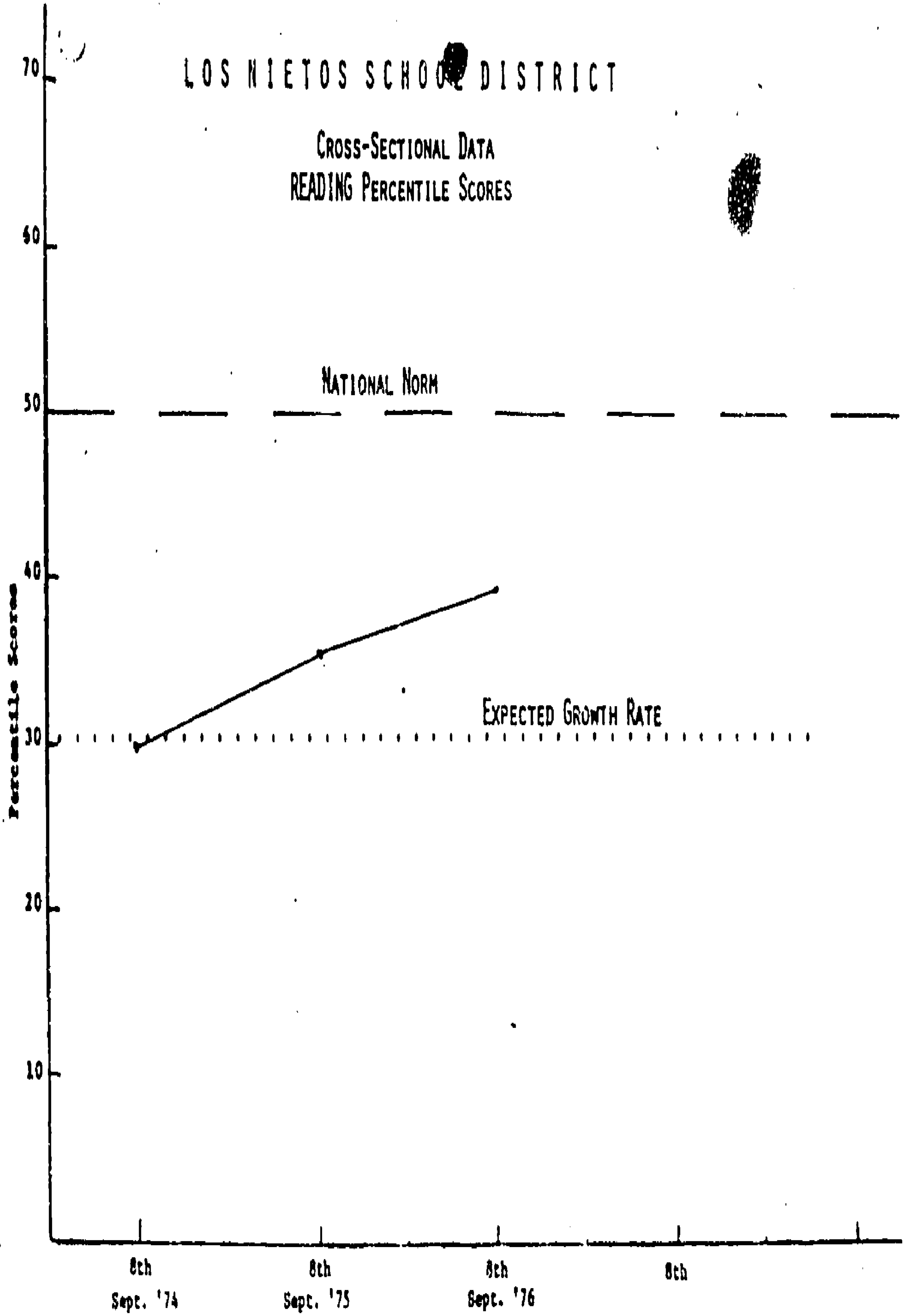

LOS NIETOS SCHOOL DISTRICT
CROSS-SECTIONAL DATA
READING PERCENTILE SCORES
70
60
50
40
30
20
10
NATIONAL NORM
EXPECTED GROWTH RATE
Percentile Scores
6th
Sept. '73
6th
Sept. '74
6th
Sept. '75
6th
Sept. '76

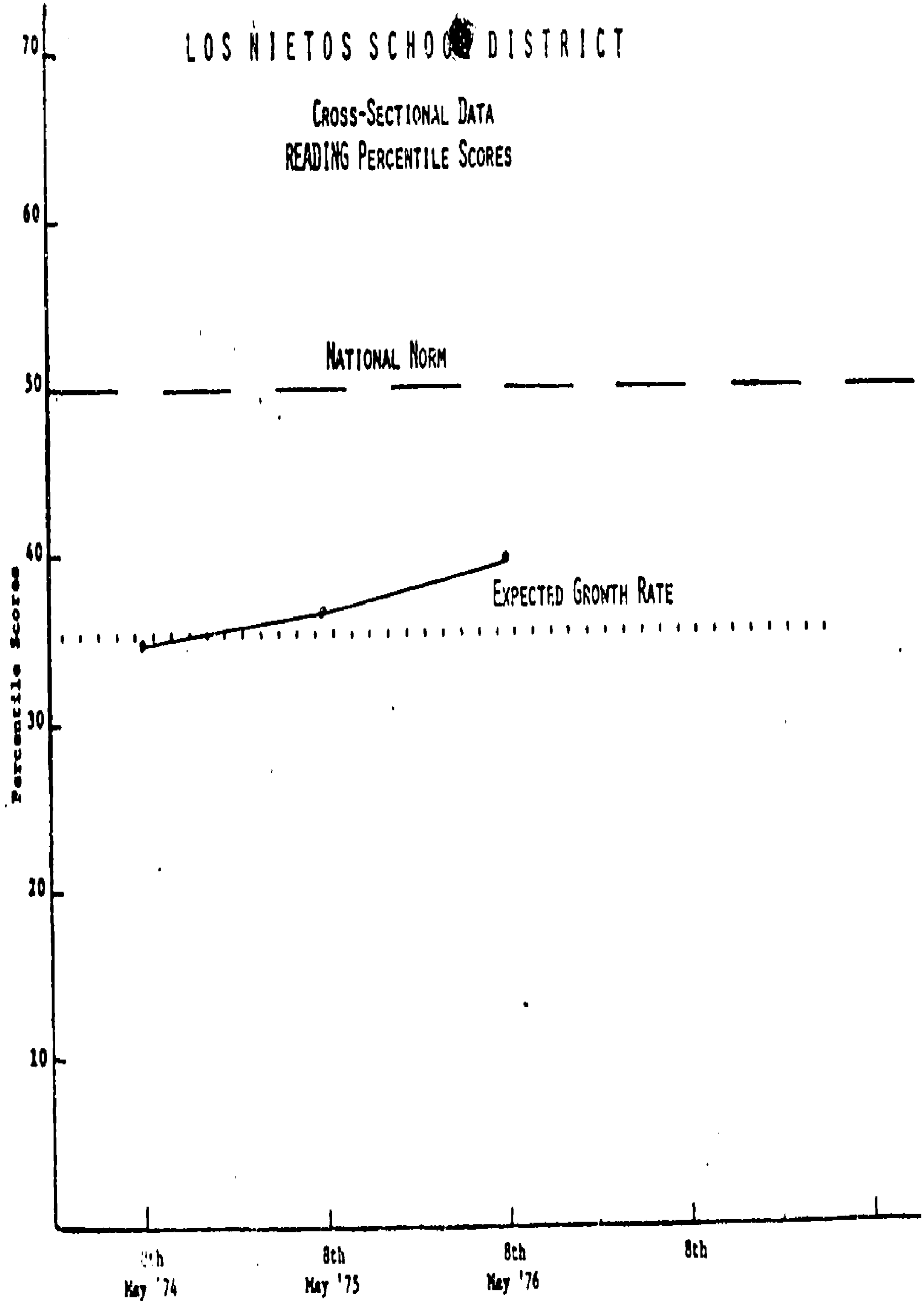


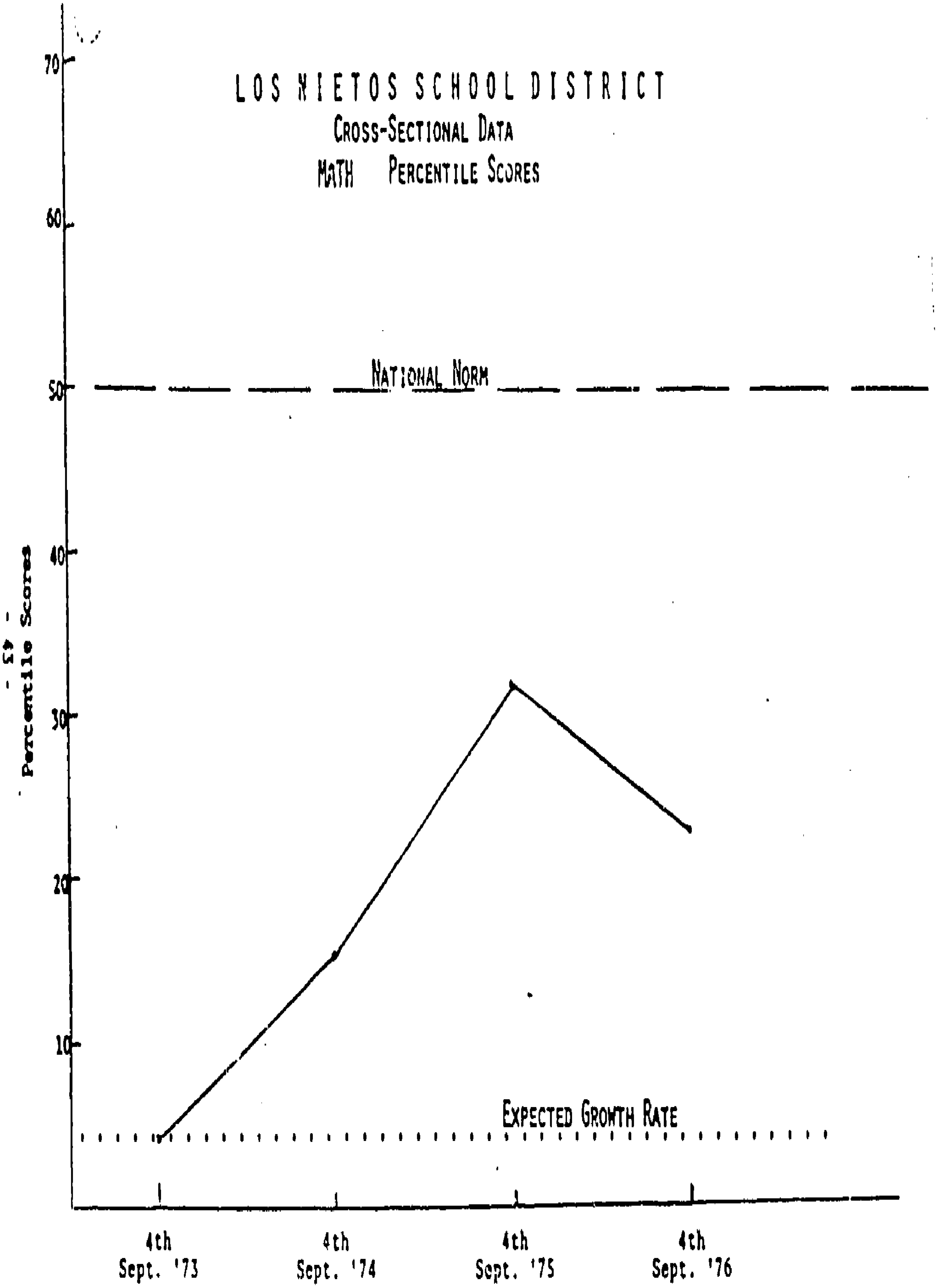
LOS NIETOS SCHOOL DISTRICT
Cross-Sectional Data
READING Percentile Scores
National Norm
Expected Growth Rate
Percentile Scores
70
60
50
40
30
20
10
7th Sept. '73
7th Sept. '74
7th Sept. '75
7th Sept. '76

- 40 -

143

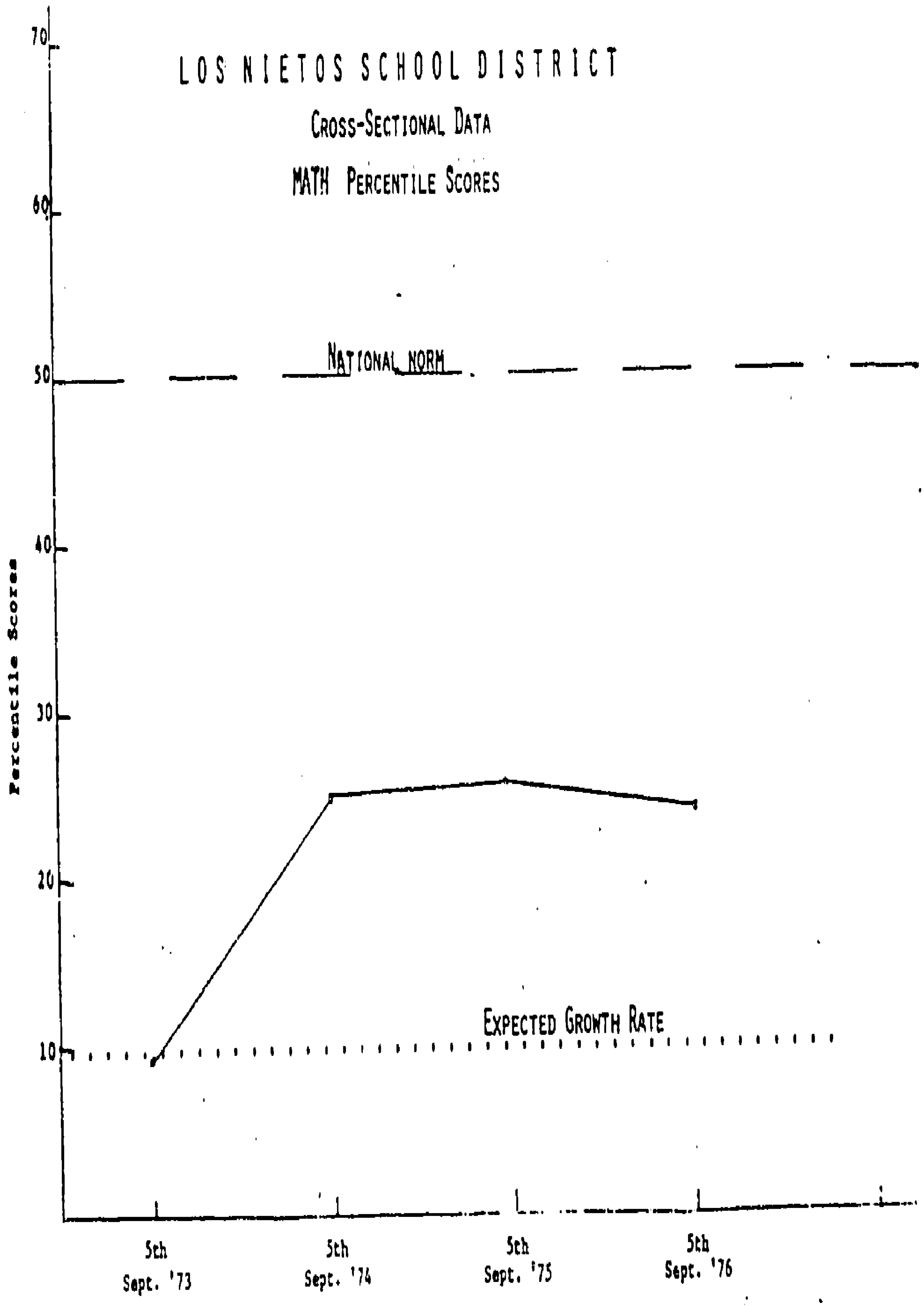

LOS NIETOS SCHOOL DISTRICT
CROSS-SECTIONAL DATA
READING PERCENTILE SCORES
NATIONAL NORM
EXPECTED GROWTH RATE
Percentile Scores
70
60
50
40
30
20
10
8th
Sept. '74
8th
Sept. '75
8th
Sept. '76
8th


LOS NIETOS SCHOOL DISTRICT
CROSS-SECTIONAL DATA
READING PERCENTILE SCORES
NATIONAL NORM
EXPECTED GROWTH RATE
Percentile Scores
70
60
50
40
30
20
10
8th May '74
8th May '75
8th May '76
8th

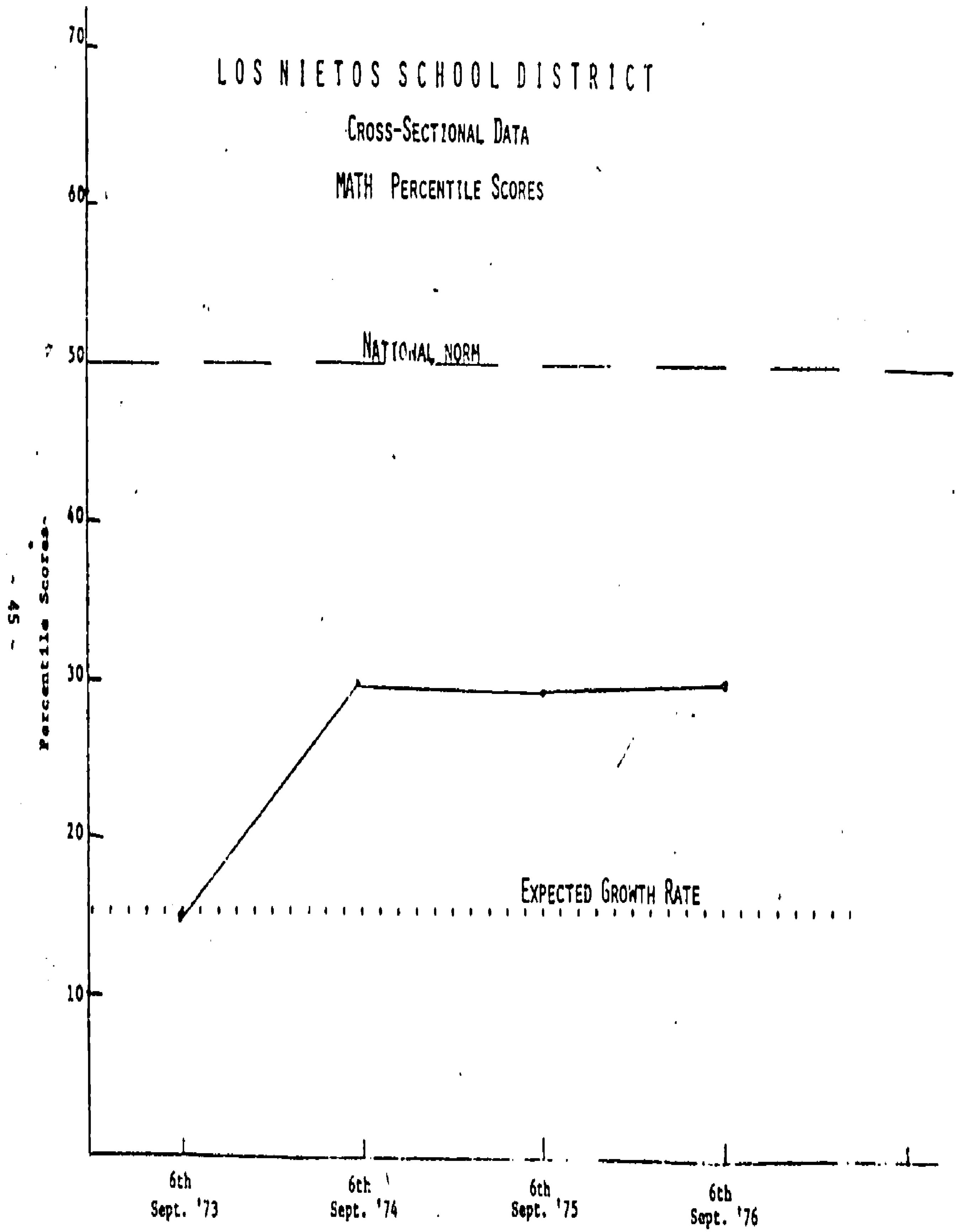

LOS NIETOS SCHOOL DISTRICT
Cross-Sectional Data
Math Percentile Scores
National Norm
Expected Growth Rate
Percentile Scores
70
60
50
40
30
20
10
4th Sept. '73
4th Sept. '74
4th Sept. '75
4th Sept. '76

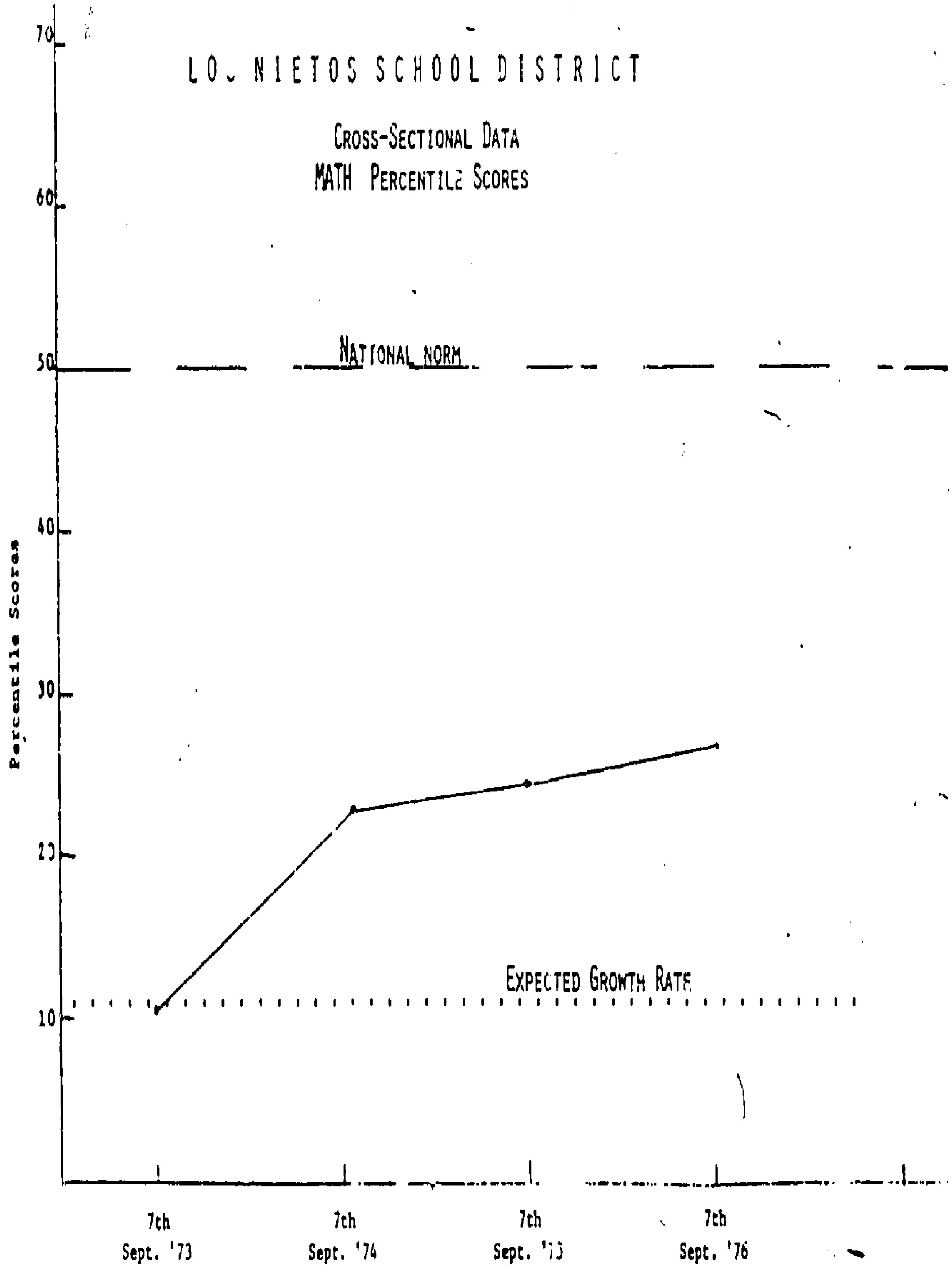
- 43 -

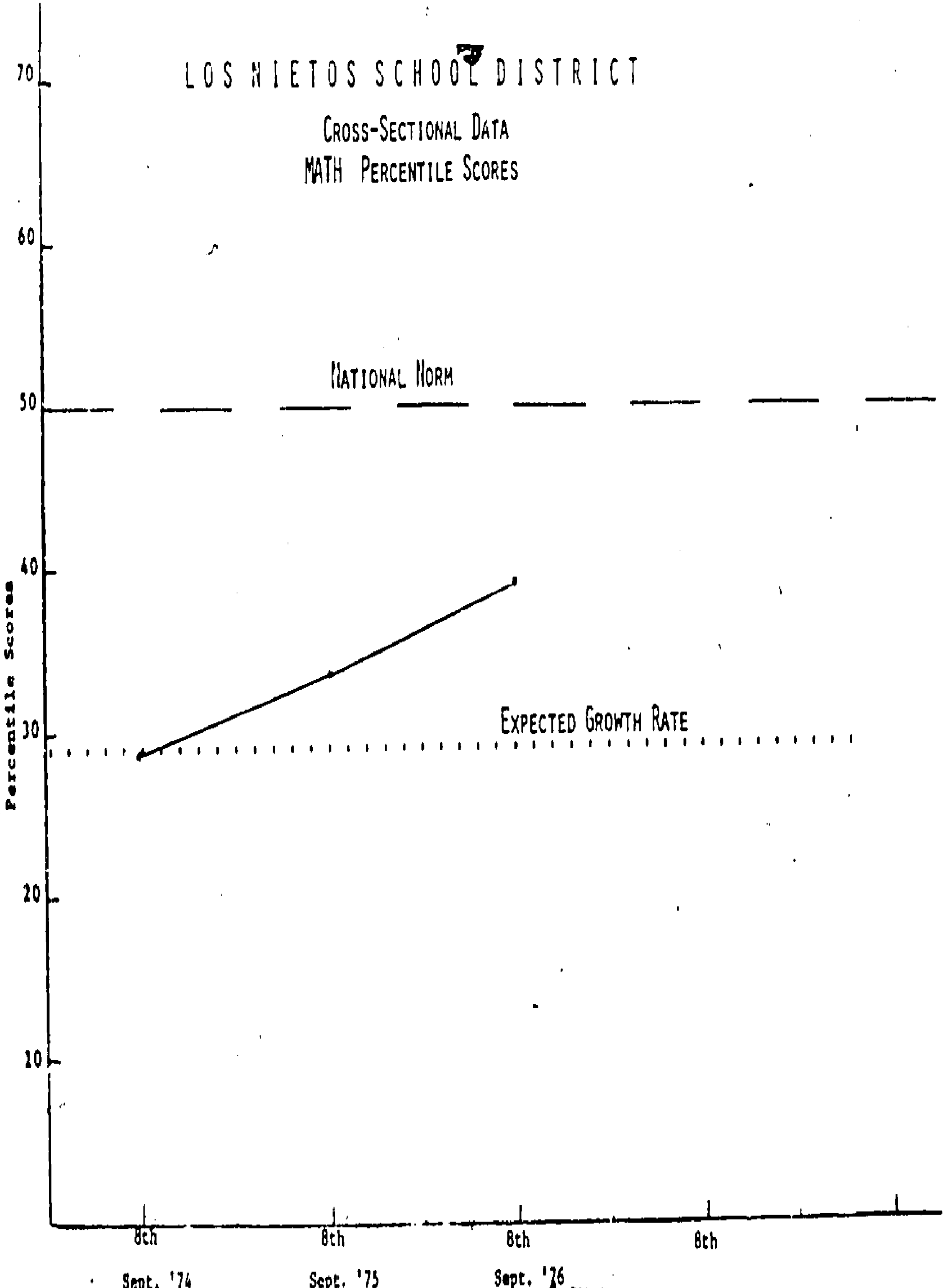
146

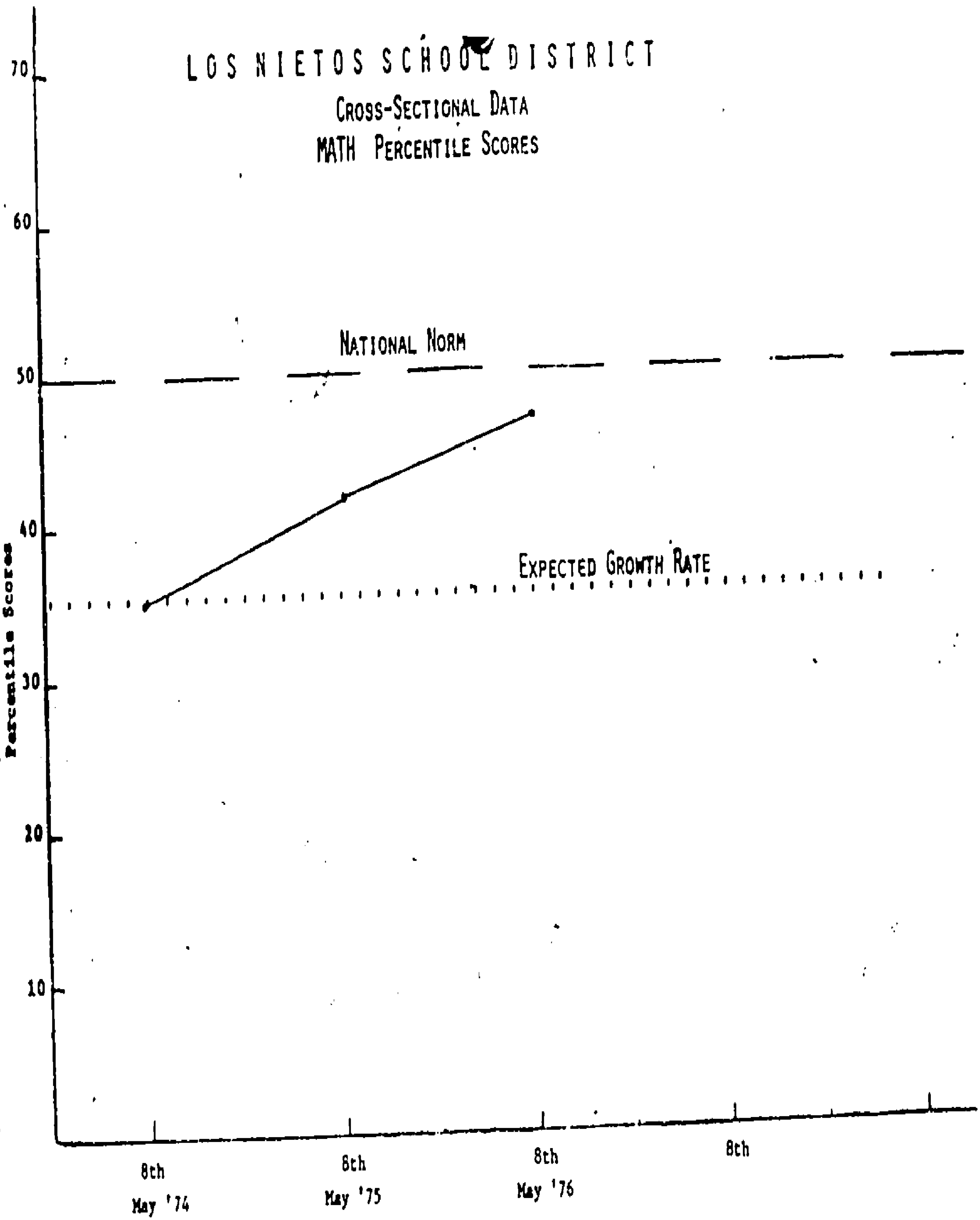


LOS NIETOS SCHOOL DISTRICT
CROSS-SECTIONAL DATA
MATH PERCENTILE SCORES
NATIONAL NORM
EXPECTED GROWTH RATE
Percentile Scores
70
60
50
40
30
20
10
5th Sept. '73
5th Sept. '74
5th Sept. '75
5th Sept. '76


LOS NIETOS SCHOOL DISTRICT
CROSS-SECTIONAL DATA
MATH PERCENTILE SCORES
NATIONAL NORM
EXPECTED GROWTH RATE
Percentile Scores
70
60
50
40
30
20
10
6th Sept. '73
6th Sept. '74
6th Sept. '75
6th Sept. '76


LO. NIETOS SCHOOL DISTRICT
CROSS-SECTIONAL DATA
MATH PERCENTILE SCORES
NATIONAL NORM
EXPECTED GROWTH RATE
Percentile Scores
70
60
50
40
30
20
10
7th
Sept. '73
7th
Sept. '74
7th
Sept. '75
7th
Sept. '76


LOS NIETOS SCHOOL DISTRICT
CROSS-SECTIONAL DATA
MATH PERCENTILE SCORES
NATIONAL NORM
EXPECTED GROWTH RATE
Percentile Scores
70
60
50
40
30
20
10
8th
Sept. '74
8th
Sept. '75
8th
Sept. '76
8th


LOS NIETOS SCHOOL DISTRICT
CROSS-SECTIONAL DATA
MATH PERCENTILE SCORES
National Norm
Expected Growth Rate
Percentile Scores
70
60
50
40
30
20
10
8th
May '74
8th
May '75
8th
May '76
8th

151

Mr. SWANSON. I would like to give others a chance to ask some questions.

Mr. GALLAGHER. Is it possible that the machines have more of a heart than the teachers?

Mr. CRANDALL. Well, they are just as nice to kids at 3 in the afternoon as they are at 9 in the morning.

Mr. GALLAGHER. In your earlier remarks I had a certain skepticism, but after listening to testimony from the Brooklyn No. 18 School District and the achievements they have made between 1974 and 1976, it is quite remarkable.

The testimony today of reversing a 16-year trend not only is laudable but almost miraculous. I am interested too in not just a product, a direct product, but as you mentioned, the byproduct of some of this. It is like an assertiveness training program, making the student less dependent on the teacher and more dependent on himself.

I do have one observation in this byproduct area where you mention, for example, reduction in vandalism and absenteeism, et cetera. These are heavy claims to place upon an educational computer system, perhaps more heavy than it can bear. It is doing a wonderful job on the direct line now and what I'm raising here is could it be possible that there are other factors involved here that could be shown to be contributing to the alleviation of some of the social problems, the cutdown in vandalism and so forth. For example what about the teacher-pupil relationship, the police relationship, the fact that children might have jobs today, especially the teenagers may have a job and they have money in their pocket and they may be less apt to be violent? What about schools that don't have this system? Has their vandalism also decreased?

Mr. CRANDALL. The schools surrounding us that have similar population groups have shown increases in vandalism, fires within buildings, increase in grafitti on the walls, and generally, the type of deterioration we have noticed.

I really get quite a bit of confidence for our claims from the experiences of Newark, N.J., which has a limited CAI program. Within those schools in Newark which have used CAI, they have had similar experience. Also, within the Chicago public schools they have experienced the same thing.

Now, it is very, very difficult to say this is a cause-and-effect relationship. I can't prove that; no. But that was the only new variable we had introduced within that period of time.

Mr. GALLAGHER. The evidence seems to be heavily circumstantial.

Mr. CRANDALL. Yes.

Mr. MONTANO. The point is very well taken and we have been wrestling with exactly what you have said. However, we have not been able to collect any data that would actually point in that direction other than that these are side effects that have happened. In fact, some of this we were not even aware of. We were basically concerned with the achievements of the students. These are the things that have happened.

Mr. GALLAGHER. Would this have an effect on the teachers and would they begin to try to find out what it is that they themselves perhaps have lacked so that they could give to the students more of this self-starting?

Mr. CRANDALL. I think we are just on the threshold on this in that we have known about locus of control for some time, but no one has come up with a way of building internality. I would say that we certainly didn't have this in mind when we started the program. To us, it has been a very valuable byproduct, but I think we have a long way yet to go for the teachers to incorporate certain classroom activities and attitudes within the youngsters that would reinforce the feeling they get from working on the terminals.

Mr. GALLAGHER. Thank you.

Mr. BELIENSON. Are there further questions?

If not, I want to thank Dr. Crandall and Dr. Montano for their excellent testimony this morning. I am sure more of the members wish they could have heard it. We hope we can be in further contact with you on this subject.

Mr. CRANDALL. We certainly appreciate the opportunity to tell about a successful program that is being funded from this city.

Mr. BELIENSON. Our next witness will be Mr. William C. Norris, who is chairman of the board and chief executive officer of Control Data Corp.

Mr. Norris, would you and any of your colleagues which you wish to bring up come forward at this point. You may proceed with your statement, and without objection, the full text of your prepared statement will be included in the record. You may present it in any fashion you wish.

[The prepared statement of Mr. Norris follows:]

THE FUTURE OF PLATO

COMPUTER BASED EDUCATION

Statement of
William C. Norris
Chairman & Chief Executive Officer
Control Data Corporation

at a hearing of
The House Science & Technology Subcommittee
on Domestic & International
Scientific Planning, Analysis & Cooperation

Room 2325
Rayburn House Office Building
10:00 a.m. October 6, 1977
Washington, D.C.

PLATO CBE PRESENTATION
FOR HEARING BY
HOUSE COMMITTEE ON SCIENCE & TECHNOLOGY

IT IS A PLEASURE FOR ME TO PARTICIPATE IN THIS HEARING. AS GENERAL BACKGROUND FOR MY PRESENTATION, IT SHOULD BE NOTED THAT ONE OF THIS NATION'S AND THE WORLD'S MOST URGENT NEEDS IS BETTER EDUCATION. WHEN ONE CONSIDERS THAT THREE-QUARTERS OF A BILLION PEOPLE IN THE WORLD ARE ILLITERATE AND THAT ILLITERACY IS RISING, IT MIGHT BE THE NUMBER ONE NEED.

CONTROL DATA'S TOP STRATEGIC PRIORITY IS TO APPLY COMPUTER TECHNOLOGY TO HELP ACHIEVE QUALITY, EQUALITY AND PRODUCTIVITY IMPROVEMENTS IN EDUCATION. IT HAS THE LARGEST SINGLE COMMITMENT OF DEVELOPMENTAL RESOURCES IN OUR COMPANY TODAY. AND THAT'S HOW IT SHOULD BE. IT IS OUR CONVICTION THAT IF SOCIETY'S MAJOR PROBLEMS ARE GIVEN PRIORITY, IN THE LONG RUN THEY WILL PROVIDE THE BEST OPPORTUNITIES FOR BUSINESS.

IT HAS BECOME OBVIOUS THAT THE SUCCESSFUL APPLICATION OF COMPUTER TECHNOLOGY IN EDUCATION WILL ONLY BE ACHIEVED THROUGH WIDESPREAD COOPERATION AMONG BUSINESS, EDUCATIONAL INSTITUTIONS AND GOVERNMENT. THESE HEARINGS, THEREFORE, ARE TIMELY AND SIGNIFICANT IN FURTHERING THAT PROCESS AND YOUR INITIATIVE IS TO BE APPLAUDED.

PLATO

CONTROL DATA'S ANSWER FOR IMPROVING EDUCATION IS PLATO

COMPUTER-BASED EDUCATION. CONTROL DATA PLATO PROVIDES BOTH COMPUTER-ASSISTED AND COMPUTER-MANAGED INSTRUCTION, INTEGRATED WITH CONVENTIONAL AND MULTI-MEDIA LEARNING ACTIVITIES.

THE SALIENT FEATURES AND ADVANTAGES OF CONTROL DATA PLATO MAY BE SUMMARIZED AS FOLLOWS:

IT PERMITS DIRECT, CREATIVE AND RESPONSIVE DIALOGUE, ON A ONE-ON-ONE BASIS BETWEEN THE INSTRUCTOR AND THE STUDENT, OR ON A ONE-ON-MANY BASIS, NOT UNLIKE THE ORIGINAL PLATO'S OLIVE GROVE ACADEMY.

BECAUSE THE SYSTEM CAN ACCEPT, REACT TO, RESPOND TO AND TEST THE INDIVIDUAL STUDENT INPUT JUST AS IT COMES FROM THE STUDENT, PLATO IS UNIQUELY POWERFUL IN TEACHING PROBLEM ANALYSIS.

AT THE SAME TIME THE SYSTEM IS ABSOLUTELY TIMELESS IN A TESTING AND DRILL AND PRACTICE MODE. IT CAN AND DOES EXERCISE STUDENTS FROM KINDERGARTEN TO PhD LEVEL.

THE UNIQUE CAPABILITIES OF THE SOFTWARE PERMIT A PERSON WITH EDUCATIONAL EXPERTISE BUT NO EXPERIENCE AS A COMPUTER PROGRAMMER TO AUTHOR COURSES ON PLATO WITH VERY MODEST ADDITIONAL TRAINING.

THE 16" SQUARE SCREEN HANDLES VERY HIGH RESOLUTION GRAPHICS

AND PERMITS SIMULATION OF MOST COMPLEX MODELS AS DIVERSE AS A CHEMISTRY LABORATORY AND THE COCKPIT OF A JET AIRCRAFT.

THE SYSTEM IS PROFOUND, PATIENT, PORTABLE, LASTING, DEPENDABLE, WORKS TWENTY-FOUR HOURS A DAY, SEVEN DAYS A WEEK, COSTS LESS AND LESS WITH EACH DESIGN IMPROVEMENT, AND CAN BE CONSISTENTLY EXCELLENT.

PLATO EDUCATION IS DELIVERED IN A NUMBER OF WAYS. ONE METHOD IS THROUGH LEARNING CENTERS. CONTROL DATA HAS IN OPERATION ACROSS THE COUNTRY FORTY-EIGHT LEARNING CENTERS WHERE PLATO CBE COURSES ARE OFFERED TO THE PUBLIC. MORE CENTERS ARE IN THE OFFING.

A SECOND DELIVERY METHOD IS THROUGH THE SALE OR LEASE OF TERMINALS INSTALLED ON USERS' PREMISES BUT CONNECTED TO THE VARIOUS PLATO SYSTEMS IN OPERATION TODAY. ABOUT SEVENTEEN HUNDRED PLATO TERMINALS ARE NOW IN USE.

A THIRD METHOD OF DELIVERY IS THROUGH THE SALE OR LEASE OF A COMPLETE PLATO COMPUTER SYSTEM.

SUPPLEMENTARY TO THESE METHODS ARE THE CONTROL DATA CBE LEARNING VANS AND CBE PORTA-CENTERS, THROUGH WHICH TRAINING CAN BE QUICKLY ARRANGED AND DELIVERED IN VIRTUALLY ANY LOCATION.

23-082 O - 78 - 11

APPLICATIONS

IN ORDER TO PROVIDE THE MOST MEANINGFUL PERSPECTIVE ON THE POTENTIAL OF PLATO, I WILL DESCRIBE BRIEFLY SOME SUCCESSFUL USES AND SOME OF THE PROGRAMS THAT ARE BEING PLANNED OR ARE IN AN EARLY STAGE OF IMPLEMENTATION.

EMPLOYEE TRAINING: INDUSTRY IS MAKING HIGHLY SUCCESSFUL USE OF PLATO FOR EMPLOYEE TRAINING. COURSES ARE NOW AVAILABLE IN BASIC MANAGEMENT TRAINING -- ACCOUNTING, ECONOMICS, EQUIPMENT OPERATION AND MAINTENANCE, POWER PLANT OPERATION, COMPUTER FUNDAMENTALS, COMPUTER PROGRAMMING AND MANY OTHER AREAS. MOST ARE INSTRUCTOR-FREE.

THE REQUIREMENTS OF SMALL BUSINESS ARE GETTING PARTICULAR ATTENTION. SMALL BUSINESSES SPEND MUCH LESS THAN BIG BUSINESSES ON EMPLOYEE TRAINING, YET THEY NEED IT MORE BECAUSE THE MARGINS FOR ERROR ARE NOT AS GREAT AND EMPLOYEES MUST BE MORE EFFICIENT TO HELP OFFSET THE LACK OF ECONOMIES OF SCALE ENJOYED BY LARGE COMPETITORS. EMPLOYEE TRAINING IN THE TRADITIONAL MANNER IS PROHIBITIVE IN MANY CASES.

BUT TODAY A SMALL BUSINESS CAN AFFORD TO HAVE JUST AS HIGH A LEVEL AND QUALITY OF TRAINING AS LARGE BUSINESS -- THROUGH PLATO.

CONTROL DATA'S INTERNAL TRAINING RECORDS SHOW THAT THE COST TO CONTROL DATA TO PROVIDE EMPLOYEE TRAINING VIA CBE IS LESS THAN FIFTY PERCENT OF THE COST OF TRADITIONAL METHODS. MAJOR DIFFERENCES INCLUDE GREAT SAVINGS IN TIME AND TRAVEL EXPENSE. THERE IS ALSO THE ADVANTAGE OF INSTANT AND SIMULTANEOUS AVAILABILITY OF A GIVEN COURSE AND ITS REVISIONS TO ALL EMPLOYEES WORLDWIDE AS OPPOSED TO THE LENGTHY AND EXPENSIVE PROCESS OF REACHING A LARGE AND DISPERSED POPULATION WITH TRADITIONAL SEMINARS IN GROUPS OF 20-25 STUDENTS.

SPECIAL EDUCATION: ANOTHER IMPORTANT USE IS IN REMEDIAL EDUCATION IN TEACHING BASIC SKILLS. AS YOU ARE WELL AWARE, SPECIAL EDUCATION TODAY IS COSTLY AS WELL AS TERRIBLY FRUSTRATING AND TIME-CONSUMING FOR TEACHERS. THE INDIVIDUAL TESTING, PRESCRIBING, FEEDBACK, RECORD-KEEPING AND ANALYZING -- ALL DONE MANUALLY -- REQUIRE TOO MUCH TIME, EFFORT AND PATIENCE TO BE DONE EFFECTIVELY. PLATO, HOWEVER, HAS INFINITE PATIENCE, IT IS PRIVATE AND DOESN'T NEGLECT ANY CHORES IN FAVOR OF SOMETHING MORE INTERESTING, AND IT PERFORMS THEM MORE ECONOMICALLY.

THE INITIAL ENTRY POINT SELECTED FOR THIS MARKET IS CORRECTIONS INSTITUTIONS. SEVEN INSTITUTIONS IN THREE STATES NOW EMPLOY PLATO TERMINALS.

BY EARLY NEXT YEAR, COMPLETE BASIC SKILLS COURSEWARE WILL BE AVAILABLE AT ALL MAJOR LEARNING CENTERS AND ADDITIONAL MARKETS FOR THE BASIC SKILLS PACKAGE WILL INCLUDE HIGH SCHOOLS, MILITARY TRAINING UNITS, COLLEGES AND CONTINUING EDUCATION FOR ADULTS.

ONE PROGRAM NOW GETTING UNDER WAY MERITS MENTION. CONTROL DATA IS WORKING AGGRESSIVELY ON A LARGE PROGRAM WITH THE GOVERNMENT TO GET INNER-CITY UNEMPLOYED YOUTH IN THE 16-25 AGE GROUP INTO PRODUCTIVE AND REWARDING JOBS. THE BASIC ELEMENT IS COMPUTER-BASED REMEDIAL TRAINING TO PROVIDE THE BASIC SKILLS. A PILOT PROJECT IS ALREADY UNDER WAY IN ST. PAUL. PROPOSALS ARE IN PROCESS FOR ADDITIONAL PROJECTS IN CHICAGO, BOSTON, DETROIT AND HOUSTON.

SECONDARY EDUCATION: SECONDARY EDUCATION IS BEGINNING TO GET MORE OF OUR ATTENTION AS WE GAIN EVIDENCE THAT PLATO CAN BE OF MAJOR BENEFIT TO INNER-CITY SCHOOLS.

WE HAVE HAD FOUR PLATO TERMINALS INSTALLED IN A BALTIMORE INNER-CITY SCHOOL FOR OVER TWO YEARS, FINANCED BY CONTROL DATA. RESULTS ARE PROVING THAT COURSE OFFERINGS CAN BE OF HIGH QUALITY, AND THE LACK OF BASIC SKILLS ARE MUCH MORE EFFICIENTLY CORRECTED. BUT EQUALLY IMPORTANT, THAT ECONOMICALLY AND EDUCATIONALLY DISADVANTAGED STUDENTS CAN BE MOTIVATED TO LEARN, CAN ENJOY LEARNING AND REDUCE THEIR ABSENTEEISM.

THE PROGRAM IS NOW BEING EXPANDED TO TWENTY-EIGHT TERMINALS SPREAD AMONG FOUR SCHOOLS. HALF THE COST OF THE EXPANDED PROGRAM WILL BE PAID BY THE BALTIMORE SCHOOL BOARD, WHICH WILL ASSUME THE FULL COST NEXT YEAR. MEANWHILE, BALTIMORE WILL BE SEEKING STATE AND FEDERAL FUNDS TO PURCHASE A PLATO SYSTEM.

ALSO TO BE ADDRESSED IS THE WORSENING PLIGHT OF SCHOOLS IN THE LESS POPULATED RURAL COMMUNITIES. A STUDY OF A SEVEN-COUNTY RURAL MINNESOTA REGION CONSIDERED A PLATO CBE ALTERNATIVE TO SCHOOL CLOSINGS AND CONSOLIDATIONS.

BRIEFLY OUR ANALYSES SHOWS THAT A REORGANIZATION OF THE CURRENT THIRTY-EIGHT DISTRICTS INTO THIRTEEN CONSOLIDATED DISTRICTS USING TRADITIONAL CURRICULA WOULD SAVE ABOUT FIFTY PERCENT OVER A TEN YEAR PERIOD, AS COMPARED TO MAINTAINING THE STATUS QUO. USING PLATO, BUT WITH NO CONSOLIDATION, THE COST IS ABOUT FIFTY-EIGHT PERCENT, AS COMPARED WITH A STATUS QUO SITUATION. IN OTHER WORDS, FOR A COST DIFFERENCE OF EIGHT TO TEN PERCENT, THE THIRTY-EIGHT DISTRICTS CAN PROVIDE QUALITY AND BREADTH OF CURRICULUM AND AT THE SAME TIME RETAIN LOCAL AUTONOMY AND PRIDE. THE NETWORK ADVANTAGES AND MOTIVATIONAL CAPABILITIES OF PLATO MORE THAN OFFSETS THE SMALL DIFFERENCE IN COST.

HIGHER EDUCATION: THE USE OF PLATO CBE IN HIGHER EDUCATION IS INCREASING. IT IS BEING USED IN VIRTUALLY ALL DISCIPLINES AS A MEANS OF INCREASING THE PRODUCTIVITY OF BOTH TEACHER AND STUDENT AS WELL AS QUALITY OF INSTRUCTION.

THE SIMULATION CAPABILITY OF PLATO IS PARTICULARLY IMPORTANT WHERE COURSES INVOLVE LABORATORY EXPERIMENTS.

CONTINUING EDUCATION: ONE OF THE MOST RAPIDLY GROWING APPLICATIONS IS CONTINUING EDUCATION.

FOR EXAMPLE, THE AMERICAN CHEMICAL SOCIETY RECENTLY ENDORSED OUR MANAGEMENT TRAINING COURSEWARE AND OUR LEARNING CENTERS AS AN APPROPRIATE DELIVERY VEHICLE. THE AMERICAN CHEMICAL SOCIETY HAS 110,000 MEMBERS, EXCLUSIVE OF STUDENTS AND COLLEGE TEACHERS. IT IS ESTIMATED THAT WITH THE PRESENT DENSITY AND LOCATION OF CONTROL DATA'S LEARNING CENTERS, THAT ABOUT 60,000 OF THEIR MEMBERS CAN BE CONVENIENTLY SERVED.

A COOPERATIVE PROGRAM WITH A COLLEGE FOR TEACHERS IS IN THE FORMATIVE STATE. COURSEWARE TO BE DEVELOPED INCLUDES THAT FOR IN-SERVICE EDUCATION TO TEACHERS AND SCHOOL ADMINISTRATION THAT IS DELIVERED OFF CAMPUS. APPARENTLY RESISTANCE IS INCREASING BY TEACHERS IN LEAVING THEIR COMMUNITIES TO GET ADDITIONAL EDUCATION. IT IS CONTEMPLATED THAT BOTH CDC LEARNING CENTERS AND ON-CAMPUS TERMINALS WOULD BE USED FOR

DELIVERING THE CBE COURSES.

ALSO, THERE ARE NOW MORE THAN 100 PLATO TERMINALS IN USE BY AGENCIES OF THE U.S. GOVERNMENT.

THERE ARE OTHER POTENTIAL PROGRAMS IN CONTINUING EDUCATION BUT I WILL ONLY MENTION TWO:

ONE OF THE BEST ENTRY POINTS FOR AGRICULTURE APPEARS TO BE THAT OF PUTTING PLATO TERMINALS IN CO-OP LEARNING CENTERS TO TEACH THEIR PERSONNEL IN MANAGEMENT AND MARKETING, AND TO DELIVER FARM MANAGEMENT COURSES TO INDIVIDUAL FARMERS.

THE MOST SIGNIFICANT STEP IN CONTINUING EDUCATION, AND I BELIEVE IT WILL BE FEASIBLE WITHIN THE NEXT FOUR TO FIVE YEARS, WILL BE PLATO CBE TERMINALS IN THE HOME. WE ARE CONFIDENT THAT AS SOON AS ENOUGH COURSEWARE IS AVAILABLE, IT WILL BE ATTRACTIVE FOR THE AVERAGE AMERICAN FAMILY TO OWN A PLATO TERMINAL. COURSEWARE COULD BECOME AVAILABLE WITHIN THE NEXT FOUR OR FIVE YEARS IF THE FEDERAL GOVERNMENT WILL PROVIDE THE ASSISTANCE TO EDUCATIONAL INSTITUTIONS THAT I WILL DESCRIBE LATER.

DEVELOPING COUNTRIES

A WORD SHOULD BE SAID ABOUT PLATO IN DEVELOPING COUNTRIES. THUS FAR CONTROL DATA HAS CONCENTRATED ENTRY EDUCATIONAL

EFFORTS IN DEVELOPING OIL-RICH COUNTRIES. EDUCATIONAL PROBLEMS THERE ARE THE SAME AS IN NON-OIL COUNTRIES -- THE DIFFERENCE OF COURSE BEING MONEY FOR DEVELOPMENT. THE PROBLEMS IN LAUNCHING AN EDUCATIONAL PROJECT IN A DEVELOPING COUNTRY ARE ENORMOUS. AFTER THREE YEARS OF EXPERIENCE IN INSTALLING TRADITIONAL TYPES OF EDUCATION IN DEVELOPING COUNTRIES, IT IS CLEAR THAT THE ONLY WAY THAT ADEQUATE EDUCATION CAN BE PROVIDED IS THROUGH THE USE OF A COMPUTER-BASED EDUCATION SYSTEM INTEGRATED WITH CONVENTIONAL AND MULTI-MEDIA LEARNING METHODS. SATELLITE COMMUNICATION WILL BE PARTICULARLY IMPORTANT.

COURSEWARE

A KEY ELEMENT IN THE SUCCESS OF COMPUTER-BASED EDUCATION IS THE MEANS TO AUTHOR COURSEWARE OF HIGH QUALITY ADAPTED TO THE UNIQUE CAPABILITIES OFFERED BY PLATO. WE HAVE MADE A LARGE INVESTMENT OF TIME AND DOLLARS TO SATISFY THIS REQUIREMENT BY MEANS OF A PLATO CURRICULUM CALLED "CREATE". IT PERMITS INDIVIDUALS OF WIDELY VARYING BACKGROUNDS, TRAINING SKILLS AND LEARNING RATES TO BECOME EFFICIENT COURSEWARE DEVELOPERS. THE FULL CREATE CURRICULUM IS COMPUTER-ASSISTED AND ENTAILS ABOUT 250 HOURS OF INSTRUCTION.

A GROWING NUMBER OF PERSONS AUTHOR COURSEWARE FOR PLATO -- AT PRESENT ABOUT 2,000, OF WHICH 250 HAVE ROYALTY AGREEMENTS WITH CONTROL DATA TO MARKET THEIR COURSEWARE.

COST

THERE IS MORE TO BE SAID ABOUT PRESENT AND PLANNED USES. HOWEVER I BELIEVE ENOUGH EXAMPLES HAVE BEEN COVERED TO PROVIDE PERSPECTIVE ON THE POTENTIAL OF PLATO CBE.

WHILE PROGRESS HAS BEEN GRATIFYING IN MANY RESPECTS, IT IS NOT NEARLY GREAT ENOUGH WHEN MEASURED AGAINST THE TREMENDOUS NEED FOR BETTER EDUCATION.

AS WITH ANY NEW ENTERPRISE, BARRIERS TO PROGRESS ARE ABUNDANT. ONE IS THAT OF THE PERCEPTION OF THE COST OF PLATO. OFTEN IT IS PERCEIVED AS TOO HIGH BECAUSE THE FOCUS IS PUT ON THE COST OF PLATO PER SE, AS OPPOSED TO THE COST/EFFECTIVITY OF PLATO. IN ADDITION, CBE IS NOT USUALLY VIEWED AS AN INTEGRAL PART OF THE EDUCATIONAL PROCESS, BUT PERCEIVED AS AN UNFUNDED INCREMENT TO TRADITIONAL METHODS.

EVEN THOUGH PLATO IS COST EFFECTIVE TODAY IN A NUMBER OF AREAS, COSTS ARE HIGH TODAY COMPARED TO TRADITIONAL EDUCATION IN OTHER AREAS AND COMPARED TO WHAT THEY WILL BE IN THE FUTURE. PLATO COSTS ARE DECREASING AND WILL CONTINUE THIS TREND BECAUSE OF ADVANCING TECHNOLOGY AND INCREASED USAGE. MEANWHILE, TRADITIONAL EDUCATIONAL COSTS WILL CONTINUE TO RISE.

EVEN WHERE CBE IS NOT YET COST-EFFECTIVE, IT IS NONE TOO

SOON FOR EDUCATIONAL INSTITUTIONS TO START USING CBE ON A PILOT BASIS, IN ORDER TO PREPARE TO TAKE FULL ADVANTAGE OF ITS POTENTIAL. MONEY FOR PILOTING IS HARD TO COME BY. MOST EDUCATIONAL INSTITUTIONS ARE TOO STRAPPED FOR FUNDS FOR TRADITIONAL METHODS TO OBTAIN MONEY FOR CBE.

THE FEDERAL GOVERNMENT SHOULD ESTABLISH A SOURCE OF FUNDING FOR EDUCATIONAL INSTITUTIONS FOR PILOTING CBE. THROUGH SUCH A CATALYTIC APPROACH EACH INSTITUTION WILL GAIN TANGIBLE EVIDENCE ON WHICH TO RE-ALLOCATE BUDGETS. THUS, CBE WILL BECOME SUPPORTED WITHIN INSTITUTIONAL BUDGETS AND A GREAT SURGE IN THE USE OF CBE WOULD BE ACHIEVED WITH MINIMUM COST TO THE FEDERAL GOVERNMENT.

OTHER BARRIERS

ANOTHER BARRIER IS THAT OF THE PERCEIVED JOB THREAT TO TEACHERS. PRODUCTIVITY IMPROVEMENT IMPLIES FEWER TEACHERS PER STUDENT. THIS CAN BE A SERIOUS PROBLEM THAT IS MADE WORSE BY DECLINING ENROLLMENTS.

BUT THIS PROBLEM IS NOT NEW IN OUR SOCIETY: THE ENGINEERING PROFESSION WENT THROUGH A SIMILAR PERIOD OF ADJUSTMENT IN ACCOMMODATING TO DECREASING DEMAND ALONG WITH PRODUCTIVITY INCREASES PROVIDED BY THE COMPUTER. BUT THE OUTCOME WAS THAT THE ENGINEER WAS FREED OF MANY REPETITIVE AND BORING TASKS BY THE COMPUTER AND IS ABLE TO CONCENTRATE HIS EFFORTS MORE HEAVILY

IN CREATIVE TASKS.

SIMILARLY, A PROFOUND ENRICHMENT CAN BE ACHIEVED IN A TEACHER'S JOB AND THE PROFESSIONAL STATUS CAN BE GREATLY ENHANCED BY RELIEF FROM REPETITIVE AND TIME-CONSUMING CHORES. AND WITH PLANNING, THE TRANSITION INTO A MORE CAPITAL-INTENSIVE SYSTEM CAN BE ACHIEVED SOONER WITH LESS DISRUPTION TO INDIVIDUAL CAREERS.

IN ADDITION, THERE IS RESISTANCE TO CHANGE FOR MYRIAD OTHER REASONS -- INSTITUTIONAL INERTIA, CONCERN FOR MAINTENANCE OF INDIVIDUAL STATUS, THE COMFORT OF THE STATUS QUO, AND SO ON -- MUCH THE SAME AS IN ANY OTHER PROFESSION.

ANOTHER POTENTIAL BARRIER CAN BE AVOIDED IF FEDERAL REGULATION DEVELOPED IN OTHER CONTEXTS FOR OTHER PURPOSES, SUCH AS REGULATION OF COMMUNICATIONS COMMON CARRIERS, IS NOT EXTENDED TO CBE SYSTEMS AND NETWORKS IN A FASHION THAT COULD INHIBIT THE DEVELOPMENT OF THE WIDEST POSSIBLE POTENTIAL FOR CBE.

FUTURE

WITH THAT BACKGROUND, LET'S LOOK INTO THE FUTURE OF EDUCATION.

FIRST, IT SEEMS CLEAR TO ME THAT ADVANCING TECHNOLOGIES HAVE DEMONSTRATED THE POWER TO REVOLUTIONIZE THE PRODUCTIVITY,

QUALITY AND AVAILABILITY OF EDUCATION. THE PRINCIPAL TECHNOLOGIES ARE THE ELECTRONIC ONES -- TELEVISION, RADIO, AUDIO AND VIDEO TAPES AND DISKS, COMPUTERS, COMPUTER CONFERENCING, CABLE TV, MICROWAVE AND SATELLITE TRANSMISSIONS, AND, OF COURSE, PLATO CBE.

THESE TECHNOLOGIES WILL BE ASSEMBLED AND CONFIGURED INTO A PLATO SYSTEM THAT:

1) DOES WHAT THE PRESENT EDUCATIONAL PROCESS DOES, BUT DOES IT WITH CAPITAL-INTENSIVE TECHNOLOGIES, RATHER THAN TRYING TO DRIVE STILL HARDER A LABOR-INTENSIVE PROCESS THAT CAN AT BEST ONLY STAGGER UNDER THE LOADS OF HIGHER NEEDS, HIGHER EXPECTATIONS AND HIGHER AND HIGHER COSTS.

2) CAN READILY ADAPT TO STUDENTS' INDIVIDUAL NEEDS AND INTERESTS AND THUS BE ABLE TO ADEQUATELY HANDLE DIFFERENCES IN LEARNING READINESS, ABILITY AND WIDE VARIATIONS IN INTEREST AND ASPIRATIONS.

3) DELIVERS EDUCATION OF UNIFORMLY HIGH QUALITY THAT IS READILY ACCESSIBLE TO ALL -- THUS ACHIEVING BOTH CONSISTENT <u>QUALITY</u> AND <u>EQUALITY</u> OF EDUCATION, WITHOUT CULTURAL BIAS.

4) WILL COPE WITH THE KNOWLEDGE [illegible]. [illegible]ERE IS A CONCENSUS THAT KNOWLEDGE WILL GROW EIGHT TO TEN TIMES DURING

THE NEXT TWENTY-FIVE YEARS. SINCE [illegible] EDUCATION IS NOT MEETING CURRENT NEEDS, IT CANNOT POSSIBLY BE EXPECTED TO COPE WITH AN INCREASE OF THIS MAGNITUDE. THIS CAN ONLY BE ACHIEVED THROUGH THE INTEGRATION INTO THE EDUCATIONAL PROCESS OF HIGH VOLUME AND READILY-ACCESSIBLE COMPUTER MEMORIES.

BY THE LATE 80'S, NATIONAL AND INTERNATIONAL NETWORKS OF CBE LEARNING CENTERS WILL EMERGE. IN THE U.S., FOR EXAMPLE, THERE WILL BE A NUMBER OF INDEPENDENTLY OWNED NETWORKS -- IN SOME RESPECTS NOT UNLIKE THE TV NETWORKS OF TODAY. ON A LOCAL BASIS, THIS WOULD INVOLVE THE USE OF CABLE TELEVISION AND MICROWAVE. ON A NATIONAL AND INTERNATIONAL BASIS, SATELLITE COMMUNICATION WILL BE USED.

THESE LEARNING CENTER NETWORKS WILL ARISE FROM THE COOPERATIVE EFFORTS OF BUSINESS, GOVERNMENT AND EDUCATIONAL INSTITUTIONS. MULTINATIONAL [illegible] WILL FASHION AND OPERATE A NUMBER OF THEM. [illegible] WILL OPERATE SOME. A NETWORK WILL "RETAIL" EDUCATION TO THE USER THROUGH LEARNING CENTERS OR "WHOLESALE" IT TO OTHER EDUCATIONAL INSTITUTIONS.

SMALLER COMPANIES WILL OPERATE LEARNING CENTERS, PARTICULARLY IN SELECTED VOCATIONAL AREAS. PRIVATE BUSINESS WILL ALSO PUBLISH AND RETAIL COURSEWARE, IN MUCH THE SAME MANNER AS

TRADITIONAL EDUCATIONAL MATERIALS ARE MARKETED TODAY.

COURSEWARE MUST BE OF THE HIGHEST QUALITY. COOPERATIVE EFFORTS AMONG EDUCATIONAL INSTITUTIONS, AUTHOR TEAMS AND INDIVIDUAL AUTHORS WILL INSURE THAT THIS OBJECTIVE IS ACHIEVED. INVESTMENTS IN INDIVIDUAL COURSES OF A MILLION DOLLARS OR MORE WILL OFTEN BE REQUIRED TO PRODUCE THE REQUIRED QUALITY.

CONCLUSION

IN CONCLUSION, LET ME EMPHASIZE THAT IN THIS PRESENTATION I HAVE ENDEAVORED TO AVOID ABSTRACTIONS AND MINIMIZE SPECULATION -- RATHER, TO PROJECT INTO THE FUTURE WHAT IS HERE AND NOW.

THE PLATO CBE SYSTEM IS HERE -- IT IS COST-EFFECTIVE NOW IN MANY AREAS. EXPANSION INTO VIRTUALLY ALL AREAS OF EDUCATION WILL HAPPEN. IT WILL RELIEVE THE PLIGHT OF INNER-CITY AND REMOTE RURAL SCHOOLS, IT WILL MOVE INTO THE HOME, IT WILL REVERSE THE TIDE OF ILLITERACY IN THE WORLD.

THE PRINCIPAL UNCERTAINTY IS THE TIME REQUIRED TO ACHIEVE THESE OBJECTIVES. IT CAN BE GREATLY SHORTENED IF THE FEDERAL GOVERNMENT WILL PROVIDE FUNDING NOW FOR SCHOOLS AND UNIVERSITIES TO PILOT CBE.

STATEMENT OF WILLIAM C. NORRIS, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, CONTROL DATA CORP.

Mr. NORRIS. Thank you. I will not present the complete text. Instead, I will highlight its salient points.

First, I want to say it has been a pleasure to participate in this hearing. As general background, I think it is certainly noted that one of this Nation's most urgent needs and one of the world's most urgent needs is education. In my company a top priority is to apply greater technology to help achieve equality and productivity improvements in education.

Education has the largest single commitment of development resources in our company today. That is how it should be. It is our conviction that if society's major problems are given priority that, in the long run, they will provide the best business opportunities. Control Data's answer for improving education is PLATO, computer-based system.

Control Data's PLATO provides both computer-assisted and computer-managed instruction, integrated with conventional and multimedia learning activities. Since there will be a demonstration of PLATO by Dr. Bitzer later, I will not take time to talk about PLATO's particular equipment features. Instead, I will move on to the methods of delivery.

PLATO education is delivered in a number of ways. One method is through learing centers. Control Data has in operation across the country 48 learning centers where PLATO courses are offered to the public. Additional centers are being planned.

The second delivery method is through the sale or lease of terminals installed on the user's premises, connected to the various PLATO computers in operation today. There are now about 1.700 PLATO terminals in use.

A third method of delivery is, of course, the actual sale of a complete PLATO computer system. Supplementary to these methods are the Control Data learining vans—what we call our porta—centers—through which training can be quickly arranged and delivered in virtually any location.

In order to provide the most meaningful perspective on the potential of PLATO, I will describe briefly some successful uses and some of the programs that are being planned or are in an early stage of implementation.

Industry is making highly successful use of PLATO for employee training. Courses are now available in basic management training—accounting, economics, equipment operation and maintenance, power plant operation, computer fundamentals, computer programing and many other areas. Most are instructor-free.

The requirements of small business are getting particular attention. Small businesses spend much less than big businesses on employee training, yet they need it more because the margins for error are not as great and employees must be more efficient to help offset the lack of economics of scall enjoyed by large competitors. Employee training, in the traditional manner, is prohibitive in many cases.

But today a small business can afford to have as high a level and quality of training as a large business, through PLATO. Control

Data's internal training records show that the cost to Control Data to provide employee training via computer-based education (CBE) is less than 50 percent of the cost of traditional methods. Major differences include great savings in time and travel expense.

There is also the advantage of instant and simultaneous availability of a given course and its revisions to all employees worldwide as opposed to the lengthy and expensive process of reaching a large and dispersed population with traditional seminars in groups of 20-25 students.

Another important use is in remedial education in teaching basic skills. I won't go into that because it was covered very well by previous speakers.

The initial entry point that we have chosen for this market is in correction institutions. Today, seven institutions in three States now employe PLATO terminals.

By early next year, complete basic skills courseware will be available at all major learning centers. Additional markets for the basic skills package will include high schools, military training units, colleges and continuing education for adults.

One program now getting underway merits mention. Control Data is working aggressively on a large program with the Government to get inner city unemployed youth in the 16-25 age group into productive and rewarding jobs. The basic element is computer-based remedial training to provide the basic skills. A pilot project is already underway in St. Paul. Proposals are in process for additional projects in Chicago, Boston, Detroit, and Houston.

Secondary education is beginning to get more of our attention as we gain evidence that PLATO can be of major benefit to inner-city schools.

We have had four PLATO terminals installed in a Baltimore inner-city school for over 2 years, financed by Control Data. Results are proving that course offerings can be of high quality, and the lack of basic skills are much more efficiently corrected. Equally important, we have found that economically and educationally disadvantaged students can be motivated to learn, can enjoy learning and reduce their absenteeism.

The program is now being expanded to 28 terminals spread among four schools. Half the cost of the expanded program will be paid by the Baltimore School Board, which will assume the full cost next year. Meanwhile, Baltimore will be seeking State and Federal funds to purchase a PLATO system.

Also to be addressed is the worsening plight of schools in the less populated rural communities. A seven-county rural Minnesota region considered a PLATO CBE alternative to school closings and consolidations.

Briefly, our analyses shows that a reorganization of the current 38 districts into 13 consolidated districts using traditional curricula would save about 30 percent over a 10-year period, as compared to maintaining the status quo.

Using PLATO, but with no consolidation, the cost is about 58 percent, as compared with a status quo situation. In other words, for a cost difference of 8 to 10 percent, the 38 districts can provide quality and breadth of curriculum and at the same time retain local autonomy and pride. The network advantages and motivational capabilities of PLATO more than offset the small differences in cost.

The use of PLATO CBE in higher education is increasing. It is being used in virtually all disciplines as a means of increasing the productivity of both teacher and student as well as quality of instruction.

The simulation capability of PLATO is particularly important where courses involve laboratory experiments.

One of the most rapidly growing applications is continuing education.

For example, the American Chemical Society recently endorsed our management training courseware and our learning centers as an appropriate delivery vehicle. The American Chemical Society has 110,000 members, exclusive of students and college teachers. It is estimated that with the present density and location of Control Data's learning centers, that about 60,000 of their members can be conveniently served.

A cooperative program with a college for teachers is in the formative stage. Courseware to be developed includes that for in-service education to teachers and school administration that is delivered off campus. Apparently, resistance is increasing by teachers in leaving their communities to get additional education. It is contemplated that both Control Data Corp. (CDC) learning centers and on-campus terminals would be useful for delivering the CBE courses.

Also, there are now more than 100 PLATO terminals in use by agencies of the U.S. Government.

There are other potential programs in continuing education but I will only mention two:

One of the best entry points for agriculture appears to be that of putting PLATO terminals in co-op learning centers to teach their personnel in management and marketing and to deliver farm management courses to individual farmers.

The most significant step in continuing education—I believe it will be feasible within the next 4 to 5 years—will be PLATO CBE terminals in the home. We are confident that as soon as enough courseware is available it will be attractive for the average American family to own a PLATO terminal. Courseware would become available within the next 4 or 5 years if the Federal Government will provide the assistance to education institutions.

A word should be said about PLATO in developing countries. Thus far, Control Data has concentrated entry educational efforts in developing oil-rich countries. Educational problems there are the same as those in nonoil countries, the difference, of course, being money for development. The problems in launching an educational project in a developing country are enormous. After 3 years of experience in installing traditional types of education in developing countries, it is clear that the only way that adequate education can be provided is through the use of a computer-based education system integrated with conventional and multimedia learning methods. Satellite communications will be particularly important.

A key element in the success of computer-based education is the means to author courseware of high quality adapted to the unique capabilities offered by PLATO. We have made a large investment of time and dollars to satisfy this requirement by means of a PLATO curriculum called CREATE. It permits individuals of widely varying backgrounds, training skills, and learning rates to become efficient courseware developers. The full CREATE curriculum is computer assisted and entails about 250 hours of instruction.

A growing number of persons author courseware for PLATO—at present about 2,000, of which 250 have royalty agreements with Control Data to market their courseware.

There is more to be said about present and planned uses. However, I believe enough examples have been covered to provide a perspective on the potential of PLATO CBE.

While progress has been gratifying in many respects, it is not nearly great enough when measured against the tremendous need for better education.

As with any new enterprise, barriers to progress are abundant. One is that of the perception of the cost of PLATO. Often the cost is perceived as too high because the focus is put on the cost of PLATO per se, as opposed to the cost effectiveness of PLATO. In addition, CBE is not usually viewed as an integral part of the educational process, but perceived as an unfunded increment to traditional methods.

Even though PLATO is cost effective today in a number of areas, costs are high today compared to traditional education in other areas and compared to what they will be in the future. PLATO costs are decreasing and will continue this trend because of advancing technology and increased usage. Meanwhile, traditional educational costs will continue to rise.

Even where CBE is not yet cost effective, it is none too soon for educational institutions to start using CBE on a pilot basis in order to take full advantage of its potential. Money for piloting should be provided. Money for piloting is hard to come by. Most educational institutions are too strapped for funds for traditional methods to obtain money for CBE.

The Federal Government should establish a source of funding for educational institutions for piloting CBE. Through such an approach each institution will gain tangible evidence on which to reallocate budgets. In this way, CBE will become supported within institutional budgets and a great surge in the use of CBE will be achieved with minimum cost to the Federal Government. There are other barriers that I could talk about, but, with that background, let us look into the future of education.

First, it seems clear to me that advancing technologies have demonstrated the power to revolutionize the productivity, the quality and availability of education. The principal technologies are the electronic ones—television, radio, audio and video tapes and disks, computers, computer conferencing, cable TV, microwave and satellite transmission, and, of course, PLATO CBE.

These technologies will be assembled, are being assembled, and configured into a PLATO system that:

First. Does what the present educational process does, but with capital-intensive technologies, rather than trying to drive still harder for a labor-intensive process that can, at best, only stagger under the loads of higher needs, higher expectations, and higher costs.

Second. Can readily adapt to student's individual needs and interests and thus be able to adequately handle differences in learning readiness, ability, and wide variations in interest and aspirations.

Third. Can deliver education of uniformity high quality that is readily accessible to all, thus, achieving both consistent quality and equality of education, without cultural bias.

Fourth. Will cope with the knowledge explosion. There is a consensus that knowledge will grow 8 to 10 times during the next 25 years.

Since traditional education is not meeting current needs, it cannot possibly be expected to cope with an increase of this magnitude. This can only be achieved through the integration into the educational process of high volume and readily accessible computer memories.

By the late 1980's national and international networks of CBE learning centers will emerge. In the United States, for example, there will be a number of independently owned networks —in some respects not unlike the TV networks of today. On a local basis, this would involve the use of cable television and microwave. On a national and international basis, satellite communications will be used.

These learning center networks will arise from the cooperative efforts of business, government and educational institutions. Multinational companies will fashion and operate a number of them. School consortia will operate some. A network will retail education to the user through learning centers or wholesale it to other educational institutions.

Smaller companies will operate learning centers, particularly in selected vocational areas. Private business will also publish and retail courseware, in much the same manner as traditional educational materials are marketed today.

Courseware must be of the highest quality. Cooperative efforts among educational institutions, author teams and individual authors will insure that this objective is achieved. Investments in individual courses of a million dollars or more will often be required to produce the required quality.

In conclusion, let me emphasize that in this presentation I have endeavored to avoid abstractions and minimize speculations—rather to project into the future what is here and now.

The PLATO CBE system is here. It is cost effective now in many areas. Expansion into virtually all areas of education will happen. It will relieve the plight of inner-city and remote rural schools. It will move into the home. It will reverse the tide of illiteracy in the world.

The principal uncertainty is the time required to achieve these objectives. It can be greatly shortened if the Federal Government will provide funding now for schools and universities to pilot CBE.

Mr. BEILENSON. Thank you, Mr. Norris. I think we have some questions for you.

Dr. SWANSON. Thank you Mr. Chairman. First of all, I would like to get into the question of what Control Data sees as the major market for the PLATO system? Where are you targeting your sales campaign? You mention industrial training, government, et cetera. Is there a major thrust to the sales campaign or do you see all market segments as able to utilize PLATO?

Mr. NORRIS. First is industry—we are emphasizing management training in virtually any industry, including the training of various skills such as powerplant operation, computer maintenance and computer programing. Second, in special education, teaching basic skills is another priority, equal to that of industry. By the first of the year we hope to be able to offer these courses in our learning centers. We will do this in a number of ways. One is in conjunction with schools. For those people who can afford it, they can have their children work directly in the learning center.

A third area of course, is higher education—this is an extension of what the University of Illinois and several other universities which have PLATO have done—we are building on the great investments that the National Science Foundation, the University of Illinois and other universities have made.

Mr. SWANSON. I would like to follow up on what we were talking about with the two previous witnesses. And you just mentioned the role of Federal origination funds to get the ball rolling on this project. Could you describe in general the nature of your agreement with the University of Illinois to give us an idea of whether funds in these development stages were necessary to assure commercial marketing of the system.

In other words, without the original NSF investment, would Control Data have launched on such a developmental project on its own?

Mr. NORRIS. Definitely not. I think this is one of the best examples of how the Federal Government, sponsoring research in conjunction with universities and industry, can get these materials into the hands of the user.

Of course, as you know, the University of Illinois work started in 1959 around 1960, we started furnishing computers and, in turn, were able to use the software and courseware. We tracked it very closely and there's just no question that we never could have afforded the investment, nor would we have had the perspective or the confidence to pursue it. It is largely because of what they have achieved in higher education that gave us confidence to make this major commitment to commercialize computer-based education.

Mr. WELLS. Before we leave that point: Mr. Norris, this is a very crucial point. We have addressed this question to earlier witnesses in terms of the pattern of Federal R. & D. and trying to define appropriate roles for various government agencies vis-a-vis the university and vis-a-vis private concerns such as your own. Could you expand a bit on this and your general philosophy as to what you see as a proper division of responsibility between the university sector, the government sector, and the private sector?

Mr. NORRIS. Well, I think that, first, society gets from business those things through which business can amke enough money to justify investment in the program.

Of course, in some cases, so much money has to be spent on research that this cannot be done by industry. This is where the Federal Government should prime the pump. I think it is very important that, when this is done, there should also immediately be a close association between the university and industry so that industry, working with the university, and in turn with the Government. In this way, all will have the same perspective and they can help guide each other's thinking.

As the work progresses then, industry will be in a much better position to apply the technology sooner in society. I think this is one of the very fine features of the relationship of the National Science Foundation (NSF) and the University of Illinois and Control Data. NSF and Illinois went along together for many years and when PLATO reached the stage that it was ready to be used, we were ready.

Mr. WELLS. Did this require a conscious corporate decision on your part to affiliate or associate yourself in some way with the University of Illinois in terms of a long, on-going relationship? How does this kind of cooperation develop? Did it come about as a potential business prospect for you and part of your long-range planning?

What we are interested in really is the general model by which, if the Federal Government is going to support research and development of this sort, what is the ultimate coupling mechanism to the marketplace? Does it depend solely upon enterpreneurs like yourself to perceive an opportunity? This is the general area I am trying to get a little bit better feel for. Is there a generalization to be drawn from the PLATO model?

Mr. NORRIS. Yes, I think, as a matter of policy, the U.S. Government or NSF, or whatever agency has the responsibility to insist that in virtually all of their research grants that there be an association with industry. Innovative ideas are not exclusive to business by any means. They originate in many places. There are people in universities, of course, who have them. But the university is not as well situated as business is to finally exploit those ideas. But by getting the university and business together very early, this process can take place. And so I think it is important for business to recognize that research done in connection with universities is, by and large, much more effective than that done within the narrow confines of a single business. The university has access to other disciplines. They have a much broader perspective and they are not so constrained by just the narrow interest of a single business. I think this is one of the university's finest attributes in its favor.

Mr. WELLS. Thank you very much.

Mr. SWANSON. I would like to follow up on your comment about the export of this technology to either the developing or the developed nations. You mention that is a potential for this technology. I have several questions here and you can respond to them in any order.

Is any of this technology currently being transferred to foreign nations and how does this generally affect our Nation in both an economic and a political sense? Are any Federal policies currently promoting or inhibiting the transfer of this technology?

Mr. NORRIS. There is very little computer based education technology being transferred overseas today, although it is my general understanding that there are no constraints on this. For example, 3 or 4 years ago we demonstrated a PLATO system in Moscow with the encouragement and assistance of the State Department and the Department of Commerce.

Secondly, I think it is very much to our advantage to work in virtually any mode that we can with other countries, developed or developing. Certainly, if the United States is going to carry out the commitment in helping developing countries, a very basic part of it has got to be computer-based education. There is absolutely no other way that this enormous educational gap that exists between them and us will ever be bridged.

I think, first of all, to have CBE available and to use it is the first thing which will happen in other countries. That is beginning to happen with the oil-rich countries, simply because they can afford it. As a matter of fact, Control Data is working with Iran and Venezuela to bring about computer-based education within the next couple of years.

Mr. SWANSON. In your estimation, is there any potential danger to the national interest in terms of exporting such a sophisticated technology?

Mr. NORRIS. I think the potential danger is in withholding the technology more than it is getting out there and using it. I believe that the best course for the United States is to move forward very aggressively and work with any country that will work with us in virtually any mode in furthering the use of computers in education.

I might add that I think the greatest competitive threat, as far as education and computers are concerned, is Japan. I think Japan perceives much better than this country the power of applying advanced technology in education and communication. In fact, they have a national policy concerning this. But they don't have the computer-based education technology that we have and, therefore, I think it behooves us—the Government, industry, and universities—to move forward with this as rapidly as we can.

Mr. BEILENSON. Are there any further questions of Mr. Norris?

Mr. WELLS. What kind of Federal funding are you suggesting, Mr. Norris, in your last sentence in terms of, "the time required to achieve the objectives can be greatly shortened by the Federal Government by funding now * * *." (Mr. Wells reading from statement.)

What kind of funding are you talking about?

Mr. NORRIS. That depends upon the size of the institution. I just happen to have been at the University of Nebraska recently and they would like to establish a broadly based computer technology laboratory. They need $500,000 for a 2-year period. They believe that after that they can absorb it into their ongoing budget.

My experience with other schools indicates that the smaller ones could get started on a pilot basis and carry it along on $250,000 to $300,000. So, relatively speaking, we are not talking about huge sums of money. I think it is important to fund the projects in such a way that the institution does not become too dependent upon the Federal Government. I think a catalytic approach should be taken, with the understanding that the institution should soon take over the project. I think this can happen in a very straightforward and effective way.

Mr. WELLS. Would you go so far as to suggest that there should be specific set-asides?

Mr. NORRIS. Yes. This is something that should be done. It is not a unique idea. Back in the 1960's the National Science Foundation had—I have forgotten the exact amount—maybe $60 or $70 million that was set aside specifically for educational institutions to enhance their computer facilities, not necessarily for instructional purposes but for any purpose. This was an enormously effective program.

Mr. WELLS. I realize this is difficult, but could you guess what would be the total amount you are talking about, a kind of a ball park figure?

Mr. NORRIS. Certainly, $60 million would have a very profound impact. I am not saying it has to be that much. I think that is something for someone else to decide.

Mr. WELLS. I take it that would be spread over a period of time.

Mr. NORRIS. Spread over a period of probably 5 years.

Mr. WELLS. Thank you.

Mr. BEILENSON. Mr. Gallagher?

Mr. GALLAGHER. You mention here in your conclusion the possibility that PLATO could move into the home. Technically how would this be done? How would you move into the home with such a program? And by doing so, would you lose that computer-student interaction that had been testified about previously.

Mr. NORRIS. You mean the teacher?

Mr. GALLAGHER. Computer-student interaction.

Mr. NORRIS. The terminal is connected through the telephone line to the large computer. When I say move into the home, I am not suggesting that the teacher is completely eliminated from the process. For example, I have eight children and I have been sending them to school all of these years. When the boy started at the University of Minnesota, it cost almost as much for transportation as it did for his tuition.

If he could do part of the work at home, there would be an enormous saving in money and in his time. One also must not forget the productivity of the student himself. The computer in the home makes it possible for the student to work at times that are most convenient for him and to cut down on the travel. He can still have the same relationship with the teacher. In fact, the teacher can be on the terminal, as Dr. Bitz[illegible] will demonstrate later. The teacher can also communicate with the student on the terminal.

Mr. BEILENSON. Thank you very much, Mr. Norris. We are most appreciative of your having taken this time to come and share your expertise with us.

The next witness is Dr. [illegible]nald Bitzer, director of the Computer Based Education Rese[illegible]h Laboratory at the University of Illinois in Urbana, Ill.

[The c[illegible]ple[illegible] p[illegible]pared st[illegible]ment of Dr. Donald L. Bitzer follows:]

ADDENDUM TO TESTIMONY OF DONALD L. BITZER AND FRANKLIN M. PROPST

HISTORY AND PRESENT STATUS

The PLATO program has been in continuous operation at the University of Illinois since 1959. From its inception, this program has been committed to the objective of bringing the power of the modern computer directly into the hands of the general public for the purposes of instruction and education, where the term "education" has been used in the broadest sense. During the period 1959 through 1967, the PLATO I, II, and III systems were developed and tested. These efforts clearly established the validity of the basic concept of computer-based education and the importance of moving from the demonstration phase to the development of a practical, widely deployable system.

Over the past ten years (under a combination of State of Illinois, industrial, private, and Federal support) this practical system, PLATO IV, has been designed and implemented. The specific goals of the program during this period have been to accomplish the system and development, to implement a syst[illegible] of at least 500 terminals, and to evaluate the effectiveness of the utilization o[illegible] the system in a variety of institutional settings and in a variety of modes of service.

This program has resulted in an operating system of the following general characteristics:

1. Approximately 1000 terminals are connected to and operate from one central computer system.

2. Each individual terminal provides to each of the users an interactive graphics capability with essentially instantaneous response to each input by the user, independently of the fact that hundreds of other users may be simultaneously using the system.

3. These terminals are geographically distributed across the entire nation with locations in more than half of the states.

4. The terminals are installed in elementary schools, community colleges, universities, federal agencies, industrial organizations, primary schools, and homes.

5. The system presently delivers approximately one and one-half million contract hours of service per year.

6. Over 6000 hours of instructional materials are presently in use. These materials range in content from pre-school reading to graduate quantum mechanics and in pedagogical style from drill-and practice to complex sim ations and interactive tutorials teaching sophisticated concepts.

7. The system is used for instruction, educational and social science research, research computation, data processing, on-line research (ranging from chemistry to biophysics), information distribution, communications, entertainment and recreation, counseling, records maintenance and compilation, information retrieval, and in a wide variety of other uses.

8. A national community of thousands of teachers, researchers, authors, and scholars and tens of thousands of students interact through the system and cooperate on a daily basis to explore new ideas and uses of the system.

The implementation of this system involved a major program with a wide variety of components, including:

1. The development of a sophisticated computer system architecture to support a large number of geographically distributed terminals using ordinary telephone lines for communications.

2. The development of a fundamentally new software system, which provides the naive user with graphics and calculational capabilities equivalent to sophisticated research languages as well as judging, branching, and other instructional options available on other CAI systems. In addition, the system provides management facilities to support the organization and operation of thousands of classes.

3. The development of a series of sophisticated graphics terminals and a series of peripheral devices designed to meet the needs of the user, rather than have the user adapt to the capabilities of "off-the-shelf" equipment.

4. The development of a new computer display technology, which has subsequently been applied to a wide variety of other computer applications.

5. The transfer of this technology to industry in order to establish a source of supply for the need of this as well as other programs.

6. The enlistment of a variety of educational institutions to participate in the testing of the system and the development of a complete range of support functions necessary for the users of a completely new medium.

7. In addition to this system development and the deployment of hundreds of terminals, thousands of hours of new course materials were developed and tested.

This program was conducted over a four and one half year period in conjunction with the evaluation efforts summarized in the following section.

IMPACT TO DATE

We have clearly demonstrated that such a system can be deployed and operated, while maintaining the high level of performance indicated above. In addition, we have shown that the technology can be effectively transferred, in that there are now industrial suppliers for all of the hardware and software components of the system. There are also three other PLATO systems in operation, with more being planned.

We have shown that the system is widely and enthusiastically accepted. Attitudinal surveys continually show almost unanimously high enthusiasm not only on the part of teachers and students but also by researchers, administrators, and other users of the system. As reported in an independent study by the Educational Testing Service, this high level of acceptance is due in large part to the intentional involvement of classroom teachers and administrators in the development of the system. This is in contrast to many educational experiments, in which solutions have often been imposed from above.

Evaluation of educational programs is an extremely complex problem. When easily-defined performance characteristics are the objective of the program, relatively straightforward and meaningful evaluation results can be obtained. However, when complex educational objectives are involved, meaningful evaluation is extremely difficult. Further, when one is faced with the problem of integrating a new delivery system with standard classroom instruction, evaluation efforts are confounded by the need to attempt to isolate the relationships between causes and effects. Also, materials developed during the early part of this implementation were produced by classroom teachers rather than by professional curriculum developers, to insure user acceptance. Nevertheless, the following [illegible] observations concerning the educational impact of the system can be made.

First, we have been able to demonstrate that, in some cases, the [illegible]mentation of standard classroom instruction with a small amount of instruction on the PLATO system can produce major overall gains. For example, in the [illegible] of elementary math, the average growth over a normal school year for 4th, 5th [illegible] 6th grade children (receiving approximately 25 minutes of PLATO instruction [illegible] day) was over 200% of that for children in control classes.

Second, out of many studies, we have documented one case, elementary reading, where the use of the system seemed [illegible] produce a small negative impact [illegible] student performance, as measured by standardized exams.

Third, we have found in many cases [illegible] significant difference has [illegible] shown in student performance on standard test instruments.

It is important to remember, however, [illegible] performance on standardized tests is only one measure of educational effectiveness. In many of these [illegible] teachers report that they clearly see other indications of improved mastery of materials by the students, students themselves express the belief that they have understood and learned more, and students indicate [illegible] by responses to questionnaires and by improved class attendance [illegible] attitudes towards specific courses and education in general were made [illegible] positive by their experience with the system.

In the final analysis, perhaps one of the most significant measures of educational effectiveness is the desire shown by teachers and students to continue and expand their use of the system. If this is the case, the educational effectiveness of the present system is very high.

Finally, we have definitely begun to see, during the past year, that users are developing greater understanding and skill in developing new materials and in managing the use of these materials. The result is that even the narrow measures are beginning to show significant positive results, where previously there were "no significant differences." The system promises to be an extremely powerful tool for educational research, potentially providing breakthroughs in understanding of the learning process as well as providing means for translating this understanding into effective teaching programs.

In summary, the system works, it is enthusiastically received, and there is strong evidence that it can have broad positive impact on teaching effectiveness. Further, in addition to the many instructional uses, it has been effectively utilized in a broad spectrum of noninstructional modes, with great success and with promise of even greater success and breadth of application in the future.

IMPLICATIONS FOR THE FUTURE

In the demonstration of the system which is to be given to the Committee, we shall attempt to emphasize that we are confronted with a technology which is much broader than an instructional system. You will see examples of a variety of on-line uses of the system, including:

1. Instruction.
2. On-line communication [illegible] other users.
3. Electronic mail.
4. Interactive computing.
5. Information retrieval and distribution.
6. Data processing.
7. Recreation and entertainment.

In addition to these services, we are beginning to explore the use of the system in:

1. Medical services.
2. Career counseling.
3. Psychological counseling.
4. Financial planning and counseling.

5. Public forums.
6. News distribution.

Not only are these services available to the users of the system at the University of Illinois, but we are beginning to interconnect with other PLATO systems. In particular, we believe that PLATO is part of the emergence of a new technology, the computer-based communication/information network. We further believe that this new technology has extremely broad implications for the nation. It is entirely feasible to implement a nationwide network, over the next two to three decades, which could link every household and institution in the nation. This network could provide all of the services listed above, and many others.

The fundamental technology for such a network exists. Many major developments which will expand and enhance the value of such a will take place over the next several years. In addition, a great deal of effort in systems engineering, in development of service packages, and in development of utilization techniques and management skills remains to be done. However, no major technological breakthroughs are required to implement a network of major social, economic, and cultural impact. This impact on the productivity of the nation and on the quality of life of our citizenry could be immense.

With the existence of such a network, any individual could instantly receive "mail" from any part of the country. All individuals could have an automated-search access to the national library. The elderly and the physically disabled could have access to an endless array of interactive enrichment activities with participants throughout the country. Any individual could receive instruction in courses offered by educational institutions across the country.

Job retraining and job relocation could be greatly facilitated and could minimize the loss of income to the individual worker. Special attention to the learning-disabled and the handicapped could be obtained on a broad scale. Communities of individuals, without regard to geographical boundaries, could interactively function in problem-solving, social, and cultural pursuits on a scale and in a fashion not previously possible.

One can go on and on about the value of such a system to the nation, in terms of productivity, quality of life, and international trade. However, this listing of specific examples fails to give an accurate perspective of the potential importance of this new technology.

In particular, our capability to solve the great problems which affect the survival of man as a species (energy production and control, population, ecology, poverty, war, etc.) is and will be directly determined by our ability to accumulate, organize, and distribute information and knowledge. In fact, a good working definition of man is that he is that species which attempts to gain adaptability (the requisite of survival) through the gathering of information (data), the organization of that data into knowledge, and the application of that knowledge. It seems eminently clear that the highest priority for man's research should be given to those activities which give promise of improving this most fundamental of all human efforts.

RECOMMENDATIONS

We strongly recommend that the Federal Government must play a major role in the exploration of this technology. It seems quite appropriate that, eventually, the private sector will and should be principally responsible for the broad-scale dissemination which we believe will occur. However, quality and social benefit, the time scale for broad implementation and availability, and the probability of the availability of the technology can all be importantly affected by appropriate Federal action. Such Federal action is required in three areas.

First, there is the need for a major pilot program based on existing technology. Under such a program, six to twelve systems, serving all levels of education, should be installed in various parts of the country. This type of effort will provide invaluable experience with regard to an area of major importance, learning to effectively utilize the technology and integrate it into the existing educational establishment. It is clear that such a program cannot be realized without Federal support. Local school district, community college, and university budgets do not provide the flexibility to support such exploratory programs.

The second area for Federal action is support of research and development in both the technology and in the area of development of new instructional and other service packages. We have indicated earlier the large amount of work required to move from the early exploration of a broad set of services delivered by a computer-based network into a practical, deployable technology. For example, in order to provide large-scale library search, retrieval and distribution over a network, a mass memory system with very fast access and transfer must be developed. In order to materially impact the job training problem, a complete basic skills instructional package as well as specific vocational skills packages must be developed. In general, the more materials that are developed and tested on a pilot basis before a large network is implemented, the more effectively this network will be utilized. We believe that the impressive results which have been achieved in some areas to date (such as previously mentioned for elementary math) can be achieved on a broad scale in other curricular areas.

The third focus of a Federal program should be in the area of research to develop a broad understanding of the social implications of this technology and to support the preparation of a plan for the implementation and management of a national network. One of the specific programs which should be considered, in this regard, is the expansion of one of the pilot programs mentioned above to include the "wiring" of a complete city, including the connection of schools, homes, and businesses to such a system. This will provide an invaluable laboratory setting to accomplish the objectives given above. Further, this initial "wired" city should be followed shortly by the addition of one or two other cities interconnected into a network, so that the broader implications of the intercommunications of such a network can also be explored.

The recommendations above are included to indicate the focus which we believe that a Federal effort should have. They are not intended to be complete presentations of a complete program. In this regard, we strongly urge the importance of the establishment of a new organization, within an existing agency, specifically chartered and funded to conduct the exploration of the computer-based communication/information network. The development of a comprehensive program would naturally be the first order of business of such an organization.

This organization should have the responsibility not only to explore and promote the evolution of the technology, but it should also conduct a major effort in the exploration of social, economic, and political implications. This agency should begin early to prepare for Congress a plan for implementation, which should outline the route of legislative action to insure rational and effective management of the technology.

There are several reasons for the need to establish a new organization. First, no existing agency has a structure which could develop such a program. Secondly, no agency has the discretionary resources necessary to operate such a program. Thirdly, a new organization, not burdened by pre-existing commitments, has a substantially better probability of developing the focus which will be critical to success in this area.

We urge prompt action on the part of the Government. Delay can mean substantial loss of both economic and human benefit for the nation. Further, we underline the importance of the coupling of the responsibility for supporting technical research with the responsibility for supporting "social impact" research within an agency, as recommended above. We are all too familiar with the problems associated with reacting to a technology after broad dissemination has occurred. It is imperative that we develop greater skill at anticipating and planning for new technologies. There is, in particular, a singular opportunity, provided by the present technology, to develop and improve this skill. We can predict with good accuracy the technical nature of this upcoming development. Further, with the implementation of the programs proposed above, we could make reasonable estimates of the types and quality of the social impact of this technology. Thus, we would have all of the elements to support effective planning. Further, expeditious action will insure that we have adequate time to complete such planning. We indeed have a rare opportunity. One would hope that it will not be lost.

We cannot hope to convince you, in this short presentation, of the soundness of these remarks. However, we do hope that we will be able to convince you that the potential importance of this new technology is sufficiently great to warrant further investigation and inquiry on the part of this Committee. Although the cost of the programs proposed here are small in comparison to the total budget for education, they will be expensive. However, the old adage still applies, "If you think that education is expensive, try ignorance."

STATEMENT OF DR. DONALD BITZER, COMPUTER-BASED EDUCATION RESEARCH LABORATORY, UNIVERSITY OF ILLINOIS, URBANA, ILL.

Mr. BITZER. Thank you, Mr. Chairman.

First I would like to thank the chairman and the members of the committee for extending to me this invitation to testify before your committee and especially to thank you for permitting us to invade your hearing room with so much demonstration equipment.

I would also like to extend my thanks to the committee staff for their cooperation and their excellent help in setting up the display equipment.

Rather than use my prepared remarks I would like to use approximately 20 minutes of demonstration time to expand on a few of the points made in the prepared remarks.

I do this because, first of all, the written word is frequently inadequate for describing this technological art, and, secondly, because misleading statements are frequently made in describing the state of the art in computer-based education.

Needless to say, because of the short period of demonstration time, I will be able to highlight only a few important aspects. However, we will be available this afternoon to give additional demonstrations for those interested in seeing more examples.

I have with me today several student computer terminals which could be located in the home, as well as in this hearing room, because they are connected to the University of Illinois by ordinary phone lines. In fact, with today's technology we connect between four and eight graphic terminals on one phone line and run them without any interference between them.

The computer terminal is designed for viewing by a student at a distance of approximately 30 inches. Thus, in order for members of this committee and those in the audience to view what is on this screen we have brought with us a television camera and several monitors which we have placed about the room.

There is a problem with this; namely, that the resolution on the television monitors is not as good as that of the computer terminal. Consequently, from time to time we will have to zoom up on a small portion of the screen in order to show you the necessary details.

Let me begin by giving you an idea of the kinds of things we do which are different from that which computer teaching systems do. Having begun in 1959, we have the longest continuous history in computer-based education. We are active in all phases of this field, including the development of hardware, software, and courseware. Our interest is at all levels of education and our pedagogical approach extends far beyond that of simple drill and practice.

The accomplishment of these goals required a flexible system. Our aim is to have a system which adapts to the needs of the users, instead of trying to force the users to adapt to the system.

At the present time we have over 3,000 authors who prepare lesson material at about 180 different sites around the country. These sites are located as far west at the State of Hawaii and spread all the way over 25 States to the east coast. One feature we decided was necessary was the ability to view graphics on the screen. [Graphic capability of system demonstrated here.] In addition to computer graphics there are several other necessary features for computer instruction. For example, I will now show a program which will demonstrate more of these features.

Thus, over 50 percent of the States have connected to the University of Illinois PLATO system. The little figures which you now see on the screen are animal figures that were designed by an elementary level classroom teacher. The system's capability which allows teachers to design special characters is very useful. Another very important feature of the system is its capability to know where the student touches the screen. This is important because there are many students who cannot use the keyboard. We decided that the student's finger would be the simplest and most reliable component for touching the computer screen.

As you can see here by this demonstration, when a child is reading along and wants to know the meaning of a word such as the word "mouse" here, he can touch the word on the screen with his finger as as I am now doing and as you see, the word turns into a picture of a mouse.

In addition, we decided that it would be important for the computer to speak the word to the student. The word "mouse" which you have just heard the computer speak when I touched the word "mouse" is information stored in this audio device connected to the terminal. The voice coming from the computer sounds like a human, because it is a recorded human voice. [Audio device and disc shown here.] On this flexible disc we are able to record 4,096 audio messages or 22 minutes total.

Since recordings as well as play backs are possible, this feature is very useful for teaching foreign languages.

When I touch this screen, it is not the terminal directly controlling the picture or the sound. Instead, this terminal is sending this information back to a computer hundreds of miles away. Being a large computer, it can make very sophisticated decisions instantaneously and send information back to my terminal as to what should be done. Even though there are hundreds of others using the system now, you can see that the response to our request for the word "mouse" was given to us within a fraction of a second.

In addition to these graphic, audio, and touch capabilities, we found that another important feature for teaching in areas such as biology, chemistry, and medical science was the capability to project slide images. The projected slide image must be of high quality color selected by the computer and superimposed over the computer-generated graphics. Although you cannot see this color slide on the moniter because we don't have a color camera, the computer terminal screen in front of me has the picture in color. [Computing slide selector demonstrated here.]

This equipment alone, does not teach, of course, but what it does is permit teachers to program it to teach in a way which is limited to their imagination and creativity rather than being limited by the flexibility of the hardware.

An interesting side note here. You are looking at a very novel flat panel display. The reason we can project color images from the slide behind the panel is because the display pane is not only flat but transparent. A 256 page color textbook can be placed on a microfiche which then can be loaded into this space on top of the terminal, permitting these images to be selected and projected on the back of the screen. This flat panel display opened up an entire new display industry in this country.

Today major computer manufacturers use this display for banking terminals, cash registers, and other business applications.

What you have just seen are standard modes of communication between the student and the computer. We had predicted that these features would be necessary in order to teach at all levels from elementary through graduate school. However, we knew also that these features would still not be sufficient to cover all possibilities. For example, in teaching music we knew that it would be important to be able to synthesize and play music. Such a feature would make it possible to use the computer as an aid in composing music.

Thus, I have with me today a box which was built to synthesize music in four voices.

[Music demonstration given.]

Music boxes with more than four voices are now being built. Having seen the music boxes, the music teacher asked if it were possible to have the music notes appear on the screen as they are played by the music box. As you can see here, we were able to accommodate them.

The ability to attach special devices is built into the terminal since we cannot predict in advance what special delivery devices might be necessary for certain types of education. As another example of a special device, we have with us today a box which will produce a computer-generated voice. As you will see very shortly, it sounds like a computer-generated voice instead of a human voice.

My next example will illustrate several things. Besides a computer-generated voice, I will give you an example of what we mean by judging concepts rather than by comparing answers. One can readily see how in the math and science areas one can judge a student's response based on stored concepts. This can be done to some degree even with the written word. I will now write a sentence and the computer will first read the sentence to me and then, after analyzing the sentence, illustrate the meaning of the sentence by producing a short skit on the screen.

[Computer voice and sentence judging demonstration.]

If you are a native in the language, the computer-generated voice is adequate. If you are not, the voice retrieval device shown earlier is necessary.

[Computer voice demonstration.]

Another important educational application is the use of the system as a simulated laboratory. We have many types of laboratories including biology and chemistry, where this kind of interaction is used. The example I am showing you now is a chemistry laboratory experiment where the student controls a distillation experiment. Here again, we are exploiting the concept of putting the control in the hands of the user.

[Demonstration of chemistry simulated laboratory.]

There are many more examples, but I see my time is up. Thank you for this opportunity to give you a brief example of the kinds of things that a computer-based education system can do.

Mr. BEILENSON. Are there questions for Dr. Bitzer?

Mr. SWANSON. That was a very impressive display about what you could call state-of-the-art technology because it is in service, as you say, in quite a few schools around our nation.

I would like to get some general background for a moment. The thing is that obviously this technology did not come to us free. I was wondering if you could first of all give us a general ballpark on what you think the total development costs of PLATO are to date and just give us a gross breakout of where the funds came from.

Mr. BITZER. In analyzing the funding of the PLATO system from its inception, I must say that the answer is rather complex because we have had many kinds of funders. First, I would divide the time period from 1959 until now into three phases. The first phase would be approximately the first 8 years when the money that was used to develop the concepts of PLATO came from the joint service program of the Department of Defense. Although they had a laboratory whose mission was quite different from what you would think of as normal education, they saw the potential usefulness of the project.

Following that initial period of time, the funds for the intermediate period of development came primarily from three significant sources: One, the Federal Government in the form of substantial funds from the National Science Foundation and the Advanced Research Projects Agency and, two, from the State of Illinois, which has made significant contributions to the tune of hundreds of thousands of dollars annually. And, three, funding has come in the form of free computer accesses from industrial firms. In reference to this last source, I might say that one shouldn't neglect the capital investment that industrial firms make in trying to produce the various components we use in the system, although I'm sure their objective in doing so is to realize a rate of return from using the components in other area.

Those three sources have been the major contributors up to the present time. If I move to the phase of development we are presently in, we still receive a significant amount of funds from the State of Illinois and will continue to do so.

Again, we receive funds in the way of equipment grants from industry, particularly Control Data Corp., and finally, we receive funds from various users which are on the system. We do have a small amount of Federal funds at this time, but it is not a significant amount.

Mr. SWANSON. What is the total?

Mr. BITZER. Over the 17 or 18 years the total would come to about \$20 million, if you add in all of the things I have mentioned.

Mr. SWANSON. What would be the total proportion of that in millions of dollars from the Federal Government.

Mr. BITZER. My guess is that the Federal Government has contributed somewhere in the neighborhood of \$10 to \$11 million, or roughly about 50 percent.

Mr. SWANSON. Given that kind of investment in terms of the Federal Government, would that have been the crucial amount of funding? In other words, I am trying to get to the question of the role of the Federal Government in such R. & D.

Mr. BITZER. I cannot say for sure that PLATO never would have happened without Federal Government help, but I can say that I'm pretty sure it wouldn't have happened in this century without the help of the Federal Government. Their funding brought together a lot of the ideas and expertise and made it possible for us to develop and implement these ideas.

Mr. SWANSON. Was that the appropriate model to follow in terms of the Federal Government subsidizing the demonstration and development aspects of your project and then having the marketing handled by a commercial corporation?

Mr. BITZER. At that time I think that was an ideal way of proceeding. I think the method of proceeding is a function of the time period you are in.

Originally, support for CAI—computer-based instruction—was in the form of very small grants for very large numbers of people across the country, the result of which really got nowhere. Then they—government—went back to larger funding for a smaller number of people. And now I think we need to go to a new phase or type of funding because the technology and knowledge of the field has changed.

In my written testimony I have proposed a plan which essentially has three kinds of participation by the Federal Government which we think are crucial if we are to succeed in the area of computer-based education. One is the area of making it possible for the school districts to use the existing technology. I might point out that in the math drill and practice areas large additional gains are shown even in children who have a very high achievement level in our school district—about 1.2 years per year in school in the normal classrrom. With computer-based education in the drill and practice area we have been able to attain twice that gain per year. This past year students gained 2.4 years per year in school in computer-presented arithmetic drill and practice areas. This gain was attained by students at the fourth, fifth, and sixth grade levels.

This type of achievement benefits not only the children who are low achievers, but also it makes possible for the high achievers to make even faster gains. Thus, we propose that money be made available to let students of all levels of achievement participate.

Second, we think there is a great deal more research to be done. We have learned a lot. We have had some successes. We have had some things which we think are successes, but we can't prove it yet. And we have had perhaps one failure. We think, that with appropriate research help at the institutional level, we can bring the same kind of success to a wide variety of programs at all levels for all kinds of children, both overachievers and underachievers, independent of what subject they are studying. However, it will take time and money. We think the Federal Government can and should play a very important role in making this research—computer-based education—possible.

Then, finally, we think it—computer-based education—is going to happen. We think the Federal Government had better help control how it happens. So we propose that before we put a computer terminal in every home, or rather before the people put them in every home by simply being able to acquire them, that we solve some of the problems and look at some of the social issues that may evolve.

We are looking at the possibilities of finding a cooperative city or segment of a city to use as a demonstration site where the schools and the homes would be served by just one system and studied to see how the people are affected after a few years. It would be good to be able to do this now before the situation is out of control.

Mr. SWANSON. I would like to touch on something you raised, the issue of the evaluation of a system like PLATO and its impact. We have been in contact with people at the Educational Testing Service who have been responsible for conducting the evaluation of PLATO, and their study yielded the following results:

Number 1, while PLATO runs and is a sucess technically and managerially, it failed to enhance the quality of the student's learning, that is, they fared as well whether they received PLATO lessons in addition to regular instruction.

Second, it had no effect on attrition, that is, PLATO did not turn on students to continue.

Third, teachers and students rated the system as clear and the lessons as good and both liked the idea of using it, hence, we could generalize that the system was enjoyable but seemed to make no difference in the level of achievement.

I would like to ask do you feel the assessment procedures utilized were adequate in this case and that the results fairly portrayed PLATO? Second, what evidence would you offer to counter this?

Mr. BITZER. First of all, that is a report based on the community college work, an area which was new to us, and I might add that being able to have the administrations and students of community colleges enthusiastic about this method of teaching and on the first attempt have student achievement be equivalent to that attained in a normal classroom is not a failure.

Our first objective, as we told ETS, was to make sure that in these institutions, particularly institutions of higher learning, the faculty and administration feel comfortable with the system and want the implementation. We have all seen many cases where good materials have been programmed for TV presentation, and students showed good achievement. However, the mode of instruction was discontinued because the method of instruction was not acceptable to students.

So it is very important that the teachers and students perceive that what they are doing is worthwhile and accept the method of instruction. Second, the very narrow measures which were made of student achievement did not measure many of the other qualities that the students demonstrated, for example, the ability to write better compositions, even though there was no improvement in their grammar. These kinds of achievements do not show up in an evaluation of that type. We think there is much room for improvement in the method of evaluation. In fact, we visualize the system as a mechanism for really looking at evaluative procedures as well as teaching procedures, and we have a large number of people across the country involved in doing just that.

Mr. SWANSON. I take it you would welcome another type of evaluation or series of evaluations. We raised this question earlier with Mr. Clinton and Dr. Hoffman. If we proceed with further evaluations whose responsibility is it to fund these evaluations and carry them out?

Mr. BITZER. I would recommend that there be evaluations by various types of institutions, one of which should be the Federal Government. Also, the institution doing the evaluation probably should not be the same institution that does the funding. First, because it puts pressure on that institution to spend money in another direction, and second, it would remove any indication of possible collusion between the evaluating agency and the funding agency. But in addition to institutionalized evaluation studies, one has to do a lot of evaluation himself.

23-820 O - 78 - 13

Let me explain that there is a problem with too much evaluation of the wrong type. There are essentially two types of evaluations. One is called formative and the other is called summative. In the formative evaluation you define what you are trying to accomplish and describe how well you are accomplishing it, whereas, in the summative type of evaluation you assume that you have worked out most of the problems and are trying to establish the fine details of the statistical results. In my opinion, there is a lot more formative evaluation needed before we get to the summative areas.

I think the biggest problem is that you do too much summative evaluation, you will forget you are out there to teach the students. There is a tendency to become interested in the experiments and in gathering the research results for our own use while neglecting the fact that there are real students out there going on to the next level. Thus, we ought to make changes when we see there is a problem and to correct those problems rather than sitting around saying it is a beautiful evaluation and we are gathering data and forgetting students. We shouldn't do too much of that type of evaluation, and I think there has been too much of that done in the past.

Mr. BEILENSON. Are there further questions of Dr. Bitzer? Perhaps you can continue questioning the doctor and if perhaps you have completed then you could go on with Dr. Volk's testimony.

Dr. WELLS. Dr. Bitzer, I talked with Mr. Norris just for a few moments about the dissemination model which seems to evolve between yourselves and Control Data, associated with a number of other agencies. I take it the State of Illinois participated, and I understand the Defense Department also provided funding. So it was a rather large number of private and public organizations involved. I am curious as to the evolution of the particular arrangement which finally came out. At what point along the line did you consciously begin to think, now that we have this potential which is arising from this research, what are we going to do with it and by what process are we going to get it into some kind of use, either the schools or industry or whatever? So let us go back to this dissemination model question and if you could express your point of view on this and give us some insight into your thought process.

Dr. BITZER. There are two viewpoints that we had as to dissemination. One thing we realized was that the university cannot be a mass disseminator. We can do a fairly large experiment but eventually, if it requires equipment and mass production of any kind, it has to be handled by industry. So as we developed our products, we looked for mechanisms for getting them produced not only for ourselves but for other people.

Along with that aspect, we had our own question of how we should disseminate the terminals which we were constructing. There were two diverse opinions as to which direction to go. One group favored concentrating on a very narrow objective, such as drill and practice in the grade schools, or a reading program. This group thought that by our entire resources and terminals in one area we could do a definite experiment and essentially guarantee that we would come out with more positive results.

The other opinion was that we are a research outfit and the sooner we learn about all of the problems the less likely we are to be stuck with a system that does one job well but cannot do anything else. Of course spreading resources over a much broader area doesn't allow us to go into the depth to solve certain problems that we would like to solve.

Nevertheless, I thought that there were enough people who were quite willing to take the sure thing and give up opportunities for the future. Particularly I thought that in a call involving Federal funds coming from something like the National Science Foundation, and people whom the Government and the State have invested in as researchers should not fall into such a conservative category that they are frightened to take new chances. And so we took what I would call the high risk direction in order to gather as much information in as wide a variety of areas as possible. Having gone through what I call the period of maximum stress a couple of years ago while trying to handle all of the broad spectrum of events, I now look back and say that we did the wise thing. I say this because in fact we now know a lot more about how to get involved in teaching in areas of applied arts and social sciences and in the elementary areas as well as the college areas. We now know how to provide the capability of lesson writing to the teachers and professors and other people interested in creating lesson material without them being experts in computers. This alone has made a significant difference in the attitude of teachers toward the medium. At the elementary level it is possible to find school districts that are completely happy to take whatever you will hand them, particularly if they are using government money to pay for it.

I must say that at the university level or upper educational levels, professors do not give up their rights so easily on what is being taught and what materials are heing used. It is important if we are to reach those areas that we involve them in creating material and in the methods of evaluation and leave the creation of new material to them.

Mr. WELLS. This probably is one of the most difficult problems that the Federal Government faces. We have within this committee another subcommittee which is wrestling with a uniform patent policy bill which has been introduced and very likely hearings are going to be held in the spring. This is going to impact the technology transfer process and we are giving a great deal of attention to the total problem of technology transfer as an abstract concept and also trying to look at it in terms of specific cases or instances.

That is why our particular interest in the arrangements you have developed with Control Data Corp. as being on the face of it the kind of model that certainly looks like a successful way to move technology from the mind of a university researcher to the marketplace via the private sector which has the mechanisms to go to the marketplace which the university does not have. Yet the question always lurks in the background and has been at the heart of a 30-year debate in Congress on what are the relative rights with respect to various parties. When the Federal Government provides funding for research the classic populist doctrine has been that it belongs to the people and therefore is in the public domain.

I will not go into a long discussion of something you are fully familiar with. But trying to set up your particular situation in the context of this larger debate, the opposing argument is that anything that is in the public domain is not likely to be developed. If it is available to everyone, then no one will develop it.

So we have had this terrible dilemma for some 30 years and each agency of Government has developed for all practical purposes its own set of patent policies despite President Kennedy's efforts in 1963 to set forth by Executive order a kind of uniform policy for the Government. Yet that did not lead to uniform policies in practice. We are now struggling with this and Congress will be struggling with it during the next session and perhaps into the following Congress before really for the first time in a generation coming up with a uniform patent policy.

I take it what you are saying is that unless you had a somewhat protected position—and as I understand the arrangement between you and the National Science Foundation—you are permitted to release the PLATO system on a nonexclusive licensing arrangement.

Mr. BITZER. That is correct.

Mr. WELLS. As of now Control Data Corp. is the only one who has approached you or that you have entered into an exclusive licensing arrangement with?

Mr. BITZER. I would have to look. We have licensed, I would say, a dozen different companies to manufacture the products which we have invented. In this country the Control Data Corp., I think, is the only corporation that we have licensed to produce the system, but we offer the entire system on a nonexclusive basis. At one time I think the Japanese also had a system license. I don't know the status of that. But certainly if another company asked us to license them, we would, because our policy at the university is to be as nonexclusive as possible. As Mr. Wells has stated, the Federal Government is agonizing over whether making things freer so that the public will appear to benefit will result in no one doing anything or whether making it more restrictive will result in someone making it available to the public. The university too, struggles over whether they can put our exclusive rights in order to make it more attractive at least for a period of time, so that someone will run the high risk of the financial investment necessary to make the product available. If not, a smaller company will only find out that a large company moves in and wipes out the risk-taking company once they prove that all the problems are solved.

Mr. SWANSON. You mentioned in fact that the University of Illinois provides PLATO service—there were two terminals you mentioned this morning, one running to Minneapolis and one to Urbana.

Mr. BITZER. We have three terminals. We are on both systems and both systems are connected to each other.

Mr. SWANSON. That means that Control Data Corp. has their own computer facility which is able to furnish PLATO terminals around the country as well as the Champaign-Urbana?

Mr. BITZER. Oh, yes, and there is another system at Florida State.

Mr. SWANSON. Does Control Data have their license to sell PLATO—what I'm trying to get at is have you segmented the market or do you both compete with each other? Does the University of Illinois compete with Control Data in providing PLATO service or how do you decide who sells to what kinds of customers?

Mr. BITZER. That is a difficult question, but I can tell you the legalistic terms.

Mr. WELLS. Should universitites be in the business of providing this commercial service?

Mr. BITZER. First of all, this is one area where you can't do the research without having customers. You cannot do it in absentia. Everybody recognizes that, including the business parties. Besides, in the long run, the benefits of the reasearch will also be for the companies involved in disseminating the technology. We—University of Illinois—consider ourselves in competition when, in any one institution, we install more than four terminals. For any institution outside the University of Illinois, if we install over four terminals we consider ourselves in competition with CDC, and we would not do that without their permission. For less than four terminals, or up to four terminals we will take, on an availability basis, anybody who would like to do some experimental research with us.

Mr. SWANSON. Say I am a school district in Baltimore and I wanted to have PLATO for my school, would there be in effect then two vendors available, the University of Illinois and Control Data from whom I could purchase PLATO?

Mr. BITZER. The University of Illinois for up to four terminals or Control Data Corp. as many terminals as you want unless it becomes a research program.

Mr. SWANSON. So then you dichotomize between experimental and commercial?

Mr. BITZER. If, in fact, a major portion of the funds involved are not just for renting service but in fact doing evaluation and developing course work and so forth, then that is completely excluded and considered research and not competitive service.

Mr. SWANSON. So basically you partition the market into experimental and nonexperimental as well as the number of terminals in use?

Mr. BITZER. And any institution within the State of Illinois, either governmental or educational, is excluded.

Mr. SWANSON. Say, I'm a small institution and can get by with four terminals and I want to buy PLATO from the University of Illinois and the other option is Control Data. How much would it cost to get the four terminals, from the University of Illinois? And what is my competing cost factor from Control Data?

Mr. BITZER. From the University of Illinois we price the product just as if we were paying for everything. But because we clearly don't have the same overhead or profit motive the costs are not the same. We ask the individual to buy their own terminals which run slightly over $5,000 each. We ask them to pay their own communication charges, whatever they may be depending on their location. Then we charge them $2,500 per year for each terminal to access the system. This access charge is like $1 per hour for whatever services they need, including maintenance of the terminal except for travel, and access to all courseware.

Mr. SWANSON. What would be the comparative CDC costs?

Mr. BITZER. My guess is that CDC costs would be three to four times as high.

Mr. SWANSON. Thank you very much for bringing all of the equipment. I might mention that the equipment will be on display throughout the rest of the afternoon once the hearings conclude. And we have mailed a "Dear Colleague" letter to members of the House and Senate.

Mr. GALLAGHER. On page 7 in your conclusion there as to the third focus, the Federal program [Mr. Gallagher quoting from statement].

As a [illegible] when I think of a national network, I'm thinking commer[illegible] BS or NBC television national network. When you speak [illegible] lly" of course a by-product of this will be activity on the [illegible] House ultimately and there are going to be Congressm[illegible] the plusses and some who see the minuses. That goes [illegible] which brings up the old adage that he who funds it runs it, [illegible] ns Federal intervention and control.

But diver[illegible] a moment, am I correct that in building this futuristic net[illegible] u speak about wiring together a complete city with homes, fa[illegible], and businesses, and a school population and then perhaps interlinki[illegible] cities and developing that way, I imagine you could wire a State together.

Well, this gets right back to what I was touching on somewhat before, who contr[illegible] all this? Who picks the peer reviewer? After the program is in pl[illegible] for a while, who evaluates it? who picks the evaluator? I think the[illegible] will be a lot of debate on this on the floor.

Mr. BITZER. [illegible]s, and I couldn't agree more. You have focused on a very impo[illegible]t point. That is the reason we suggest that the Federal Government get involved at a very early stage and designate some new unit in one of the existing agencies to start looking at these problems as early as possible.

My guess is that even without control it would probably happen anyway. We are linked together with several systems now and we could probably link together hundreds of systems and millions of terminals within the next 10 years. If they are made available in the free marketplace, people will buy them and they will be linked to the system. In this case, expansion and strategies developed without careful preplanning may give undesired side effects, whereas, if we plan very carefully now, I think we can develop the necessary governmental laws, restrictions or regulations, which will guarantee better service and minimize any dangers.

Mr. GALLAGHER. Do you envisage a single national network or a plurality of systems?

Mr. BITZER. I visualize the network as being very much like the telephone service, a regulatory type agency in the sense that it will provide its service but it will not tell you how to use it.

Of course, the services will be much more extensive and involved. For example, such things as instantaneous communication worldwide and national libraries will be available. We are working now on a system to provide on-line capability and access to a 2-million-volume library with the capability to search it in a fraction of a second. Those kinds of services would drastically change the way people use their existing services, and there would be a substitution of communication for transportation. We could bring high quality libraries and searching capabilities to everybody in their homes, making large libraries available for the general public as well as to professors. We think these things are going to happen. We can show you some of these things now and that's what makes us think that will happen on a large scale eventually.

Mr. GALLAGHER. You refer to a telephone system. That is a neutral object where you have a dialect between yourself and the party you talk to. The party you talk to has not yet been programed and it is spontaneous. You do have the interaction we have heard about today, but you still have to program the initial material which the student is tapping. So is that an apt analogy I wonder.

Mr. BITZER. I think so, in the sense that I also view this network as a medium—people ask what PLATO teaches. It is not PLATO which teaches. It is the material and things that people have done that either teach or do not teach, utilizing PLATO as a medium. I view PLATO as being a medium with which you can do things you have not done before.

Certainly there will be things available on the system that will be valueless. They probably won't make any difference. People won't use valueless things very long. And there will be things of great value. I think we have to establish very soon a program which will help encourage the valuable things and discourage the valueless ones. I can see that as a role for the Federal Government. Otherwise, it is going to take the route of commercialism and you are likely to turn on your terminal and get a 3-minute commercial on what is available at the local store.

Mr. GALLAGHER. If you object to television programs you can always protest and you have other avenues to put pressure on the New York networks, whereas if the Federal Government is involved you can protest by not paying your taxes but then you're thrown in the slammer.

Mr. BITZER. An important aspect of this system is that we have a lot of competitive lessons in the same area. Right now in the classroom, if a professor decides to teach a given philosophy, which most of us find offensive, we don't even know about it. It is very hard to find out. It is sort of a sacred hall for a professor to say what he wants in his class. I think we will provide the same type of situation in this system, except it won't be secretive any more, because everybody can see it.

I think that you will get enough feedback and incentive to do the right job. This can be accomplished in part by opening the system up to anybody who wishes to participate; by making it possible to write competitive lesson materials; and by establishing some reasonable reward system such as royalties for materials used.

Mr. GALLAGHER. Getting back to what Dr. Crandall said, you turn these kids from externally to internally controlled and you leave the house in the morning at 8 o'clock and you come home at 5 and you have a bunch of rebels on your hands. So I want you to think about that.

Mr. BITZER. Thank you very much Mr. Chairman for allowing us to appear here today.

Mr. BEILENSON. Our next witness is Dr. John Volk, the product line manager of Hazeltine Corp. Doctor, it is good of you to come over here and discuss this matter with us today.

STATEMENT OF DR. JOHN VOLK, PRODUCT LINE MANAGER, HAZELTINE CORP.

Dr. VOLK. Thank you very much for inviting me. I'm going to talk about the TICCIT, the computer-based instruction program today. I will first tell you a little bit about the history of the program and then describe the system and tell you about some of the results we have had and their initial applications and try to be specific there and then finally point out some opportunities where I think the Federal Government could perhaps be doing more today than it is to further this technology.

[The complete prepared statement of Dr. Volk follows:]

PREPARED STATEMENT BY JOHN VOLK

Good afternoon, my name is John Volk; I am director of engineering for Hazeltine Corp.'s Educational Systems Group. Hazeltine Corp. has for over 50 years been a leader in the development and application of information electronics technology, including basic contributions to the development of color television, military electronic systems, and computer terminal equipment. The corporation has annual sales approaching $100 million, its stock is traded on the New York Stock Exchange, principal offices and corporate headquarters are located in Greenlawn, N.Y.

Hazeltine's Educational Systems Group was organized within this past year to manufacture, support, and to market the TICCIT [1] computer-based instructional system. Offices of the Educational Systems Group are in McLean, Virginia.

The development of the TICCIT system began in 1968 under the private sponsorship of the MITRE Corporation (a Federal Contract Research Center). In 1971 the National Science Foundation (NSF) awarded MITRE the first in a series of contracts to implement and demonstrate the feasibility of this system for use in community colleges. Brigham Young University joined with MITRE in this effort. Prior to Hazeltine's involvement with TICCIT, I was head of MITRE's Computer Systems Department and was directly responsible for the development of the TICCIT system. Between 1971 and 1976 many organizations came to MITRE expressing interest in the system for their own instructional needs. However, neither MITRE nor Brigham Young University were in a position to manufacture, sell, and service TICCIT systems on a continuing basis. MITRE did though build TICCIT systems for the U.S. Navy, the New York State Education Department, and Gallaudet College in addition to the systems it built under its NSF contract for Brigham Young University, Phoenix College, and Northern Virginia Community College. At this point, it was determined that the public interest would be best served by making the system commercially available. With NSF's advice and consent, MITRE solicited proposals from industry for the commercialization of TICCIT and after a lengthy evaluation selected Hazeltine.

TICCIT was developed to provide the kinds of interactive instruction you have seen demonstrated today using low-cost "off-the-shelf" technology. The system includes a central computer system that can provide individualized instruction simultaneously to as many as 125 students. Students receive instruction at student terminals which include a color television set and a typewriter-like keyboard. The student's learning experience is, in general, a dialog between the student and the computer. The computer presents rules, definitions, and examples on the TV screen at the student's behest. The computer also presents to the students practice questions and tests. The student responds to questions and requests specific information by typing on his keyboard. The computer analyzes the answers typed by the student and displays on the student's TV a message indicating whether the answer was correct or incorrect and, if necessary, an indication of the kind of error made by the student. It also maintains records and prepares reports on student progress as an aid to the teacher. Every TICCIT student proceeds at a pace and works on instructional material matched to his knowledge and ability. Teachers monitor the progress of TICCIT students, providing guidance and assistance.

TICCIT is distinguished from other computer-based instructional systems in several ways. The most obvious distinction is the use of color television technology in the student terminal. Color television receivers today are remarkably low-cost/high-reliability devices—they cost only marginally more than the usual computer display and provide two very useful extra features. First of all, computer-generated displays can be in color (color adds interest, can be used to focus attention, highlight key points). Second, full motion video sequences can be incorporated into the computer-based system. For instance, a video tape of a professor explaining

[1] TICCIT (Time-shared, Interactive, Computer-Controlled Information Television) is a trademark of Hazeltine Corp.

a difficult concept can automatically be retrieved and shown to the student on his TV in conjunction with his computer-based instructional material. There are other advantages as well, by connecting a TICCIT system to a cable television system it is possible to bring computer-based instruction into the home. This, in fact, has been done in Buffalo, New York. Severely handicapped children receive computer-based education using their home TV as the display. The final and potentially most important advantage of being television-based is that our system is compatible with video disc technology and the considerable benefits it will bring to computer-based Instruction.

However, another on-technical distinction of TICCIT has been of much more importance to the success of the TICCIT system. A problem faced by all instruction technologies has been the development of instructional material (or what we call "courseware"). Early workers in the field of computer-based instruction found courseware development to be the most significant impediment to success—they could make the hardware work, but the writing and debugging of courseware was a never ending process. Every developer of computer-based instructional systems has had to face this problem and develop tools to solve it. TICCIT takes a system approach to the entire problem of developing consistently good courseware. Vic Bunderson's group at Brigham Young University deserves much of the credit for this work. TICCIT differs in that the courseware development system assist the teacher in development of instructional strategies, makes entry and revision of courseware similar to advanced, widely used, word processing systems, and has an automatic data gathering and reporting system that provides teachers with reports on the difficulties students are having with courseware. In fact, the approach built into the TICCIT computer is almost identical to the courseware development process (called Instructional Systems Design) which is now being pressed into service for all instruction technology within the military.

TICCIT systems are now installed and providing instruction at eight sites across the country. Over 500 student terminals are in the field. The systems are being used for instruction in mathematics and English composition in community colleges, in the operation of advanced weapon systems at Naval Air Stations, and in basic skillswith handicapped children.

In general, TICCIT has been found by users to be a technically reliable system, free of the defects commonly associatedwith instructional technology. The system has been so reliable that most users do not even keep statistics on system reliability. At one typical installation where statistics are kept they show the system is up and working properly over 99 percent of the time it's scheduled for student use.

TICCIT has been used the longest at Northern Virginia Community College and Phoenix College. Both schools continue to use TICCIT today. Educational Testing Service (ETS) has collected substantial data on TICCIT's impact on these schools and is under contract to the NSF to report on the educational impact of TICCIT in these two schools. (The report will be available within ninety days). The ETS study compares TICCIT students with students in traditional classes taking similar courses. We expect the ETS report will show that in comparing students that complete their courses TICCIT students achieve significantly more. We also expect the study will show though that most students lack the discipline to work completely at their own pace. TICCIT teachers have consequently accepted as part of their responsibility to set progress goals for each student that are reasonable considering his individual ability. Overall, we have been very pleased with how well these systems have worked.

Use of TICCIT by the Navy is also proceeding well. Crew members are being trained for the S3–A anti-submarine warfare aircraft. Reports from Navy personnel responsible for operation of the system indicate that since TICCIT was put into use, fewer instructors are required and students learn their material faster. TICCIT was justified for installation in the Navy on the basis that training traditionally offered in expensive weapon system simulators could instead be accomplished with TICCIT—the Navy's analysis showed an expected saving of over $25,000,000 by purchasing two TICCIT systems instead of several weapon system simulators.

The use of TICCIT for special education with severely handicapped students in Buffalo, New York, and deaf children at Gallaudet College's Model Secondary School for the Deaf (MSSD) have been personally very rewarding. Use of the system in Buffalo began in 1975—results though are difficult to quantify, it is hard to put a cost effectiveness measure on the success a terminally ill child experiences learning math. Community support of this system has been great. In fact, since federal and state support of the project ended last year, local charities stepped in and continued operation of the system on their own. The system at MSSD has only recently become operational and data on its use is not available.

Overall, from a cost effectiveness standpoint, TICCIT has been most successful in its military training applications. In military training, reduction in training time can result in significant cost saving, as can substituting TICCIT for more expensive training equipment. Student motivation is not a problem. For these same reasons we expect that training in federal agencies like the Social Security Administration, Internal Revenue Service, and in industrial training can also be cost effective today.

I believe, and I think the message is clear today that the computer-based instructional systems available now are ready to be much more broadly applied than they are today and that their use can result in improvements in instructional effectiveness and cost reduction. However, application of these systems, despite their obvious value, is not growing rapidly.

Personally, I have been most surprised by the small number of applications of this technology within the military services. The need for improvement in military training cost effectiveness is well documented. The need for individualized instruction, the disastrous outcomes that can result from inadequate training, and the difficulty the military has in developing good instructors are all apparent. Many officers and civilians directly responsible for training acknowledge the benefits of TICCIT and other computer-based instructional systems but appear to receive little support from the military training bureaucracies when they propose the application of such systems.

Part of the impediment to use of computer-based instruction in the military services are the various regulations associated with the purchase of automatic data processing equipment. Even though a system like TICCIT is used exclusively for training, its procurement is administered as if it were a general purpose computer system. These procedures have little relationship (from either a technical or administrative standpoint) with a system like TICCIT. Attempting to follow them has been conservatively estimated to add two years to what would normally be an 18 month procurement cycle. Computer systems incorporated in military weapon system and process control systems are excluded from these regulations—computers that are part of an instructional system should also be excluded.

Broad military use of computer-based instructional systems would do more than cut the DOD's training budget. Large scale production of computer-based instruction will result in lowered costs for these systems. In addition, broad use will encourage more private investment in this technology, increase competition, again lower cost even more, and probably improve performance. I believe the net effect will be to bring the cost of computer-based instructional systems down to the point where they can be broadly applied in public education. The military services should be considering broad application of computer-based instructional systems now.

In spite of these problems, though, one can only be optimistic about the future of computer-based instructional systems—several good systems are available "off-the-shelf" today, we know that computers can make instruction more efficient, a general dissatisfaction exists with the cost and effectiveness of traditional means of instruction, and it is apparent the cost of computer based instruction will continue to fall and that the capabilities it offers will significantly increase. Broad use of computer-based instruction is inevitable!

Dr. Volk. First of all, as to the history of TICCIT, the TICCIT system development began almost 10 years ago at the Mitre Corp., which is a Federal contract research center located in Boston and in Washington, D.C.

In 1971 the National Science Foundation awarded Mitre the first in a series of contracts to implement and demonstrate the feasibility of this system for use in community colleges. Brigham Young University joined with Mitre in this effort.

Prior to Hazeltine's involvement with TICCIT, I was head of Mitre's Computer Systems Department and was directly responsible for the development of the TICCIT system. Between 1971 and 1976 many organizations came to Mitre expressing their interest in the system for their own instructional needs.

However, neither Mitre nor Brigham Young University were in a position to manufacture, sell, and service TICCIT systems on a continuing basis. This presented a dilemma to Mitre and to Brigham Young University.

Nevertheless Mitre did build a number of TICCIT systems for the U.S. Navy, for Galludet College in Washington, D.C., and for the New York Department of Education. Finally, after consultation with the NSF Mitre went out to industry and solicited interest in the TICCIT system and eventually received proposals from industry to commercialize TICCIT.

NSF was involved in this entire process. Last year about this time Hazeltine Corp. was selected to be the commercial vendor of TICCIT.

The TICCIT system provides interreactive instruction, provides kinds of instruction similar to what can be done with PLATO or in the Computer Curriuclum Corp. system. It sort of falls in between those two systems in terms of cost and capability. We think it is a very good compromise.

What I would like to do is show you a few pictures. Earlier today Dr. Hoffman warned that those of us who would be talking would show you many pictures of smiling people using our systems and you should be on guard against those kinds of pictures.

But I thought it would be helpful just to show you a couple of pictures just to give you an idea of what happens with this kind of system.

[Slide.]

First of all, a word on what TICCIT stands for. I won't even try to say it. That was a name that was developed by a committee.

[Slide.]

The TICCIT computer system provides interreactive instruction to many students simultaneously, in fact, as many as 125 students can receive different instructional material, each at their own pace, interreacting with the computer at their own TV terminal.

A typical student terminal consists of a color TV set and a keyboard. Like Dr. Bitzer demonstrated so ably a few moments ago, the computer can display on the screen pictures, information, and questions. The student can answer those questions by typing on a keyboard or by pointing at the screen with an oval pointing stick which we call a light pen. There is a dialog which goes back and forth. The computer keeps records of the student's performance and prepares reports for teachers, quizzes students, and gives tests, all the kinds of things you would normally like to have happen in an instructional environment.

Teachers are a key part of teaching with TICCIT. TICCIT does not remove the teacher entirely from the teaching process. It changes the role of the teacher instead. The teacher is not inolved so much in lecturing but is involved more in guidance and motivating students and helping them with specific problems.

[Slide.]

Now TICCIT is different from other systems in the technology that we use and in the way that we enter instructional material into the computer system. I'm just going to hit on one facet of the technology and that is that we use color television receivers for TICCIT instructional material.

We do this for several reasons. First of all, with a color TV you can obviously display information in more colors than just black and white, or in the case of the PLATO system, orange. It is possible to show full color pictures that are generated by the computer. And that would be quite helpful in tying concepts together and highlighting key points, and so forth.

Another important advantage of using color television is that it is possible to integrate full-color motion pictures into the presentation For instance, if you wish to show an experiment to a student, instead of showing a computer simulation of the experiment on the TV screen, you can actually show the real thing. The student can see everythnig that is going on just like he would if he were in the laboratory.

Another advantage is that because we use television technology it is possible to connect a TICCIT system to a cable television system and bring these same kinds of computer services that you have seen demonstrated here today and that you have heard about into people's homes. We have in fact done this. We are bringing instruction to handicapped children in Buffalo, New York, into their homes. They do not have a special computer terminal. They use their home TV set as a display and they talk back to the computer with a little keyboard connected to the computer system via a telephone line.

Another advantage is that TICCIT is riding the technology wave that is coming up with video discs. Video disc technology offers the capability of accessing literally tens of thousands of pages of information off of a single record.

Video-based technology is completely copmatible and we think it will have a major impact on the cost of the system. As interesting as those technological features are, though, the impact that TICCIT has had on most users, the most phenomenal impact, is in the courseware development area. In the examples you saw today that Don Bitzer put up, you might get an idea of how difficult it is to invent instructional materials for a computer-based system, to be so clever as the people were who put those particular sequences up on the system. Most people find it very difficuit to do that.

We have tried—and Dick Bunderson will confirm this, I'm sure, in a few moments—we have tried to allow for a procedure that allows for good quality material to be entered systematically. We feel that the material we have put up on TICCIT today demonstrates that quality. TICCIT systems right now have been installed and are operating at eight sites across the country. They are providing instruction in community colleges. They are providing instruction at military bases and they are providing instruction at special education centers.

In general, we have found that these systems have been highly reliable. In the past, instructional technology has gotten a bad name because the equipment did not work most of the time. We get comments like at the North Island Naval Air Station where we have a system installed, that TICCIT is the most reliable instructional system they have on the base. We are very proud of that. TICCIT has been used longest at two community colleges, one within about a 15-minute ride from here in Alexandria, the Northern Virginia Community College, and another, the Phoenix College in Phoenix, Ariz.

The result of TICCIT's impact in the schools we feel generally has been very good.

Educational Testing Service has been gathering data on the impact of TICCIT there and while that report has not been released yet, we have seen enough of the data to draw a couple of conclusions. One is that TICCIT does make a significant difference in student achievement. Another is that the mode of implementation of TICCIT of bringing this kind of instructional material into the school, the way you do that and the way you work with teachers is very important. We implemented an English course and a mathematics course, multi-semester courses, and we implemented the math course in a way where teachers had practically no real role. They were just there to answer questions that students had. And for the English course, we gave the teachers a major role, one where they worked with students almost on a daily basis in small groups, et cetera.

We found that in both cases, both math and English, the students who completed the courses learned more than the students did who completed regular college classes.

We found that student motivation was much higher in English courses and overall the program was much more successful. So we see that as a sign for the future and when we go into other community colleges in the future and other various public education system we will encourage our users to be careful about the mode of implementation and make sure that the teachers are carefully involved in the course of study and that they don't consider this technology as a means of eliminating the teacher from the process.

The use of the TICCIT by the Navy is also proceeding well. Crew members are being trained for the S3–A antisubmarine warfare aircraft. Reports from Navy personnel responsible for operation of the system indicate that since TICCIT was put into use, fewer instructors are required and students learn their material faster.

TICCIT was justified for installation in the Navy on the basis that training traditionally offered in expensive weapon system simulators could instead be accomplished with TICCIT—the Navy's analysis showed an expected saving of over $25 million by purchasing two TICCIT systems instead of several weapon system simulators.

Overall, it has been a successful program and one which our Navy colleagues tell us saved them over $25 million. The use of TICCIT for special education is much harder to quantify from a cost-effectiveness standpoint. I think it is a wonderful thing to do, but I think people get all hung up when they try to talk about dollars and cents in this area.

Generally, we believe that TICCIT has been most effective and most successful from a cost effectiveness standpoint in military training. The reason for this is because students can complete their courses faster with TICCIT and they are being paid salaries. There is, therefore, significant cost savings. Also, the fact that TICCIT can be substituted for more extensive training equipment results in cost savings. We believe for the same reasons other Federal agencies like Social Security Administration, Internal Revenue Service, and in areas like industrial training, you will find that there will be considerable cost savings possible today to computer-based education.

I hope that part of the message that you glean from all the comments today is that those of us who have developed computer-based education system or who are marketing them today believe that these systems can be cost effective for certain applications and that they should be more widely used than they are now.

I personally am very surprised by the small number of applications of this technology, especially within the Federal Government. The military training area is an area where it is especially surprising to me, the need for improvement in military training cost effectiveness is well documented. GAO has made a very interesting study a couple of years ago which showed that the student-teacher ratio in military training is approaching one-to-one. We are almost down to the point where there is one instructor for every student in the military. The need for individualized instruction and the disastrous outcomes that can result from inadequate training and the difficulty the military has in developing good instructors are all apparent.

Many officers and civilians directly responsible for training acknowledge the benefits of TICCIT and other computer-based instructional systems, but appear to receive very little support from the military training bureaucracies when they propose applications of such systems.

Part of the impediment to the use of computer-based instruction in the military services are the various regulations associated with the purchase of automatic data processing equipment. Even though a system like TICCIT is used exclusively for training, its procurement is administered as if it were a general purpose computer system. These procedures have little relationship—from either a technical or administrative standpoint—with a system like TICCIT.

Attempting to follow them has been conservatively estimated to add 2 years to what would normally be an 18-month procurement cycle. Computer systems incorporated in military weapon systems and process control systems are excluded from these regulations—computers that are a part of an instructional system should also be excluded.

Broad military use of computer-based instructional systems would do more than cut the DOD's training budget. Large-scale production of computer-based instruction will result in lowered costs for these systems. In addition, broad use will encourage more private investment in this technology, increase competition, again lower cost even more, and probably improve performance.

I believe the net effect will be to bring the cost of computer-based instructional systems down to the point where they can be broadly applied in public education. The military services should be considering broad application of compu'ʼr-based instructional systems now.

It would be wonderful to me if my children, who are not disadvantaged, could have computer-based education. The way it is today it is only those minority institutions that can get Federal funds that have it.

Mr. BEILENSON. Thank you very much. I think Mr. Swanson may have a couple of questions.

Mr. SWANSON. How much does it cost to buy or rent the TICCIT system for 1 year?

Mr. VOLK. The cost of the TICCIT system—generally they start at a price of around $300,000 and go up from there. When we prorate the costs, the costs are something less than $1 per student contract hour, maybe 75 cents, or in some cases as low as 50 cents per student contract hour.

Mr. SWANSON. I would like to get back to the questions we were focusing in on with Dr. Bitzer. Hazeltine has a nonexclusive contract to market TICCIT as well as several other organizations?

Mr. VOLK. There was a very long and deliberate process that we went through with the National Science Foundation and with the Mitre Corp. to acquire rights to use the data that was developed under this program. There are no patents involved. Basically, it is just engineering data that was handed from the Mitre Corp. to Hazeltine Corp.

The agreement that was worked out included payments by Hazeltine to the NSF, royalty payments, as part of the agreement. Another part of the agreement was that there would be a certain amount of exclusivity for a short period of time to give Hazeltine an ability to just establish itself in the marketplace.

I'm sure, as you know, the first couple of years of a venture like this is just all outgoing funds and the feeling was within NSF and within Mitre that there should be encouragement to a private company to make that front-end investment.

Mr. SWANSON. Thank you very much.

Mr. BEILENSON. Thank you very much, Dr. Volk. I appreciate your coming to share your knowledge with us.

Our last witness is Dr. C. Victor Bunderson, president of the World Institute for Computer Assisted Teaching, Inc., from Orem, Utah.

[The complete prepared statement of Dr. Bunderson is as follows:]

THE TICCIT PROJECT AND ITS IMPLICATIONS FOR GOVERNMENT POLICY

C. VICTOR BUNDERSON,

PRESIDENT

WICAT, INC.

and

PROFESSOR

BRIGHAM YOUNG UNIVERSITY

OCTOBER 6, 1977

DESCRIPTION OF THE TICCIT PROJECT

Brief History of the TICCIT Project

Early in 1971, the National Science Foundation funded two organizations, the MITRE Corporation of McLean, Virginia, and the University of Texas CAI laboratory, with two separate but related contracts for investigations leading to the further development of MITRE's TICCIT computer system concept. TICCIT stands for Time-Shared, Interactive, Computer-Controlled Information Television. The concept of using mini-computers, television and cable distribution to produce a low-cost CAI system had been developed extensively by MITRE on the strength of a substantial internal commitment prior to this time.

MITRE was to design and develop hardware and software, and Texas to develop courseware in freshman mathematics and English, the entire system targeted to meet instructional needs in junior colleges. A needs survey conducted under the University of Texas contract resulted in the finding that the major needs of junior colleges lay in so-called remedial mathematics and English. Substantial additional courseware development was required, and it was proposed that additional courseware teams be established at Brigham Young University's Instructional Research and Development Department under the direction of M. David Merrill. NSF subsequently funded MITRE for follow-up work with Texas and BYU as subcontractors for courseware systems design and development, co-ordinated by the Texas Lab.

The story of the origin of TICCIT, with its unique learner-controlled courseware and the "factory" to produce it is a story of cross-fertilization between these three organizations. Unlike manufacturers of computing equipment, the not-for-profit MITRE Corporation was able to respond with highly flexible and creative systems-engineering solutions to software and hardware requirements implied by the instructional needs and goals generated by Texas and BYU. The capabilities thus developed in turn stimulated the imagination of the developers at the universities. The research of the Texas Laboratory in learner control and in instructional design and packaging for computer-based systems provided a base of expertise in courseware development for CAI. The research in instructional psychology and instructional design and development at BYU provided empirical and theoretical perspective free from the self-limiting constraints which exist in yesterday's systems (in this case the IBM 1500 at Texas) but not in tomorrow's systems.

Because of a number of advantages at BYU, the director of courseware project at Texas, C. Victor Bunderson, his associate, Gerald W. Faust, and half a dozen other key staff members elected to move to BYU in the summer of 1972. The Texas subcontract was terminated by MITRE because of the management and budget advantages of consolidation of BYU.

The TICCIT hardware, software and courseware was completed by the conclusion of the contract in June 1976. Substantial investment was required to complete this contract by MITRE, BYU and the two test community colleges -- Phoenix College of Arizona and Northern Virginia Community College of Alexandria. These organizations completed the project at their own expense when the NSF funds proved insufficient for this ambitious undertaking and were not extended.

Hundreds of students began taking the TICCIT lessons in the fall of 1975 at the two community colleges. The system has been evaluated by Educational Testing Services at these two sites. Evaluation of TICCIT at the university level was undertaken starting in 1975 by the Computer Teaching Research Center at BYU. The ETS evaluation report is now in draft.

form and will soon be released. A series of evaluation reports are also available from BYU.

TICCIT Hardware. Large CAI systems like PLATO form a network of terminals connected to a powerful central computer by means of expensive telephone lines. By contrast, TICCIT was designed to serve a sizeable number of students in one location by means of inexpensive mini-computers.

Two Nova mini-computers can service 128 terminals at one campus site.

The color display terminals are an attractive feature of TICCIT. Using Sony color T.V. displays, TICCIT can present digitally-generated characters and graphics, on a grey background, in any combination of white, black, red, yellow, green, blue or blue-green. Free-form contours as well as computer-generated graphs can thus be displayed. The color and graphics are extremely powerful for prompting and cueing of various sorts. Pre-recorded audio messages can be switched, random access, to the terminals, as can short video-tapes originating from cassette players. A standard typewriter keyboard permits upper- and lower-case alphanumeric entry. Another special keyboard at the left permits cursor pointing and cursor movement with flexible editing. A set of special learner-control keys is available at the right side of the keyboard. The keyboard and the display capabilities are a reflection of the unique instructional theory behind the system.

TICCIT Software for Authoring. The crisp digital color displays with graphics are a hallmark of TICCIT, but the best display is useless without software tools to assist in authoring good courseware.

TICCIT software utilizes the color display hardware fully. Characters can be modified "on the fly" to produce any character set or to compose any graphic, whether describable easily by an elementary function or as a digitized version of free-form artwork. A modified television camera and graphics entry system scans and digitizes the artwork, which is then stored centrally. The graphics editor permits authors to plot any elementary or parametric function and to edit these and the digitized artwork at will.

Software to aid authors has taken a variety of forms. The graphics camera and editor is only one part of the user interface designed to make the TICCIT computers easy for authors to use. The authoring system is more than an "authoring language" such as found or other CAI systems. Such languages are written to control the basic hardware and logical capabilities of a given CAI system. They do not include in their semantics the fundamental concepts of systematic instructional development, a growing body of knowledge used to develop the TICCIT courseware. An authoring system is an integrated set of computer programs, formatted manuscripts, and management procedures designed to facilitate the various steps in the instructional development process.

MITRE developed the operating systems, compilers, and related software for use by authors and students. Brigham Young University developed software to permit data entry and editing, graphics entry and editing, report generation for teachers and authors, and other user utility programs. Manuscript formats were developed for use by authors in producing maps, tests, objectives, rules, examples, practice problems, and helps and the same formats were embodied in the authoring software. Similar manuscript formats and on line embodiments for coders were developed to provide for display specifications, file creation, and answer analysis coding.

The TICCIT Courseware and Instructional Theory

The term "courseware" refers to educational materials, whether in the computer or associated with it (eg. handbooks). It should be distinguished from "software," which refers to computer programs to support authors, teachers, and students regardless of what courseware is being used.

The instructional model of learner control is a major contribution of the TICCIT project. The structured student language gives students control over the content of instruction by means of "maps" which allow the student to choose with few restraints any units and lessons to survey, then study. Students also control instructional strategy, by means of learner-control commands like "RULE," "EXAMPLE," "PRACTICE," and "HELP." Students receive help on strategy through an advisor program which gives them information designed to improve their learning strategies.

The learner control keys are tied to a theory of instruction which says that certain instructional components (like "RULES," "EXAMPLES," "PRACTICE PROBLEMS," "HELP's" and "MAPS") designed in a certain way, will promote learning. The evaluation of this instructional approach, both on TICCIT and on other media where it has been implemented, has been quite positive. The approach enables learners engaged in self-study to learn rapidly and well.

This is fortunate, since the model also leads to a systematic, efficient process for authoring materials that is highly cost effective compared to other methods of authoring. The authoring system first implemented on TICCIT is a major scientific and technological accomplishment.

This authoring system resulted in the production of a large body of courseware at Brigham Young University. Starting with a review of arithmetic, the mathematics materials extended from a review of fractions through elementary and intermediate algebra and elementary functions (except trigonometry). The English meterials provide two catalog courses, a remedial grammar and mechanics course, and a freshman composition course, in which the teacher's role is vital in generating ideas and grading writing assignments, but not in teaching structure or editing skills.

This authoring model is now being used successfully by a number of companies who employ former TICCIT project staff members and at a number of colleges and training centers who employ TICCIT or BYU graduates. Several thousand segments of instruction using this approach have been developed beyond the 300 - 400 segments originally developed for the TICCIT community college projects. Most of these thousands of segments are on media other than TICCIT, which shows the generality of the instructional model.

Results of the ETS and BYU Evaluation of TICCIT

The ETS evaluation reports on TICCIT and PLATO will soon be published. ETS has shared the preliminary versions with BYU, MITRE, and others. From these preliminary versions, several conclusions stand out:

1. When used as an adjunct to the classroom, neither TICCIT nor PLATO produces reliably significant differences over classes which do not use them.

2. When used as an integral scheduled part of either mathematics or English classes, TICCIT students do significantly better than non-TICCIT students.

3. The teacher variable is of great significance in determining the performance and the attitudes of students, both in TICCIT and non-TICCIT classes.

4. There is a difference of about 20 percent in completion rate in favor of non-individualized classes over individualized classes (TICCIT classes in this case). This reduces the cost-effectiveness of TICCIT well

below that of the classroom for standard effectiveness criteria such as those used by ETS.

5. The success rate of students who take TICCIT math more than once seems to indicate that the courseware does not provide sufficient remedial depth to teach some of these students. This may account in part for the completion rate problem.

It appears that the ETS evaluation has been competently done and that it "tells it like it is" insofar as what happened in the community colleges during the period of evaluation.

How does this correspond to the evaluation at BYU, with a different student population and some different ways of staffing and organizing TICCIT courses?

Effectiveness Data

Experience at BYU confirms observations 1 and 3 above. As an adjunct to the classroom, rather than as a total reorganization of the classroom, TICCIT does no better than the average class. The attitude of the teacher toward TICCIT and the ways he or she permits students to use TICCIT overwhelm other variables. As for observation 2, TICCIT was not significantly better in math classes we taught. However, at BYU the tests were not carefully developed as were the ETS tests, to be fair to both the classroom and TICCIT. They were developed with no reference to TICCIT whatsoever. TICCIT students do not differ significantly from classroom students on such department developed objective tests. This is true in both Math and English. For essay tests in English and for overall pass/fail ratio on the CE English Composition exam, TICCIT students do significantly better. This favorable edge seems to be increasing as we gain more experience with

TICCIT English. TICCIT math is no longer is use at BYU. The content was poorly matched to the existing BYU math courses.

Data on the English Course has been quite favorable. It indicates that 64.6% of TICCIT students pass the GE writing competence exam compared to 55.5% of classroom students having the same teacher. This is due primarily to better scores on the essay test, where 78% of TICCIT students got a score of 1 or 2 (5 point scale) while only 67% of non-TICCIT students with the same teacher got 1 or 2. These data are based on 137 non-TICCIT students and 160 TICCIT students over three semesters. The same set of teachers taught with TICCIT and non-TICCIT students.

Human Environments and Completion Rates

Our greatest divergence with the ETS results is in observation 4, completion rate. At BYU we immediately adopted a model which involved some classroom interaction. Initially in math this consisted of one classroom session per week out of a 3-hour class. This class meeting gave the teacher an opportunity to help the students pace themselves. (Quizzes were used for pacing.) It also provided an opportunity to teach strategies and answer questions. The first semester the TICCIT classes taught by TICCIT author, Dr. Boessenroth, had a higher completion rate than the classroom. The next semester two BYU math professors reluctantly agreed to teach with TICCIT. One had a higher completion rate (72%) and one a lower rate (33%) than the classroom (about 65%).

In English we now have two models, a class model and a small group model. The class model meets two times per week in class and one time plus extra time on TICCIT. The small group model meets one time per week in class and the other two sessions on TICCIT or in a small group with the teacher. We have established quite reliably an 88% completion rate in the class model and, (for two experimental classes only so far), a 96% completion rate for the small group model. We expect this figure to stay above 90% when all variables are properly handled. These are:

- An "opening social" to learn names of classmates, teacher, and proctors, and how to use TICCIT
- Self-selection of 6-8 small group memberships (not ability grouping)
- Scheduling at open, adjacent carrels by group. (A table of facing terminals, open, for visual contact)
- Meeting in class once/week for assignments and pacing
- Meeting with the teacher 1/2 period per week for small group discussions
- Friendly and helpful proctors with some content knowledge

The small group and class models are both successful products of our "human environments" research. The conventional classroom completion rate at BYU is at most 82% in English. It is actually less than 82%, for this figure is measured from the 3rd week to finals. A goodly number of students drop out by the 3rd week.

If these high completion rates achieved at BYU could be obtained at the community colleges by introducing the human environments variables, perhaps the TICCIT classes would meet or exceed the cost-effectiveness of regular classes.

Completion Rate and Effectiveness Scores

Our results at BYU do not correspond to observation 5 either. There is a strong regression of final math scores on the number of TICCIT lessons passed, (see Figure 2 of Appendix 2) and contrary to our earlier data for English (Figure 1 of Appendix 2), a similar regression in English has shown up in the most recent data. This means that if we can keep our BYU students working, most of them will learn from the TICCIT lessons. This does not mean that the ETS result is not valid for community college students, nor that the TICCIT lessons cannot or should not be improved so that more lower ability students will succeed. Quite the contrary.

Formative Evaluations and Needed Revisions

The ETS results that lead to observation 5 are probably partially correct. Even with a good human environments model there will probably be a substantial number of community college students who could not learn all they need from the existing TICCIT lessons. This is not an indictment of the concepts behind TICCIT, or CAI in general. Math is a cumulative subject and some students' deficiencies reach too far back for our lowest level lessons and helps to reach. In addition, it is common knowledge that the TICCIT lessons were barely debugged, and never revised based on formative evaluation data. Our formative evaluation data indicates that about 60% of the math lessons fail to meet our criteria with BYU students. How much worse it must be for the community college students. The faulty lesson figure is much lower for the English lessons, probably less than 20%. The math course was the sacrificial lamb of the TICCIT project, pushed through without an opportunity to see it working on an operating TICCIT system. We were able to delay the English project long enough to learn more about good lessons on TICCIT, and to maintain a higher level of quality control.

A study by Reigeluth and Schneider indicates that the Math lessons which fail on Schneider's lesson quality reports are most often deficient in the lesson tests. Authors did not use the test logic well in many cases, and made the tests too hard. We have some ideas for improving the logic, such as providing more orientation to students and more feedback.

We have many indications from the extensive data and observations we have collected in the past four years that it is not just the courseware, but the hardware and software, that could be profitably revised. Improvements in the primary instruction logic (learner control commands), MAP logic, test logic, and advisor logic have now been partially specified. We are seeking the opportunity to implement and test these improvements.

The Politics of CAI

The effort to bring TICCIT into service at the colleges and at BYU has been as instructive in revealing the political aspects of CAI introduction as in producing scientific data on authoring, learning, and human environments. There is nothing in this data, from the colleges or from BYU, which could not be rectified by design improvements in the courseware, human environments, hardware, or software. That is, the data can be interpreted to suggest that significantly better results for TICCIT classes on all variables can be achieved through another cycle of revision. The TICCIT experience is teaching us where these improvements are needed, and will continue to be enormously fruitful in pointing us toward the needed design improvements.

Redesign of TICCIT courseware, hardware, and software alone is not enough, however, for the roles and habits of the people who use it must change as well. The politics and incentive systems within colleges and universities do not readily adjust to these new roles and habits. Indeed, the departments not only control staffing patterns, resources, and rewards for those who may choose to try TICCIT, but can determine whether anyone will be permitted to try it at all. It appears to take about two years for a faculty member first to become involved through normal processes and then to learn enough to use TICCIT successfully.

Teachers are caught in an incentive system which does not reward involvement with CAI (see Ernest House's book "Politics of Educational Innovation"). But the administrators are caught between the teachers' attitudes on one side, and on the other between a financial squeeze coming from their governing boards. CAI centers at Penn State, and Stoney Brook have died recently because of this squeeze.

THE FUTURE OF TICCIT

Five Groups Who Carry on Aspects of the TICCIT Project

The five groups consist of two profit making corporations, two non-profit corporations and a group of users of the TICCIT system in higher education in the military.

Profit-Making Corporations. In 1972, a profit-making corporation, Courseware, Inc. was established in Orem, Utah. It was oriented toward the use of the instructional theory first implemented on the TICCIT system, and geared toward the production of quality courseware. Courseware, Inc., now in San Diego, California, established a thriving contract business, primarily with the Department of Defense. The business deals with organizing authoring teams to produce high quality courseware using the instructional model first implimented in TICCIT. Courseware, Inc. has developed training programs for TICCIT authors.

The second profit making group was established in 1976 when the Hazletine Corporation responded to the request for proposals from the MITRE Corporation (prime contractor on TICCIT) with a proposal to take over the hardware and software assets of the TICCIT project. Hazletine negotiated a two-year period of exclusiveity with NSF. Hazletine is attempting to market the TICCIT system to users in the Department of Defense and the civilian sector. Due to Hazletine's efforts, the software and hardware systems are now much more reliable and use more up-to-date equipment.

It is expected that if Hazletine is successful in marketing TICCIT, the hardware and software will continue to evolve and improve. Hopefully, in the future Hazletine will be able to utilize some of the newer technologies (e.g. microcomputers and videodisc players attached to TICCIT - like color displays). These will make the instructional model and authoring advantage of TICCIT more widely available.

Non-Profit Corporations. The Mitre Corporation was prime contractor on the TICCIT project and also on a number of ancilliary projects which attempted to take the TICCIT concepts of computer controlled television and extend them into the community over 2-way cable. Mitre conducted projects in home centered two-way television in Reston, Virginia; Stockton, California; and Amherst, New York. Mitre retains the knowledge and talent to conduct such projects now.

A new non-profit corporation, WICAT, Inc., an Institute for Computer-Assisted Teaching, was established in 1976 by Dustin H. Heuston of New York City and C. Victor Bunderson, then Director of the Computer Teaching Research Center at BYU. Dr. Joseph Lipson, former Academic Vice President of the University of Mid-America, and Dr. James Schuyler, the computer scientist who designed and developed MULTITUTOR and other powerful authoring packages, have joined WICAT.

WICAT was established on a non-profit basis in order to attract capital from private donors, Foundations, and industrial groups, as well as governments. It was seen as the only way to establish a funding base which could survive the 1 - 3 year boom and bust cycles of funding characteristic of private industry and government funding. WICAT was also established in order to provide independence from the accountability structures which exists in universities and schools, oriented toward teacher-centered learning and the maintanence of the status quo. WICAT is not committed to the existing TICCIT system, but rather sees now as the time to take the next step and implement the best aspects of TICCIT on newer technologies. The learner control aspects of TICCIT, the color television display of TICCIT, and the convenient authoring aspects of TICCIT are all developments which should be incorporated on newer technologies, including microcomputers and videodiscs.

WICAT is emphasizing courseware designed for non-traditional educational audiences who are more likely to be able to accept and use student centered learning systems.

The TICCIT Users. The first five users of TICCIT systems are 1) Brigham Young University, 2) Phoenix Community College, 3) Northern Virginia Community College, 4) Two air-crew training programs for the Navy's Viking S3A aircraft at San Diego, California and Cecil Field, Florida, and 5) the Model Secondary School for the Deaf, District of Columbia. These users do not have a users' group or any formal organization; however, they are all serviced by Hazeltine, who provides them with updates to the software and hardware. The three colleges and the Model Secondary School use versions of the TICCIT courseware first developed at Brigham Young University.

It is safe to say that none of the users are using TICCIT as it was originally intended. It is gravitating toward research and development at Brigham Young University, and as a goal for the development of new courseware which might be adapted to newer and cheaper forms of technology, such as the videodisc. At other sites, it is being implimented more and more in teacher centered, rather than student centered ways, contrary to its original design.

The Issue of Teacher Versus Student Centered Learning. For purposes of this discussion we will define a teacher-centered system as an educational system in which the teacher (and the administrative structure) controls the schedule, the method and pacing of student evaluation, and the pace and content of information presentation. A negative aspect of a teacher-centered system is a distortion of the cherished concept of academic freedom. The concept originally meant granting to teachers and scholars freedom of inquiry and the freedom to present honestly their own view of the curriculum. It meant freedom from outside prescription of curriculum content. The distortion is that academic freedom is often interpreted as meaning that the teacher is not accountable for what goes on in the classroom. Thus, incompetent teaching and unfair evaluation practices sometimes develop and are sometimes shielded behind the banner of academic freedom.

A student-centered system, on the other hand, is one where the student exercises greater control over the choice of content objectives, schedule and pace, and method of presentation. The student participates in self-evaluation and the standards for evaluation are publicly available to both the teacher and the students before the course begins.

The teacher's role in student-centered systems changes from one of playing a central role in a classroom to one of being a resource to the students. The teacher's human skills of motivation and encouragement are called upon to a greater extent because students have the freedom to falter and delay as well as succeed. The teacher's skills in small group and one-to-one interaction with students are called upon to a greater extent. The teacher's role as a model of a professional person representative of a discipline is extremely important in both the student-centered and teacher-centered systems.

There are some subjects for which technology and para-professional teachers would be adequate to enable most students to achieve the objectives. In other subjects the modeling, tutoring and counseling functions of the teacher are essential for most students.

One of the implications of a student-centered system is that it can lead toward increased productivity, that is, it can lead to greater student learning per unit of cost. The productivity of student-centered system occurs in part because evaluation of students is publicly available. Thus, alternate procedures for achieving the objectives can be compared. By contrast, a teacher-centered system does not lead to greater productivity; indeed, quite the reverse occurs, since the goal is to reduce the teacher-student ratio.

The experience of the TICCIT Project should be contrasted with PLATO and CCC. Both PLATO and CCC accepted the teacher-centered system as a given and have attempted to fit within it. Both have found that it is possible to develop courseware and to install systems which can assist teachers in the present system. At least in the elementary school, students show achievement gains. TICCIT, on the other hand, attempted to introduce a student-centered learning environment featuring strong learner control of instruction. The result was that for those students who finished, learning improved significantly. However, a significant percentage of students did not finish who otherwise would have finished in the classroom.

It is probable that TICCIT will gravitate more and more toward a teacher-centered system among the user groups who still work with it.

Summary. The future of TICCIT is uncertain. The evolution of the hardware and software system in its present form depends upon the success of the Hazeltine Corporation in marketing TICCIT, primarily to military training centers. The survival of the instructional model and the authoring approach seems assured by the large number of projects which Courseware, Inc. is now engaged in with the Department of Defense and some industry and academic users. A more recent branch in the evolution of the TICCIT instructional theory and authoring approach, that of WICAT, Inc., is aimed at translating these powerful methods onto new technologies such as videodisc and microcomputers. Thus, the contribution of TICCIT to the science of learning and instruction and to the processes of authoring seems assured.

The success of TICCIT as a student-centered learning system (or, as it was called initially, a "Mainline CAI system") seems greatly in doubt. It appears that existing educational institutions will not easily be able to adapt to a student-centered, productivity-oriented model. They will either reject TICCIT entirely or modify it to conform in the adjunctive teacher-centered approach which has met with greater acceptance in the CCC and PLATO projects. Student-centered learning in non-traditional settings seems more promising.

IMPLICATIONS FOR GOVERNMENT POLICY

Keyboard and Display Standards for the New Technologies. The current issue of "Scientific American" on microelectronics assesses the technological revolution in electronics. This issue not only describes the microelectronics explosion which is entering into all phases of our national life, but the issue is filled with advertisements for personal computers costing as little as $299.00. A large percentage of the courseware originally implemented on TICCIT and CCC computers (and to a lesser extent on PLATO) can now be implemented on very low cost devices. If the manufacturers of these low cost devices are not educated in what has been learned for the past 15 to 20 years of pioneering in computer-assisted instruction they will establish standards which may be inferior. Standards are now being set by random processes, and will result in widespread use of standards detrimental to good education and training. An example is the inconvenient and poorly engineered typewriter keyboard that now is a permanent fixture throughout out society. Another example is the inferior NTSC 525 line television standard which cannot now be changed. The opportunity is slipping by for the government to influence the development personal computer technology in socially beneficial ways.

Continuity of Funding. One of the major reasons the government does not now have strong programs which will influence the new technology is the 1 to 3 year funding cycle characteristic of government funding. The TICCIT and PLATO projects were funded for periods of five years. This time period proved inadequate to solve the human environment problems, and even some of the technological problems associated with implementing CAI on a large scale. Funding was discontinued by the National Science Foundation for both TICCIT and PLATO at the crucial moment when both attempting to turn the corner into full implementation. The result in the TICCIT project was that the courseware could not be revised, an essential step in the production of all quality courseware. There is good evidence that a sizeable percentage of the lessons need extensive revision. There is also good evidence now that the development of faculty support and skilled use of the system occurs over a period of years rather than a period of months.

The NSF program which sponsored PLATO and TICCIT was transferred to the Education Directorate within NSF, where it was not viewed with favor. At the same time, outside criticism of TICCIT and PLATO was influential in cutting off further support for these projects at a crucial time. Thus, the teams which had been assembled over a period of five years, at least for TICCIT, were disbanded and disseminated to a variety of different organizations.

It is necessary to keep the teams together for periods between 10 and 20 years to work on the problems of introducing technological change into society. This is an interdisciplinary problem involving cooperation between computer scientists, engineers, instructional scientists, and those dealing with the sociology of change in organizations. The latter problem, sociology of change in organizations, is particularly time consuming and requires long years of careful work. The government, however, has been unwilling to provide funding for the period of time necessary to keep teams together working on these problems.

One approach is for the government to establish 3 to 6 centers with adequate funding for 6 to 10 years. The social potential certainly justifies it.

Support for Non-traditional Programs. Because of the importance of the sociology of change problems, it seems that an important strategy for the government is to support the development of non-traditional programs. These programs can focus on the drop-out, the delinquent, the unemployed, and on other people who are rejects from the present educational systems. These programs can also emphasize innovative instruction directly in the home. Non-traditional programs can bypass the organizational structures of teacher-centered education institutions. It is possible that through the establishment of non-traditional programs which are not placed under the jurisdiction of the traditional academics, alternatives can emerge in our society which later can be adopted by academic institutions in order to better compete. An example of a reputed non-traditional program not freed from traditional structures is the University of Mid-America. The present organization of UMA places it under the jurisdiction of eight college presidents. It is unlikely that a non-traditional program can thrive when its growth competes with tha traditional programs. It is unlikely that General Motors would ever have introduced the sub-compact. It is unlikely that IBM would ever have introduced the mini-computer. Alternatives must be introduced through independent organizations not accountable to the traditional teacher centered structures.

Removal of Beuracratic Bottlenecks. The Department of Defense training effort is a multi-billion dollar per year effort. It provides a leading edge for innovation in training in our society. Historically, the Department of Defense has already pioneered many of the applications of instructional technology. For example, recently General DePeu issued an order that the Army schools would introduce self-paced instruction and study the cost effectiveness of this instruction. This effectively introducad a student-centered productivity-oriented environment. I had the good fortune to visit Fort Sill recently as a consultant and see the results of the self-paced courses that have been developed and implemented there. General DePeu's order has been followed faithfully and with very promising results. Preliminary cost effectiveness data shows a projected savings over 5 years of 1990 man years of personnel time (the students are paid). This translates into a savings of over $17 million dollars.

Unfortunately, Fort Sill is in danger of foundering on the problem of work. It is too much work to keep all of the records and keep track of all of the diversity which occurs when students are released to move at their own pace. A course which once took 8 weeks now takes 3 to 12 weeks depending upon the speed of the student. How can the students' graduation date be predicted soon enough so that orders can be cut, paper work filed, airplanes arranged for to transport him to his next duty assignment, etc.? This is only one of the problems which confront an organization which tries to introduce self-paced instruction. The information management problem is too great and the paper work is too voluminous. As a result, Fort Sill has a great requirement for computer support to the management of this paperwork, scheduling, and student testing and perscription process. They have found a training device developed by the Navy, called Versatile Training System (VTS). It uses a PdP 11/70 computer. However, there are those within the Army who would classify it as an automatic data processing system. As such, it falls under a voluminous regulation called 18-1, which requires approximately 2 years of preparation and paper work before a system can be ordered. With the rapidly changing technology in computers, a two-year wait period assures that Fort Sill's instruction program will founder because of the work problem. It also assures that any computer that they order now will be obsolete by the time it is delivered in two and a half years, because of the pace of change of computer technology.

Regulation 18-1 was instigated to prevent the proliferation of computer systems in offices, etc. at the tax payers expense using year-end money. It was not intended that this regulation should stifle the Department of Defense's efforts to improve the cost effectiveness of training. Yet, this is the result.

The revolution in micro-electronics will continue for many years and governmental agencies like the Department of Defense (which can be so influential in developing new technologies for all sectors of our society) should be free to introduce well-justified applications in a short period of time. They should be encouraged to test them over a few years, amortize their costs, then move on to the newer equipment which will be available then.

STATEMENT OF DR. C. VICTOR BUNDERSON, PRESIDENT, WORLD INSTITUTE FOR COMPUTER ASSISTED TEACHING

Mr. BUNDERSON. I think it is very important that hearings like this are being held. I am grateful that this hearing is being held and that I will have an opportunity to testify here.

I will speak as an instructional scientist, one who is interested in the algorithms—or the knowledge and models—that come out of these projects like TICCIT and PLATO. This knowledge is more important than the specific hardware configurations themselves. I am interested in hardware algorithms, the software algorithms, the courseware, and the human environments algorithms. In other words, in how we can design hardware that has the capabilities you have seen demonstrated today on PLATO and illustrated on TICCIT. We need to understand how we can design software that lets authors produce materials faster; how we can design the presentation strategies to teach effectively the kinds of lessons you have seen illustrated on PLATO and perhaps have read about on TICCIT. We need to understand how to structure these lessons together in large and complex systems and how we can organize the teachers, and other people. This human organization issue has turned out to be the No. 1 problem of the TICCIT project; namely, what human environments will permit or will not permit the system to operate successfully?

I think we are sitting at a time in history where it is possible to change the history of education. Five hundred years ago an invention broke the back of the oral tradition for passing on the content of knowledge. That invention was the book. Over the centuries the book has produced a quantum leap in what can happen with education. Here we sit in 1977 and we have low-cost microprocessors, video disks, and other new technologies which can break the back of another part of the oral tradition. That is the necessity to transfer the interactions of instruction on from mouth to mouth, from teacher to student, and student to student.

The staff member sitting in Mr. Gallagher's seat asked the question: "Can't the teachers learn these new procedures that are working on the computer at the school that was so successful?" The answer is "Yes"; but, they cannot perform all of the work that is necessary to do it. We can now replicate these successful interactions because the computer is a two-way interactive device which can replicate that aspect of the oral tradition.

So I believe that computers in education offers a breakthrough of the same order of magnitude as the breakthrough provided by the book. It allows us to replicate not only the content but also the interaction aspects of instruction. That makes it fundamentally different from TV or other kinds of media which do not permit practice with feedback and other kinds of interactions.

CAI is not just another new medium. Here we sit in 1977 noticing that everything else we have tried in society has not worked too well. We have poured millions of dollars into education since the Great Society and even earlier and we have found that since 1968 our scholastic aptitude test scores nationally have been going down every year. We have found that 42 percent of our black 17-year-olds cannot read and 12 percent of them are out of work. And we find that other methods, as testified to earlier, aren't working with title I funds. CAI gives us something that is replicable and has a known cost; a cost which will continue to decrease. CAI is working with both disadvantaged and other students.

Thus it is possible now for Congress to change the history of education. However, let me speak from our experience with the TICCIT project, and observations of other projects, about what seems necessary to bring about this change.

If you could put the lights down, I will show you a few slides, and I will talk about three categories: Hardware, software, and courseware.

What I have to say about hardware and software is basically that some of the brilliant engineers and computer people on TICCIT, PLATO, and other projects have done enough fundamental work that we now know how to produce effective interactions on these kinds of devices. It is now time to take them to the next step where they become so inexpensive that they can be widely disseminated. To do that we need to use microprocessors and video disks and we need to stay close to the consumer market. The problem with TICCIT and PLATO is that they are both rather expensive and they are both rather special purpose.

Yet I hope that the algorithms that have been discovered on these two systems can be made more widespread and can get into the consumer market through some of the game programs and learning systems that are coming into the home. There are very inexpensive systems that can actually do many of the things we have seen demonstrated today.

TICCIT has a terminal based on a color television receiver, such as is found in most homes. It also has a special keyboard.

This illustrates the kind of color graphics that can be displayed on the screen.

Here are some graphics from an English course. These graphics are quite high resolution and quite high quality for a television set.

Notice that color can be used to highlight the key words in this lesson from the TICCIT English course.

Here the student can be looking at a video tape, hearing the audio track from that tape over earphones, or he can be listening to audio while working in his spelling lesson.

Here is a special keyboard that the students use. This is perhaps one of the most important contributions of TICCIT—A learning language. The learner controls the language which allows students to set their own strategy and it frees them from a fixed linear strategy. The student can choose whether to look at rules, examples, or to practice from this learner keyboard.

In so doing the student gains some of that locus of control back for himself, because he is the one who is in charge. He is the one who has been selecting how many practice items and how many times to push the "help" button, how many times to look up at the map or look at the adviser.

Let us continue with other key elements here that orient him as to where he is in the structure. The student can move up to a higher level or down to a lower level by using this learner keyboard. We have found that the students increase in their skill in learning and become better learners through use of this language.

Mr. GALLAGHER. Mr. Chairman?

Mr. BEILENSON. Yes.

Mr. GALLAGHER. Your "bard" and "easy" I assume is degree of difficulty.

Mr. BUNDERSON. When the student has pressed the rule, he has an option of seeing an easier version—which was written by some fellow students—or a harder version which is "like the teacher says it." When he requests his example or practice, the "hard" button will take him to a harder problem whereas the "easy" button will take him to an easier problem.

Mr. GALLAGHER. I just had the thought that in a classroom situation among his peers the student is not about to ask the teacher to back off because they want something easier. I am trying to get at the handle mentioned earlier. It is almost a dispositional change on the part of the student, a change in his personality or disposition.

Mr. BUNDERSON. We have something similar to the Los Nietos effect on disposition but unverified. We collected the data, but it's very hard to nail things down. We had some junior high school juvenile delinquents come in to BYU and use TICCIT. And we found that they were tremendously motivated by it, which is quite remarkable because they are totally turned off by school. They were so motivated that their attendance changed from 15 percent to over 80 percent. Ono student who was a runaway hid his gun outside and came into the school in order not to miss his TICCIT appointment.

And their grades started going up in the junior high that they were leaving to come to these TICCIT lessons because the counselor used the computer as a motivational tool to get these students to change their attendance habits and work habits at school. [It is not just the computer, but the way skilled people use it.]

We hypothesize that there are a few very important reasons for this effect. One is that the computer is totally nonjudgmental. These students are always "put down." We saw the library personnel put them down. Other BYU students were making just as much noise but these students were marked and labeled and so they were put down by the library personnel. Apparently all of the people around them always expect them to fail and always expect them to be bad.

But the computer never puts them down. Similarly, they are used to being able to "beat the man" by getting at him emotionally and they can never get at the computer emotionally, so they respect it.

And finally, the point that was brought out earlier: They are able to make progress. The computer gives them a task they can succeed at, even if it's just starting them out by playing games. And it is a tremendously motivating task for them. So I think it's very fundamental that these systems be used for people who are disadvantaged and people who are "welfare trapped."

Let me move on here. I think this effect on the disadvantaged is one of the major accomplishments that should be transferred on. It should be experimented with on TICCIT but it should also be transferred to some newer technologies.

Let me show you what I mean. Pulled out from the panel there is the TICCIT terminal processor which is a minicomputer, 32K memory.

Now here is the kind of chip that that computer can be placed on in a few years. Right now computers of only slightly less power can be placed on one chip and the memory on another.

By early 1980's the memory and the computer will be on one chip like this.

Here are the disc drives, each of them costing around $12,000 and storing about 150 million characters of information that make up the TICCIT data base: English and math courses, and graphics and audio, and software programs are stored on these discs.

Here is a new device, the video disc, which can be played on a player attached to a TV set.

This one video disc record that you see has a capacity, when recorded in digital form, of 10 billion bits of digital information storage. This is 400 times as great as each of those 6 discs that I showed you that each cost $12,000.

Mr. GALLAGHER. Did you say 10 billion?

Mr. BUNDERSON. Yes; I said 10 billion bits on one of those video discs. And digital storage is now being worked on—the one I am showing now is an analog storage device which holds approximately—it is not clear that you can read that into a computer yet—you can storage the images, however, on this. And you can store 54,000 single frames. Very easy to work with.

And this will illustrate a freeze-frame. When you have a movie on one of these, as this child is demonstrating, there can be 30 minutes of motion. However, this motion can be broken up into 54,000 still frames. These go by at 30 per second in order to get the illusion of motion. We are now working with the McGraw-Hill Corp. on an interactive video disc and we have found that we can take out 10 seconds of motion and add 300 pages of information, so that effectively we can marry the technology of the book (pages), with the technology of the movie (motion). And as we move toward using this with digital code, the entire TICCIT English course could be stored on one of these as still frames or 66 sets of courses as large as both TICCIT English and math could be stored on one disc, digitally, in the future.

Now this is the kind of breakthrough that I think is very fundamental. It is like the book, because it will be so low cost that it can be placed in every home. In fact, since the home TV game market is so agressive, what I fear is that things will be placed in the homes with keyboards and learning models that are very, very inferior and don't take advantage of what's been learned in the TICCIT project, the PLATO project and CCC projects and others. This would be unfortunate. It would be like what happened with the typewriter, when we were stuck with a keyboard that is very inferior from a human engineering point of view; or like what happened with our television standards, which are inferior to those of Europe.

And if there is some way Congress can help exploit what has been learned and get it into industry so that the mass-produced consumer items will have some of this knowledge in them—this is something I believe you have an opportunity to influence.

Now the courseware was the third item I wanted to discuss.

Here is the index number on a still frame. This shows that using the consumer model video disc, a person can get to any of 54,000 still frames by searching to an index number. A microcomputer could do the searching automatically.

Here I have an illustration of what it would look like. You would have a keyboard with your computer in it, having memory and character generator. You would have a video disc player and a television set. This would go into the homes in the not too distant future and would be extremely cost effective. Perhaps there could be a plasma panel too. I wouldn't rule that out because the PLATO project has a great many points to offer. However, that would not give it the color that has proved to be so effective on the TICCIT project.

Mr. GALLAGHER. This is not what the previous witness was speaking about when he talked about wiring a city and linking homes with industry?

Mr. BUNDERSON. I don't think either of the previous witnesses would rule something like this out.

Mr. GALLAGHER. This is self controlled. Did he mean that?

Mr. BUNDERSON. I don't think either of the previous witnesses would rule out the video discplayer. I know John Volk wouldn't and I know Dr. Bitzer is working on video discs which would store information for audio and slides for PLATO. However, I don't think that Dr. Bitzer has emphasized the local control that is inherent in this.

Now this system could operate locally, but it could also dial up a large computer such as PLATO and bring lessons into the local memory, probably with bubble memory, which has more capacity. And then it could access the video discplay for color slides and audio.

Mr. GALLAGHER. Thank you, Mr. Chairman.

Mr. BUNDERSON. The nonprofit institute that I represent has taken the position that this is the most likely technology for moving into the homes and we are placing our bets on the development of this, although we are not ruling out the possibility that that display may be a plasma display, something like we have seen demonstrated today.

Now these learning keys I think are an example of some of the knowledge that has been gained that is not finding its way into some of the home consumer products that are flooding our markets today.

The rule and example and practice keys have now been cross validated as a way of developing instruction that works. The data from the TICCIT project is promising. The students in the community colleges who finished the TICCIT lessons did significantly better than students in control classrooms, in a large number of comparisons.

This was true in both math and English. Surprisingly, at BYU in English we found that the students who took TICCIT classes did better on their essay examinations. They did not do better on their grammar and mechanics examinations, which was the prediction of many people.

Actually, it appears that when we mix teachers and TICCIT in the proper way, the students benefit significantly. The problem that the evaluation revealed was that large percentages of students did not finish. When you are placed in an individualized self-paced learner-controlled environment, students did not have the habits and traditions to keep working on their own schedule, whereas, the classroom schedule paces them to completion, with an A or an F, et cetera. They are externally controlled, that is true, but they have the habit of getting through. So about 20 percent fewer students finished out of 100 percent in the community colleges. At BYU we felt that this problem was due to something called a lack of human environment, that is, that the teachers and the students were not organized properly.

So we created a few human environment models where we had people working in small groups or in a classroom once a week. There was some social pressure to get through. There were friendly proctors who knew each student's name and there was an open social atmosphere where people got to know one another and so felt that they were part of the community. We got over 90-percent completion rates in the small group model compared to 53 percent on TICCIT English in the community colleges.

Actually, this is better than what was happening in the regular classrooms at BYU—about 75 percent—so we feel that through the organization of proper human environments the teacher must become a motivator. The computer will just sit there unless the students have some motivation to go up and use it. They won't capture the enthusiasm and excitement unless there is something in the community that encourages them to do so.

We got a 90-percent result in an English course compared to 53 in the community colleges. We think that is quite significant. There may be other factors: It may be that the BYU students were more able and the courseware worked better for them, but I think a major portion of it is the need to organize excellent human environments. And this would be important in the home, as Mr. Gallagher brought out. We must learn how to do this in the home if home learning is to become popular.

Now what are some recommendations from all this? One has to do with the fact that schools are teacher-centered environments and it is difficult for them to change because they are locked in that way by tradition and by the expectations of the whole society. I think the Government should sponsor nontraditional learning such as learning centers and alternate schools and learning in the home because this is the only way to set up what we would call a student-centered environment. In such systems, the student controls the pace and the content and has something to say about how the evaluation is handled.

I think one reason Dr. Bitzer's community college data was as it was—no significant differences—is that it was a totally teacher-centered environment and the teachers did not exercise the variables that allowed the student to utilize the computer properly. I am sure there are other factors, but we tried this too with TICCIT. And when we used TICCIT in a teacher-centered—or what we call an adjuctive model—the students don't do any better than they do in the classroom. So, that's a dilemma.

We can't penetrate TICCIT into the schools very well because it requires teachers to change their roles to a student-centered model. However, if you revert to a teacher-centered model, you don't get the kind of significant differences in favor of the computer plus the teacher that you get in a student-centered model. So that's why I'm recommending that rather than try to change the schools—which I think is next to impossible—most innovations die in that environment after the innovators leave—one should try effectively to allow this technology to seep into nontraditional forms, into homes, into offices, and into the dealerships of the automobile companies, and other industries with training problems and especially into the Department of Defense, which has always been a leading edge in our society for innovation in training.

Now one thing you could do there would be to remove some restrictions which Mr. Volk mentioned. There is a regulation 18–1 that classifies a computer training device like TICCIT as an automatic data processing (ADP) system. It takes 2 or 3 years to negotiate a new ADP system in DOD. Right now Fort Sill has introduced training of an individualized student-centered nature and they project over the next 5 years savings to the training command of $17 million by savings in student salaries while they're being trained. The students will be out working instead of being trained, to the tune of $17 million. However, they are overwhelmed by paperwork. It's this work problem that the computers are helping teachers to perform. Not that the teachers couldn't do these things, it's just that it would take one teacher per student, a teacher who is infinitely patient. The computer can do work at the speed of light and so it will allow Fort Sill to keep this self-paced program going—if only 18–1 could be gotten by so that they can get the computer that they selected to help them keep track of the progress of the students in the self-paced environment.

So I think we should stay close to nontraditional and the consumer markets. We should break some of the bureaucratic bottlenecks in the Department of Defense and other parts of the Government that could use CAI in their own training programs and save money. We should set up R. & D. programs that are given a longer period of time. To establish these human environments had to be done out of our carcasses after the NSF funding ran out. And the politics within NSF were such that we were not able to get additional funding and we desperately needed it to take the next step. We lost our teams, our programers, and engineers, and we were barely able to do these studies of human environments with small research loans provided by Brigham Young University.

The political strain was so great that I felt it best to step out, feeling that it is not easy to do this kind of research within the university teacher-centered environment. These projects require longer periods of time than the 1- to 3-year cycles that are now possible within NSF and the other organizations. It is a problem that is an 8- to 10-year problem when you're attempting social changes. So my appeal is that you try to set programs up that last longer and allow the complexity to be worked with over a period of years.

I will stop for questions.

Mr. BEILENSON. We thank you for your interesting and informative testimony. Are there any questions of Dr. Bunderson?

Mr. GALLAGHER. I am a little bit confused. You mentioned that schools are not about to change and you are looking for new vehicles. The witnesses we had here on Tuesday and some we have had here today indicate on the face of their testimony that significant changes in the schools have been made in Brooklyn and out West, almost qualitative changes, as I mentioned a moment ago, not just increasing the student's knowledge but almost attitudinal and dispositional changes.

How would you square that?

Mr. BUNDERSON. I thank you for that question.

First, let us look at Los Nietos. I would regard Los Nietos as a kind of alternate school, essentially. They have very unusual leadership. The men who testified here are unusually informed and capable and the population is essentially that population which demands that something be done. Therefore, the program is more of an alternate program than a traditional program you would find in regular schools. And it is heavily funded by the Government. In the other programs CCC has found a little window or little way to fit into a teacher-center program. They are not introducing a student-centered environment at all that would change the self-image of the students. I don't believe they would claim to have data that says that they are making dramatic changes in student self-image, but they just fit into this little window and use title I money to spend 15 minutes a day, which really doesn't threaten the teachers that much.

Now I don't wish to put teachers down because I feel that they struggle under enormous odds to do a good job and I essentially feel it is too much work for them. I just don't think they are allowed to change very much the way the system is organized and I don't think the school superintendents are allowed to change very much. They are not going to be allowed to change until they see this other kind of education in offices and homes so that the parents and taxpayers will see that there is an alternative and they will stress it.

But if you look at the history of innovation you see that innovations are allowed to thrive for a little while and then when the innovators go away it usually reverts to a teacher-centered classroom model. This effect goes clear back to the Winnetka plan and other individualized plans which have been attempted and have reverted.

Mr. BEILENSON. Again, we thank you very much for coming out today and sharing your knowledge with us.

The full text of all the written statements which we have been given by all of the witnesses will be included in the transcript, so you need not worry about those points that you might not have covered in your oral testimony here today.

The meeting is adjourned.

[Whereupon, at 2:20 p.m., the subcommittee was adjourned to reconvene on Wednesday, October 12, 1977, at 10 a.m.]

COMPUTERS AND THE LEARNING SOCIETY

WEDNESDAY, OCTOBER 12, 1977

House of Representatives,
Committee on Science and Technology,
Subcommittee on Domestic and
International Scientific Planning,
Analysis and Cooperation,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10 a.m., in Room 2325, Rayburn House Office Building, Hon. James H. Scheuer (chairman of the subcommittee), presiding.

Mr. Scheuer. This session of the Committee on Science and Technology, Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation will come to order.

This is the third day of hearings on our topic, "Computers and the Learning Society." Today we focus on, "The Future: Research, Development, and Planning," following several days of testimony we have already heard concerning computer managed instruction and computer assisted instruction.

If these two approaches can achieve meaningful results in terms of learning gains then the future prospects of computer power linked to learning appears to be highly important.

It is on the way this future might develop, as well as the necessary Government policies to foster the wisest use of our Nation as computer resources, that we focus today.

It is a great pleasure to welcome the four witnesses. The leadoff witness will be Dr. James E. ery, president of EDUCOM in Princeton, N.J.

Dr. Emery would you please take the stand.

Your entire testimony will be printed in the record at this point, so if you want to chat informally you may so so.

(The complete prepared testimony of Dr. James Emery is as follows:)

Testimony of

E D U C O M

before the

House Science and Technology Committee

by

James C. Emery
President
EDUCOM
Princeton, New Jersey

ctober 12, 1977

THE IMPACT OF INFORMATION TECHNOLOGY ON EDUCATION

TESTIMONY OF DR. JAMES C. EMERY
PRESIDENT, EDUCOM, PRINCETON, NEW JERSEY

I. TECHNICAL ADVANCES

WE ARE IN THE MIDST OF EXPLOSIVE ADVANCES IN INFORMATION TECHNOLOGY THAT ARE DESTINED TO HAVE PROFOUND EFFECTS ON ALL LEVELS OF EDUCATION. THE COMPUTER IS BOTH THE SYMBOL AND THE CENTRAL FOCUS OF MANY OF THESE ADVANCES, BUT OTHER AREAS OF TECHNOLOGY ARE ALSO MAKING SIGNIFICANT CONTRIBUTIONS. THE FEDERAL GOVERNMENT HAS AN IMPORTANT ROLE IN FOSTERING THE DEVELOPMENT OF THE TECHNOLOGY AND ELIMINATING SOME OF THE EXISTING CONSTRAINTS THAT INHIBIT ITS EFFECTIVE APPLICATION.

THE DRIVING FORCE BEHIND MANY RECENT DEVELOPMENTS IS THE FANTASTIC PROGRESS THAT HAS BEEN MADE IN ELECTRONICS. ELECTRONIC CIRCUITS HAVE BEEN GROWING IN CAPABILITIES WHILE THEY SHRINK IN SIZE AND COST. AS A RESULT, THE COST OF PERFORMING A GIVEN FUNCTION HAS BEEN GOING DOWN BY A FACTOR OF TEN EVERY FIVE YEARS OR SO.

ADVANCES IN COMMUNICATIONS HAVE BEEN LESS PRONOUNCED BUT ARE NEVERTHELESS VERY SUBSTANTIAL. SATELLITE COMMUNICATION IS AN OBVIOUS EXAMPLE, BUT LESS WELL-KNOWN DEVELOPMENTS IN SWITCHING TECHNOLOGY ARE LIKELY TO HAVE EVEN MORE IMPORTANT EFFECTS. WE ARE MOVING TOWARD AN ERA IN WHICH RAPID, RELIABLE, AND INEXPENSIVE COMMUNICATIONS WILL BE UNIVERSALLY AVAILABLE.

SIMILAR ADVANCES ARE TAKING PLACE IN OUR ABILITY TO STORE AND RETRIEVE ALL FORMS OF INFORMATION. VIDEODISC TECHNOLOGY, FOR

23-082 O - 78 - 16

EXAMPLE, PROMISES TO OFFER AN EXTREMELY COST-EFFECTIVE MEANS OF STORING AND DISTRIBUTING VAST QUANTITIES OF PICTORIAL IMAGES, TEXT, AND QUANTITATIVE DATA.

IN SHORT, WE ARE RAPIDLY APPROACHING A WORLD IN WHICH OUR ABILITY TO PROCESS INFORMATION -- TO COLLECT, TRANSMIT, STORE, RETRIEVE, AND DISPLAY IT -- GREATLY EXCEEDS ANYTHING WE HAVE EXPERIENCED IN THE PAST. WE CAN ONLY DIMLY PERCEIVE THE POSSIBLE IMPACT THAT SUCH INFORMATION ABUNDANCE MAY HAVE ON THE EDUCATIONAL PROCESS -- AND, INDEED, ON OUR ENTIRE SOCIETY.

II. LIKELY CONSEQUENCES OF THESE DEVELOPMENTS

THERE IS RELATIVELY LITTLE UNCERTAINTY ABOUT DEVELOPMENTS IN INFORMATION TECHNOLOGY OVER THE NEXT FEW YEARS: THEY ARE VERY LIKELY TO CONTINUE AT THE SAME RAPID PACE THAT HAS BEEN ACHIEVED DURING THE PAST TWO OR THREE DECADES. WE CAN PREDICT WITH GREAT CONFIDENCE THAT THE COST OF "HARDWARE" -- COMPUTERS, STORAGE DEVICES, COMMUNICATION EQUIPMENT, AND THE LIKE -- WILL DECLINE TO THE POINT THAT IT WILL NOT CONSTITUTE A SIGNIFICANT FRACTION OF THE TOTAL COST. WE CAN THEREFORE AFFORD TO DISTRIBUTE SUCH HARDWARE QUITE LIBERALLY AMONG STUDENTS, FACULTY, AND ADMINISTRATORS IF THIS SERVES THEIR NEEDS MOST EFFECTIVELY.

PERSONNEL COSTS, ON THE OTHER HAND, WILL CONTINUE TO INCREASE AND WILL UTTERLY DOMINATE ALL OTHER ECONOMIC CONSIDERATIONS IN APPLYING INFORMATION TECHNOLOGY. THE PERSONNEL COSTS ASSOCIATED

WITH THE DESIGN AND DISTRIBUTION OF INSTRUCTIONAL MATERIAL WILL, FOR EXAMPLE, GREATLY EXCEED HARDWARE COSTS.

MANY OF THESE PERSONNEL COSTS ARE LARGELY FIXED REGARDLESS OF THE VOLUME OF USAGE OF THE PRODUCTS PRODUCED. THUS, THE COST OF PRODUCING A COMPUTER-ASSISTED COURSE IN, SAY, TORTS LAW IS MUCH THE SAME IF IT IS USED BY A SINGLE LAW SCHOOL OR IF IT IS USED THROUGHOUT THE COUNTRY. THE HIGH FIXED COST OF PRODUCING THIS MATERIAL PROVIDES AN OBVIOUS INCENTIVE FOR SHARING HIGH-QUALITY EDUCATIONAL PRODUCTS AS WIDELY AS POSSIBLE.

SHARING CAN BE ACHIEVED BY PHYSICALLY TRANSPORTING THE EDUCATIONAL MATERIAL TO THE POINT OF USAGE. WHATEVER HARDWARE IS REQUIRED TO SUPPORT THE MATERIAL -- SUCH AS A "MICROCOMPUTER" FOR DELIVERING COMPUTER-ASSISTED INSTRUCTION -- CAN BE PROVIDED AT A RELATIVELY LOW COST. IN MANY SITUATIONS THE SHARED USE OF HIGH-COST MATERIAL BY MOVING IT TO A LOCAL MICROCOMPUTER WILL PROVIDE THE MOST COST-EFFECTIVE WAY OF OFFERING EDUCATIONAL OR ADMINISTRATIVE SUPPORT.

THE PHYSICAL DISTRIBUTION OF MATERIAL BY THIS MEANS DOES HAVE LIMITATIONS, HOWEVER. IF THE MATERIAL IS UNDERGOING CONTINUAL REVISION OR ADDITION -- AS IN THE CASE OF A REFERENCE FILE OF CURRENT NEWSPAPER ARTICLES -- FREQUENT PERIODIC DISTRIBUTION MAY PROVE TOO CUMBERSOME, EXPENSIVE, OR TIME CONSUMING. MORE FUNDAMENTALLY, IF PERSON-TO-PERSON INTERACTION IS INVOLVED, ONE-WAY COMMUNICATION IS NOT FEASIBLE. IN SUCH INSTANCES, COMMUNICATION NETWORKS WILL PLAY AN ESSENTIAL ROLE.

These networks allow the rapid exchange of information in ways that largely erase the barrier of distance. Instructional or research material can be developed and maintained at one location, and then accessed over communication lines by users at other locations. A chemist in Massachusetts, for example, may thus be able to use a computer program operated in Texas for the purpose of performing specialized chemistry calculations. Similarly, a handicapped child in California may receive personal attention from an educational specialist in New Jersey by means of an "electronic mail" system that provides very low cost person-to-person communication.

III. The Future Educational Environment

Technology now available or soon to emerge from the laboratory will present us with new opportunities for developing and delivering educational services of all types. How we choose to exploit these opportunities is not yet clear, but reasonable predictions can be made.

We are likely to see a proliferation of "intelligent terminals" to support education and research. Incorporating a powerful "microcomputer," an intelligent terminal will be able to provide most computer-based services on a stand-alone basis -- that is, without having to communicate regularly with some distant computer. A communication network may in such cases provide invaluable aid to the user in locating and ordering instructional or research material, but once the material has been delivered to

THE LOCAL TERMINAL NO FURTHER ACCESS TO THE NETWORK WOULD BE NECESSARY (AT LEAST UNTIL NEW OR REVISED MATERIAL IS WANTED).

COMMUNICATION NETWORKS ARE LIKELY TO PLAY ANOTHER EXCEEDINGLY IMPORTANT ROLE -- PROVIDING ACCESS TO UNIQUE OR HIGHLY SPECIALIZED RESOURCES. IN MANY CASES ACCESS TO THESE RESOURCES MAY ONLY BE FEASIBLE OVER A NETWORK, SINCE THE PHYSICAL DELIVERY OF THIS MATERIAL WOULD BE TOO COSTLY OR TOO TIME CONSUMING. SOME "DATABASES," SUCH AS BIBLIOGRAPHIC ABSTRACTS OR TABLES OF ECONOMIC DATA, ARE SO LARGE THAT THEIR PHYSICAL DISSEMINATION IS NOT PRACTICAL. SOME COMPLEX COMPUTER PROGRAMS ARE TOO LARGE TO FIT WITHIN THE LIMITATIONS OF A LOW-COST INTELLIGENT TERMINAL. SUCH RESOURCES CAN BETTER BE ACCESSED OVER COMMUNICATION LINES, WITH THE ACTUAL OPERATION TAKING PLACE AT THE SITE PROVIDING THE SPECIALIZED SERVICE. THE RESULTS OF AN INQUIRY OR A COMPUTATIONAL TASK CAN THEN BE TRANSMITTED OVER THE NETWORK AND DISPLAYED AT THE USER'S LOCAL TERMINAL (USING A TV-LIKE SCREEN OR A TYPEWRITER-LIKE PRINTING DEVICE).

AS THE TECHNOLOGY EVOLVES, IT IS LIKELY THAT PERSON-TO-PERSON COMMUNICATIONS THROUGH "ELECTRONIC MAIL" OR "TELE-CONFERENCE" SYSTEMS WILL PROVE INCREASINGLY USEFUL IN EDUCATIONAL INSTITUTIONS. ALREADY ELECTRONIC MAIL SYSTEMS ARE ALLOWING CLOSE COOPERATION AMONG RESEARCHERS IN FAR-FLUNG LOCATIONS. THESE SYSTEMS HAVE PROVEN SO EFFECTIVE AND OFFER SUCH UNIQUE SERVICES -- FOR EXAMPLE, THE ABILITY TO LEAVE A PERMANENT COPY OF A MESSAGE IN A COLLEAGUE'S ELECTRONIC "MAILBOX" FOR LATER RETRIEVAL AT THE RECIPIENT'S CONVENIENCE -- THAT EVEN PERSONS WORKING AT THE SAME LOCATION

OFTEN FIND THAT AN ELECTRONIC SYSTEM STRONGLY COMPLEMENTS FACE-TO-FACE COMMUNICATION. AS FAMILIARITY WITH THESE SYSTEMS BECOMES MORE WIDESPREAD, THEY ARE LIKELY TO ASSUME AN INCREASINGLY IMPORTANT ROLE IN TEACHING, RESEARCH, AND ADMINISTRATION.

IV. Federal Policy Issues

A NUMBER OF IMPORTANT POLICY ISSUES SHOULD BE FACED AT THE FEDERAL LEVEL. THE FOLLOWING ARE AMONG THE MOST IMPORTANT:

- FUNDING RESEARCH AND DEVELOPMENT OF EDUCATIONAL TECHNOLOGY.
- FUNDING THE OPERATIONAL PHASE OF DELIVERY SYSTEMS.
- REVIEW OF INTERNAL REVENUE SERVICE REGULATIONS IN ORDER TO ENCOURAGE GREATER SHARING AMONG TAX-EXEMPT EDUCATIONAL INSTITUTIONS.
- REVIEW OF FEDERAL COMMUNICATION COMMISSION REGULATIONS IN ORDER TO ENCOURAGE ELECTRONIC MAIL AND SIMILAR COMMUNICATION SERVICES.

LET ME EXPAND JUST A LITTLE ON EACH OF THESE POINTS.

THE NEED FOR R&D SUPPORT IS PRIMARILY FOR FUNDS THAT CAN BE USED FOR APPLIED RESEARCH AND FOR THE TRANSLATION OF RESEARCH POSSIBILITIES INTO PROTOTYPE DELIVERY SYSTEMS. A NUMBER OF FUNDING SOURCES CURRENTLY EXIT FOR BASIC RESEARCH, BUT FUNDS ARE EXTREMELY LIMITED FOR THE APPLICATION OF THE FRUITS OF RESEARCH. IN THE COMMERCIAL WORLD, DEVELOPMENTAL AND OTHER START-UP COSTS ARE A RECOGNIZED INVESTMENT THAT COMPANIES PROVIDE IN THE EXPECTATION THAT THESE COSTS WILL BE RECOUPED THROUGH LATER SALES REVENUES. IT IS MUCH MORE DIFFICULT FOR EDUCATIONAL INSTITUTIONS TO RAISE INVESTMENT CAPITAL, PARTICULARLY WHEN THE APPLICATIONS INVOLVE

THE SHARING OF TECHNOLOGY BY A NUMBER OF INSTITUTIONS.

IT IS EXPECTED THAT SYSTEMS FOR DELIVERING EDUCATIONAL AND RESEARCH MATERIAL WILL BE SELF-SUPPORTING ONCE THEY ARE OPERATIONAL. IT IS THE MOVE TO OPERATIONAL STATUS THAT WILL REQUIRE FINANCIAL SUPPORT WHILE VOLUME OF TRAFFIC BUILDS UP TO A SUSTAINABLE LEVEL. ONCE THE DELIVERY SYSTEM IS FULLY OPERATIONAL, THERE SHOULD BE NO NEED FOR CONTINUED SUBSIDY -- ALTHOUGH FOR VARIOUS REASONS IT WOULD PROBABLY BE DESIRABLE TO PROVIDE DIRECT SUBSIDIES TO CERTAIN USERS OF THESE SYSTEMS (SUCH AS HANDICAPPED CHILDREN, FOR EXAMPLE).

SOME CURRENT INTERNAL REVENUE SERVICE INTERPRETATIONS OF THE INTERNAL REVENUE CODE CONSTRAIN TAX-EXEMPT EDUCATIONAL INSTITUTIONS FROM ENGAGING JOINTLY IN ACTIVITIES THAT WOULD BE ENTIRELY PERMISSIBLE IF PERFORMED INDIVIDUALLY. THIS SITUATION TENDS TO INHIBIT SOME VERY USEFUL SHARING OF RESOURCES FOR EDUCATIONAL PURPOSES. THE ADVANTAGES OF CONTINUING THESE RESTRICTIONS SHOULD BE WEIGHED AGAINST THE DISADVANTAGES OF REDUCING THE SHARED USE OF EDUCATIONAL TECHNOLOGY.

ELECTRONIC MAIL IS BEGINNING TO BE USED FOR EDUCATIONAL AND RESEARCH PURPOSES. IT PERMITS COLLEAGUES AT WIDELY SEPARATED CAMPUSES TO COOPERATE AND PERFORM RESEARCH JOINTLY. TELE-CONFERENCING TECHNIQUES ARE BEGINNING TO BE USED AS A COST-EFFECTIVE SUBSTITUTE FOR FACE-TO-FACE MEETINGS. AT SOME POINT THESE DE FACTO USES OF COMMUNICATIONS TECHNOLOGY FOR EDUCATIONAL AND RESEARCH PURPOSES WILL NEED TO BE CLARIFIED AND FORMALIZED IN

APPROPRIATE REGULATIONS OF THE FEDERAL COMMUNICATIONS COMMISSION. IT WOULD BE HELPFUL IF THIS COULD BE DONE IN WAYS THAT WOULD ENABLE AND ENCOURAGE THE USE OF THIS TECHNOLOGY.

V. CONCLUSIONS

IT IS DIFFICULT TO FORECAST THE PRECISE CHANGES IN EDUCATION THAT WILL STEM FROM THE REVOLUTIONARY ADVANCES IN INFORMATION TECHNOLOGY. WE CAN PREDICT WITH CONFIDENCE, HOWEVER, THAT THE CHANGES ARE LIKELY TO BE PROFOUND AND PERVASIVE. IT IS ENTIRELY APPROPRIATE, THEREFORE, THAT THIS COMMITTEE IS GIVING SERIOUS CONSIDERATION TO THE WAYS IN WHICH FEDERAL POLICIES CAN CHANNEL THE TECHNOLOGY IN USEFUL DIRECTIONS.

WHAT IS EDUCOM?

EDUCOM is a nonprofit organization founded in 1964 to promote cooperative efforts and deal with common problems in the application of systems technology in higher education and research. Its activities are concerned with such areas as:

- the application and management of computer technology in academic instruction and research.
- the use of data processing and management information systems in college and university administration.
- the applications of computer technology in libraries and for information dissemination.

EDUCOM's current membership includes over 250 university and college campuses, which together enroll more than one-third of all students attending four-year colleges in the United States. Its unique contribution is to bring together faculty, administrators, and technical experts from member institutions to focus on effective and economical ways of using systems technology to satisfy the needs of higher education.

EDUCOM serves the higher educational community through activities such as:

- disseminating information and promoting cross-fertilization of ideas through conferences, workshops, and publications.
- promoting sharing and exchange of specialized computer and information resources among colleges and universities.
- providing consulting services on the management and use of computer technology in institutions of higher education.
- negotiating discount agreements with computer equipment suppliers for the benefit of members.
- promoting research on problem areas of general concern to the higher educational community.

EDUCOM is organized so that its member institutions can and do play an active role in developing goals and policies. Institutional Representatives, appointed by the President of each member institution, serve as the link between EDUCOM and the faculty and administration of their campuses. Representatives bring to EDUCOM conferences and task forces the views, problems, and proposals of their institutions concerning computer and communications technology, and share with their colleagues on the campus the latest ideas and developments obtained through EDUCOM.

WHAT ARE SOME OF THE ISSUES EDUCOM ADDRESSES?

- Developing s,.tems for networking and resource sharing.
- The need for and the advisability of discipline-oriented computer centers.
- Pricing and budgeting for computing services in colleges and universities.
- The relative place of computing in institutional priorities.
- Uses of minicomputers and hierarchical computing.
- The interface between university administrators and university computing.
- The potential educational use of cable television and its integration with computing.
- Satisfying the growing demand for computing capability in higher education.
- The role of state governments in educational computing.
- The role of simulation modeling in applying computing to university organization.
- The use of computer and video technology in instruction.
- Cost-effective ways of providing library and bibliographic services.

EDUCOM SERVICES AND ACTIVITIES FOR MEMBERS

The EDUCOM Consulting Group provides analysis and advice relating to the planning and use of computer and other technologies in higher education. Drawing on experts from EDUCOM member institutions and members of the EDUCOM staff, a consulting team of individuals with appropriate skills and experience is formed for each assignment. Recently completed consultations have dealt with planning for computing activities, computing center organization, university management information systems, acquisition of minicomputer systems, and models for financial planning.

The EDUCOM Bulletin, a quarterly magazine, is in its twelfth year of publication. Circulated to over 10,000 faculty and staff members of EDUCOM institutions, the Bulletin provides reports on presentations at conferences, reports of research projects, descriptions of applications of technology to higher education and articles by authorities in fields describing functioning systems of interest to the educational community.

Annual Conferences provide a forum for discussing resource sharing, computer networking, the development of information systems, and other topics of current interest.

Proceedings of each regular conference are published in paperback book form and distributed free to Institutional Representatives as well as to conference participants.

Special Seminars are scheduled on topics of concern to members. Funded by foundations or attendance fees, these meetings provide a source of expertise and experience to all members. Seminars are typically scheduled for one day, and, to minimize travel expense for participants, are repeated in regional locations if registration warrants.

Research Reports and Monographs are published in areas of interest to higher education. Published as paperback or hard cover books, these reports are available at reduced prices to faculty and staff of member institutions.

Discounts on the purchase or lease of computing equipment and related materials from selected vendors are available to EDUCOM members. These arrangements allow individual members to deal directly with the vendor, taking advantage of the centrally negotiated discount.

Informal Communications to members include letters to presidents, memos to Institutional Representatives, and other mailings that keep member institutions informed about developments in the sharing of resources and the use of computing and other technologies.

SPECIAL ACTIVITIES

Planning Council. The establishment of the Planning Council on Computing in Education and Research ushered in a new stage in EDUCOM's development. During 1975, its first full year of operation, the Planning Council developed a research plan and initiated a number of studies related to computer networks. Twenty-one colleges and universities participate in the Planning Council, and each provides financial support of $10,000 per year for five years. The Council is governed through a Policy Board and a Technical Committee; each member institution has a senior representative on each of these committees. Planning Council activities include the development of a prototype network for computing resource sharing, benchmark studies of members' computer centers, meetings of regional networking groups, support of discipline-oriented computing user groups, and a variety of special studies and projects leading to the enhancement of the network.

EDUNET. With encouragement from EDUCOM and funding from the Planning Council, a group of consumers and suppliers of university and college computing services began to share resources through networks in 1976. The set of resources and facilitating services provided by EDUCOM is call EDUNET. The computing facilities at MIT, Dartmouth, SUNY, Yale, and Stanford are currently available through Telenet and/or TYMNET, both "value-added" communications vendors. EDUNET also includes several other university and research facilities that are not Planning Council members. Further additions are expected in the future. One of the facilitating services supplied to EDUNET participants is an on-line directory of the resources available, which is accessible through the SPIRES database management system at Stanford University. As additional computing resources participate in EDUNET, the on-line directory will be expanded.

Network Simulation Project. Closely related to Planning Council activities is a major EDUCOM research project that has developed a simulation model of an inter-institutional computer network. Use of the model in gaming exercises will help answer questions about networking and its potential impact on participating institutions.

EDUCOM Council Task Forces enable EDUCOM to draw on faculty and administration of member institutions to develop guidelines, checklists, and reports using the combined experience of members to deal with pressing current problems of a genera nature.

Legal Education. Discounts have been arranged for EDUCOM members subscribing to a computer-based legal reference service. Experiments in using computer-based exercises for teaching law over a network are being conducted. The results of these experiments should have general applicability to other disciplines and will be disseminated through an EDUCOM report.

Financial Planning. Computer-based models for long-range financial planning developed at Stanford University are being adapted for use by other colleges and universities. The generalized models and procedures for using them will be made available to other interested institutions at the conclusion of the project.

RESEARCH PROJECTS

EDUCOM conducts research on the application of computer and communications technology to areas in which significant results can be achieved with the combined resources of its members.

Past research has included studies of:

- The use of information systems in medicine and libraries.
- Plans for a biomedical communications network.
- System configuation and technology required for an agricultural information network.
- Factors inhibiting the use of computers in instruction.
- The use of computer simulation in socio-economic policy research.
- Planning for computing service for higher education by state agencies and institutions in the United States and Canada.

Current research includes:

- Use of a simulation model in gaming exercises to gain a better understanding of institutional behavior in a computer network.
- Pricing and budgeting of computing services within colleges and universities.
- The provision of user services to aid users in accessing computing resources.
- A comparative study of the manner in which states have developed and implemented plans for providing computing service to higher education.

January 1977

STATEMENT OF DR. JAMES EMERY, PRESIDENT, EDUCOM, PRINCETON, N.J.

Mr. EMERY. I prefer to do that. Thank you very much for the invitation to present our views. EDUCOM vies itself as a technology transfer agent within higher education. And, of course, the matters for discussion at these hearings are very much of interest.

We think they are of supreme importance to the higher education community and all of education, and for that matter, all of society, because we are touching on matters which we think will have a very profound effect in many areas of our culture and society, not just education.

The technological advances that we are primarily focusing on these days are advances in electronics and much of the dramatic improvements in the technology have been focused or concentrated on developments in the computer area. It is hard to think of any technology that has advanced at so startling a rate as has electronics and computing.

In a little over three decades the raw computing power has gone up by perhaps a factor of $1 million and the costs have gone down by perhaps a factor of 10,000 or more. If you compare that, for example, with transportation, the transition to the horse and buggy days to the car represented about a tenfold increase in speed.

The transition from the automobile to the jet age again represented about a factor of 10. So in most areas of technology a tenfold increase has had profound sociological impacts.

Here in three decades in the computer field we have seen six orders of magnitude, six tenfold increases in computer power and we are only just now beginning to see some of the impacts that might have.

Others later in the program will talk about some of the fruits of this technology. I think that dramatizes it as well as anything I might say.

Other areas of technology, besides computers, are also of relevance in talking about the way technology might impact education. Communication certain is improving rapidly, about 10 percent per year.

That is not as dramatic as computer technology, but it is very important and will have important consequences. Let me say a little bit about the consequences, as we see them, of these technological developments.

First of all, the startling advances in electronic technology will permit very widespread diffusion of computer hardware. The computer here is a $600 item. That is representative of the way the technology is going. When I first got interested in computing some 20 years ago, the computer I started out with had a monthly rental of perhaps $3,000 to $4,000. This $600 machine is more powerful in many ways than that machine was back in those days. So we will see very widespread diffusion. Everybody who has a need for a dedicated computer of that sort will be able to get access to one. The real problem will be the high cost of personnel to develop the system capable of using these systems. There is some danger in putting a lot of money into hardware and as a result adding to the total cost in education because of the personnel cost to operate. This I think gives a very strong incentive to various mechanisms for sharing the software and data bases necessary to take advantage of the very low-cost hardware.

That in one sense is one of the main purposes of EDUCOM and some of the things that some of our colleagues are working on.

As we see it, there are two basic mechanisms for transferring the very people-intensive software that is necessary to use these systems properly. One is through the physical transfer of the programs and data. You simply move a cassette with the necessary information to record the program. That can be very useful and in fact in terms of the total amount of sharing that probably would represent the major form of it.

On the other hand, there are other types of sharing where that physical transfer is simply not going to be very effective. In certain cases that we have dealt with programs are far too large to transfer onto little cassettes.

One of our experiments going on now, for example, is use of CAI material for teaching law students. The material was developed at the University of Minnesota and is now being used fairly widely by law schools throughout the country.

The material is large enough and complex enough that transferring it through physical transport of the programs has proven not to be very practical and access over network has proved to be completely practical. So we see use of communications networks as being an important way of transferring software and data bases.

As we see it, the way the computer environment in education is evolving will be toward hierarchical where much of the computing, in fact, the majority, certainly, will be done locally on low cost minicomputers.

We also see, though the need for State and regional networks and national networks. Already a number of States, Michigan and California, for example, have developed statewide computing networks that have proven to be successful. Certain regional networks, such as the one in New England, have been established. The one in New England now is meeting a very important series of needs in that area.

EDUCOM has established a network called EDUNET which serves a national market linking colleges and universities so that they can share computer resources. The great advantage of these regional and national networks is that they will allow access to resources that otherwise would not be available. I think one of the important consequences would be that geographical location will cease to be an important restriction in accessing these resources. There is no reason for even small institutions to be denied the best resources available throughout the country because they can be readily accessible through these national networks.

Mr. SCHEUER. Are you going to tell us anything about the computer applied to the learning process?

Mr. EMERY. The other testimony will get into that in more detail. Some of the successes we have had have been the use of networks to access CAI material. The CAI material—computer assisted instruction is an example where it can go both ways.

One very attractive way to support computer-assisted instruction is through these little dedicated computers where everything completely stands alone and there is no need to access remote sources.

In other cases, such as the University of Minnesota Law School material the size of the programs and the rapidity with which the changes are introduced in today's programs has been such that trying to physically support multiple versions of that in different computers has proven to be infeasible and so under those circumstances computer networks have proven to be very cost effective and they are currently being used, and part of the experiment we are currently conducting is looking into the effectiveness and the economics of that. It looks very attractive at this point.

Mr. SCHEUER. Of what?

Mr. EMERY. In this particular experiment it is law school material dealing with a course in evidence or tort law. There have been a couple dozen courses or more developed both at the University of Minnesota and some at Harvard. The work that has been done at those universities now is available through this network to their 10 law schools now currently using that.

Increasingly, they are using it as part of the mainstream educational process in those law schools. I think that is representative of the use of this kind of material. Certain business schools are relying very heavily on computer-assisted instruction for teaching some of the basic materials. The great advantage of CAI material in these cases is that it allows you to take full advantage of the computing power of the computer.

For example, my own experience in use of CAI material has been in business school type courses in which one can teach, for example, a course in inventory control or production scheduling. You can ask the student to make choices and the computer then can determine with immediate response the consequence of say a given inventory policy. It will point out what the cost of that decision is and what sort of service you will give to your customers and that sort of thing. So by invoking the computational power of the computer one can give real life simulation of what the business school student otherwise would not be able to see until after long years of experience.

Dr. SWANSON. In talking about this there are essentially two different kinds of technology. What you are talking about in terms of networking is your computer at your university talking to another at another university and presumably there are users at either end interchanging information. On the other hand we have what you call the hardware revolutoin reducing the size and cost of the units that can stand alone and perform many similar functions. Are there differentiated or specialized roles that each of these types of technology should play, especially in the area of teaching people?

Mr. EMERY. I think there are two classes of issues here. One is just the general cost effectiveness of CAI material in general whether it is delivered from a remote terminal through a network or delivered on a local stand-alone computer. To be sure, the economics can change with the way you do that, but it would seem to me the main cost of developing CAI material and the main issue is the cost of developing the material, the people cost necessary to write the programs and instructional material.

The question of whether you deliver it over a network or a local computer is really a technical and economic question. It does not affect profoundly, in my opinion, the overall effectiveness of CAI as a learning device. There are certain cases where because of the size of the material or because it changes very rapidly, where the networks are simply more cost effective than trying to do it locally. In most cases I suspect that local stand-alone computers will be the most cost effective way.

Mr. SCHEUER. Cost effective way of doing what?

Mr. EMERY. Presenting instructional material using the CAI techniques. There is a certain disenchantment with some of the CAI material which was developed. A lot of money has been put into that. The evidence is not overwhelming that this is an up-to-date improvement and cost effective.

Dr. SWANSON. Is there a specialized role of the nerworks that are supposed to come into play? Are they doing soemthing other than delivering CAI materials? Are they providing communications between scholars who then in turn teach people in the traditional way?

Mr. EMERY. That is the other basic reason for using the network where person-to-person interaction is required. Particularly in certain research type environments, such as electronic mail and teleconferencing and that sort of thing, this has proven to be enormously valuable, in fact, so valuable that in many circumstances colleagues that are at the same institution who perfectly well can meet face-to-face have found the power of the electronic mail, the ability to send messages to a colleague and then the colleague can get it at his or her own convenience, the power to do that has been great enough that a lot of times colleagues with next door offices choose to use the electronic mail system to communicate.

Dr. SWANSON. Have their been any studies on how that enhances the learning process for the students, or is it such a new idea that it has not been evaluated?

Mr. EMERY. To my knowledge, it has not yet been applied to the sutdent, because the costs up to now have been prohibitive. In the educational community it has only been applied, to my personal knowledge, in the research environment.

Personally, I don't see any obvious example of use of electronic mail in the conventional type learning situation. I can see special cases like handicapped children where you have specialized resources that are not available throughout the country that could be accessed through telecommunication. That might offer some very powerful capability.

But, say, for the large scale type of teaching situation I'm not sure that electronic mail would play a useful role there.

Dr. SWANSON. If you are a governmental decisionmaker and you are trying to decide where to allocate scarce public funds, both in terms of research and demonstration projects, do you put it into grants to local school districts who will in turn probably buy stand alone or miniature computers along with the available course materials, or do you put it into a system to develop large computing networks in the hopes that there will be some kind of trickle-down theory of dissemination?

Mr. EMERY. It is a very good question and it is one which I might say parenthetically is haunting not just the Federal Government but all large organizations. They face exactly identical problems. My feeling is that if money is just freely made available so everybody can get their own thing, there would certainly be some useful results of that, but there would be tremendous duplication and tremendous costs that would be incurred, a lot of which would be hidden. People would be spending time developing systems that are already duplicated elsewhere in the system.

My personal bias would be as much as possible to get money into the hands of the direct user rather than having it go to large national organizations when they dole out the money.

Even though I am associated with a national network I would much rather have the money decentralized. But I think the Federal Government should be concerned that in allocating money of that sort that mechanisms be set up that do allow effective sharing because I see some very serious problems if effective sharing mechanisms and necessary incentives are not built in. There are a number of Federal issues in terms of copyright laws, in terms of standardization, and in terms of the tax laws.

Right now the tax laws in a number of cases discourage sharing, because in order to preserve the nontaxed status of educational institutions, they try to avoid getting nonrelated income. So there are a number of disincentives for sharing which I think Congress should direct some attention to.

Mr. SCHEUER. Do you have anything to say about the application of computer-assisted learning to elementary school kids, teaching kids to read and write and count and making them functionally literate which is something our school system seems to have great difficulty in doing.

Mr. EMERY. It does, indeed, sir. I don't consider myself to be an expert. Certainly, from my own personal experience I have found that young children have been eager to accept the use of the computer and it is startling how rapidly kids can get onto a computer and become familiar with it. Some work has indicated that teaching handicapped children and disadvantaged children through CAI computer type systems is attractive in that it sort of impersonalizes the instruction process and they feel less inhibited. So I think some useful results may come from that. I'm not enough of an expert that I can say much more than that.

Mr. SCHEUER. Jim, do you have any questions?

Mr. GALLAGHER. Dr. Emery, on page 3 you mention the high personal cost remaining rather static where there are more users subscribing to the service. One of our later witnesses will testify that—this brings up the personnel costs—that we live in a computer—we are computer illiterates, I think is the way he phrased it and he said there is much training to be done. His thinking is as to feedback into the computer and so forth. Would'nt this increase personnel cost if you have to train teachers to train the users?

Mr. EMERY. It would indeed. In fact, it is one of the costs I referred to as in some cases the hidden cost of being able to exploit the very low cost electronics. So we may be deceiving ourselves if we think the hardware is going down in cost, if we find ourselves spending a lot more money on personnel costs. I am fairly optimistic that systems can be developed that allow the use of the low cost electronics without people being trained in any sort of deep technology.

Increasingly, systems are being designed to be more humane and self-instructing and I'm relatively optimistic that we will be able to provide most of these advantages to the nonsophisticated user with relatively small amounts of training. It is not the same sort of situation we face now with current technology where a user, if he wants to use the computer, has to make a fairly serious commitment to learning how to use it. That is becoming increasingly less true as the system becomes more powerful and more human-like languages are developed.

But it is a serious problem and that is a good question.

Ms. LOFLIN. Dr. Emery, on Tuesday we're going to have a joint session on use of computers in education of the handicapped. Could you tell me to what extent electronic mail systems are used to aid the handicapped?

Mr. EMERY. There is a system called NIMUS which provides access to instructional material for handicapped children. That is just now going through a second phase where it will become at least one alternative they are considering and what I suspect will be achieved is the development of a on-line national system for providing directory information to locate instructional material.

So at the very least, the network can be useful in getting the actual physical material to the ultimate user by means of a network, to locate it and hopefully also to tie into the logistics part of the system, so that if somebody says I want to see that, it will be mailed to them through normal distribution channels.

There is also some talk of providing access to specialized human resources over the network in training handicapped children. That is just barely starting. So right now there is in place very little. But there is some serious work to try to exploit the technology and I think it has quite a few prospects.

Mr. GALLAGHER. On page 6 and 7 you mention that in the commercial world developmental and other start up costs are recognized expenses which companies provide in the expectation that the costs will be recouped from later sales of the product. Then you say it is much more difficult for educational institutions to do this. This is true. They are strapped. But why cannot educational institutions team up with the industrial sector to provide the seed money and so forth? They are doing it today in a modest way.

Mr. EMERY. They are, indeed. In fact, in the work EDUCOM is doing we have an organization called "The Planning Council," in which there are 22 university members. They are themselves paying $10,000 per year as part of this joint shared activity. So they are putting in frontend money. We are also using the private sector, for example, communications. We are not trying to run our own network. We are buying communications services from a private firm.

So I totally agree that we should resort as much as possible to the resources the universities are willing to put up as frontend money and to the private sector. We are doing that. There are still other start-up costs that are difficult to get the private entrepreneur to assume or that universities are willing jointly to fund.

We think over the long term we can bootstrap a lot of these costs; that is, we can just sort of gradually let the system become self-sustaining. But if we want to accelerate the development of these national networks, we think that at least some modest elective funding by the Federal Government would be very useful.

Mr. GALLAGHER. Do you envisage the computer user paying additional fees? This is a relatively new field to me and I am speaking as a layman. I think in terms of CBS and NBC and the entertainment network. When you buy a television set you buy it from a certain company but the service, that is, the input, comes from Madison Avenue. And in a sense it is a freebie. Madison Avenue receives its income from corporations. When it is pumped into a home or school, won't there be an additional fee for the time-hour basis or instructional material?

Mr. EMERY. I think indeed there will be. In fact, that is our general premise, that the network will be self-sustaining, primarily sustained by user charges. We think the evidence is that the users will be willing to pay for the service. There are certain classes of users. Handicapped children is probably the most obvious case, but disadvantaged children also would apply, or maybe students in rural areas where communication costs are particularly high where they may not be able to bear the full cost. It would be entirely appropriate for state or local governments or even the Federal Government to provide selective subsidies.

But subsidies, in my opinion, should go directly to the user so that they have the option of what services they want to buy on the network. I don't think it would be desirable for the Federal Government or other governments to provide heavy on-going subsidy for the network operation.

I think basically it should be operated through a market mechanism where the users decide what services they want and they pay for them.

Mr. SCHEUER. Thank you very, very much, Mr. Emery. I appreciate your coming out today.

The next witness will be Dr. Seymour Papert, director of the Artificial Intelligence Laboratory at MIT. Again, Dr. Papert, your testimony will be reprinted in full at this point in the record, so you can chat with us informally.

[The prepared statement of Dr. Papert is as follows:]

This Time It's For Real

A Statement Presented at Hearings on "Computers and The Learning Society"

Held by the House of Representatives Science and Technology Subcommittee on International Scientific Planning, Analysis and Cooperation (DISPAC: Chairman, James H. Scheuer)

By Seymour Papert

Cecil and Ida Green Professor of Education, M.I.T.
Professor of Mathematics

Massachusetts Institute of Technology

Part I: Summary and Policy Recommendations

During the nineteen eighties small but immensely powerful personal computers will become as much a part of everyone's life as the TV, the telephone, the printed paper and the notebook. Indeed computers will integrate and supercede the functions of these and other communicational and recreational home technologies. I emphasise: this will happen independently of any decisions by the education community. The driving force lies in industry. This computer presence has a tremendous potential for psychological impact including improvement of the process of learning. It will effect adults, children and babies in homes as well as in schools and in places of work. Although the coming of the computers is inevitable, the way they will be used can be influenced very profoundly.

The computer presence of the nineteen eighties must not be confused with the relatively modest and primitive computer aided instruction already practiced in some schools and tested as part of projects such as PLATO. We envision everyone having his own computer. Every child will have access to a thousand times the computer power available to students in PLATO trials.

The presence of the computer affects the problem of education in the following ways:

---people living in a society increasingly permeated by the computer presence will need to know about computers. Computation will be added to the 3R's as a basic skill.

---the presence of the computer and people's skill in using it will deeply change the way everything else is learned.

As an analogy to illustrate the concept of computers changing the way in which everything is learned, consider a contrast (expressed caricaturally for brevity), between the natural way French is learned by children growing up in France and the formal way it is taught in schools in the United States. In France, babies learn colloquial French effortless and effectively by speaking it. In classrooms, they are drilled in rules of grammar, the process is painful and not very effective. My research shows that the compurer allows knowledge which is presently badly taught by formal means to be well learned in a natural way. Knowledge whose learning can be transformed in this way includes:

---mathematics...computers are mathematics speaking beings. Properfly used, they allow children children to learn math like babies learn to speak.

---written language...all children learn to speak the colloquial dialects in a natural way, but very many have difficulty with learning more sophisticated uses of written language. The computer can provide a learning environment in which sophisticated written language is learned like spoken colloquial language.

***Thus, the new technology leads to a

global, holistic rethinking of education; of how and where it happens, and of what is learned by whom. To be used effectively it must not be constrained to such local incremental goals as improving the teaching of fifth grade arithmetic. The federal agencies and the education community as a whole are used to thinking in terms of improvements of an existing system rather than to holistic-global redesign aimed at improving over-all performance. To bridge this gap new funding policies are needed for demonstrations and study of learning environments totally redesigned so as to respect the integrity of the new technologies.

Proposals for pilot projects of a holistic nature have been rebuffed by funding agencies with comments tantamount to: "prove you can swim first and then we'll let you get into the water". This policy sacrifices the opportunity for knowledgable and responsible research groups to try well thought out methods of using the new computers before they become widely available.

The policy makes it certain that the computers will be used either amateurishly, fadishly or under the influence of the educational software houses with the best advertising agent . As much as a decade might be needed to get back.

from that situation to the more rational one we could easily have at the outset.

Steps to be Taken

1. Recognize that we are in a critical situation which requires the deployment of substantial resources.
2. Create a high level advisory committee on Psychological and Educational Effects of Computers.
3. Establish atleast two Academic Centers of Excellence whose faculty, research staff and technical resources will be adequate to carry out holistic projects and to train professionals for work in the area between computer science and the human sciences.
4. Provide at least $20 million per year to the N.S.F. and to the N.I.E. with an explicit mandate to establish programs for fundamental and applied research in areas related to new uses of computers in education and in the home.
5. Provide $20 million to the Bureau for the Education of the Handicapped with an explicit mandate to create holistic projects on informational prosthesis.

Part II: Elaborations

Hopes for substantial improvement in education have frequently been raised by new technologies, by psychological theories, by new curricula, by new organizational forms or simply by new educational techniques. Experience has made disappointment in these hopes a social expectation. An attitude of conservatism and scepticism about education reform has been reinforced in the education community and in the public at large. The prevalent mood is "back to basics" (i.e. to traditional content) and several studies have concluded that money spent on "technology" is money wasted.

In the present conjuncture, this attitude, although we can understand its origins, is inappropriate. For this time, the computer has brought us to the verge of a true revolution in the way people learn, a revolution which will produce changes as far reaching as the changes produced by the past century of technical progress in such fields as medicine, communications, transportation and (alas) warfare. The computational revolution is certain to happen; it is driven by industry rather than by the educational community. It will take place in the home whether or not the schools accept it.

Just as neither the scepticism nor conservatism which were prevalent at the turn of the century could have held back the development of the automobile and airplane, so too, the diffusion of the computer into the lives of everyone will take place during the next decade whether educators are sceptical or not. But there is a very serious danger that a lack of well informed and timely policy making will result in the trivialization of the potentially powerful computer impact. Without an immediate stock-taking we may be digging ourselves into ways of using computers which could turn out to be counterproductive to education. In sounding these warnings I am mindful of patterns followed by the social appropriation of other technologies. For example, in the case of the automobile, we first allowed many millions of vehicles to be constructed and then, much later, worried about how to repair damage to the atmosphere, to energy resources, to cities.

Although it is obviously impossible to forsee every way in which new computer technology could be misused or underemployed, we are now in the presence of some clear cases of both. The Federal Government is in a position to provide leadership and to make available the resources which could greatly enhance the social benefits of computer technology in the area of education conceived of in the broadest possible sense. What is unique about the computer is that its imminent mass diffusion into the home offers us the social possibility of broadening our definition of education. The home computer will make it make sense to speak of "the learning society."

Such energetic action is needed now. The education community all the way up from its grass roots in the schools to the policy makers in the Office of Education is profoundly out of touch and out of harmony with the pace and the spirit of rapidly moving, sophisticated technology. In the case of computer technology, the gap between educators and technologists now constitutes a real crisis for rational planning.

The situation is comparable to what would happen if nuclear power had been invented at a time in history when the military establishment was accustomed to thinking in terms of cavalry charges. It is sometimes argued that while failure to adapt to the latest technology in armaments could constitute a national crisis, in the case of educational technology we can afford a social policy of "wait and see." This argument is myopic. A "wait and see" position in contemporary education is fabulously costly in monetary and in human terms. I illustrate by citing two examples:

The Social Cost of Incoherency

The most basic cost of "wait and see" is that incurred by individuals. In the United States alone, a million children a year are lost to the educational process, many of them irreversibly. They drop out or they settle for functional illiteracy although they possess a diploma. The sensitive use of the computer presence could have made an important, perhaps crucial difference to their educational experience. Even more dramatically, the computer could release a hundred thousand physically handicapped people from a life of isolation, dependency and cultural deprivation. Computer technology, now at hand, could open the door to social contact, knowledge and economic independence for these people. At present computers are not being used effectively to address these human problems. To do so would require constructing a new system which would embrace many aspects of the individual's life and provide in a coherent spirit many different services in a coherent and integrated way. However, the tradition of research and development in this area as in education research as a whole, is to make small innovations, each in one particular function. By their nature, no one such innovation can make a significant difference, nor are the different innovations made by different people compatible with each other.

The cost of "wait and see" means that we have no coherent plan to attack serious problems in a serious, holistic way. "Partial", ineffectual patchwork efforts are inevitable because of the bias towards them in funding programs. You cannot build a new computer culture the way you would make a minor curriculum reform.

Social Cost of Allowing a Method to Dig In

The arrangement of keys on a typewriter is irrational and inefficient. It was adopted in the early days when typing too fast jammed the keys of primitive typewriting machines. It remains because the psychological as well as monetary costs of recycling all the typewriters and retraining all the typists is prohibitive. The arrangement of the second row of keys in this irrational system is QWERTY and I call this phenomenon of the persistence of anachronistic technology the QWERTY phenomenon. A QWERTY process is already at work in how the educational system is using the computer. It has adopted methods of use which were dictated by the primitive nature and high cost of computers in the previous decade.

It is obvious that the diffusion of modern personal computers into a culture can result in a rapid evolution of a population, its general educational level as well as its technological and scientific sophistication. If we "dig in" with anachronistic models of computer use, other countries will be able to move much faster than we in taking advantage of the computer's educational potential. In fact, it is already happening. Other societies are less hampered by QWERTY-like residues. In our situation we can reassert our lead, but we can only do so if we act with a sense of urgency. First, to recognize that there is a problem -- and then to mandate research in this field which explores the holistic approaches to the problem that "traditional" educational studies are constrained from doing.

My opinions on these subjects come from over fifteen years of research in the area of the intersection between computer science and the human sciences. I have been particularly concerned with studying ways in which the process of learning and intellectual development can be enhanced by the computer presence.

An MIT we have studied how children of elementary school ages who have learned to program computers in our LOGO computer-rich environment are able to use computer concepts to understand their own processes of learning and logic. For example, they can think about how they "debug" a problem as a way of correcting it locally without having to demolish the whole and appreciate this programming strategy as a way to solve all kinds of problems, even those that come up far away from a computer terminal. We have watched children learn to use psychological ideas which would normally be considered far too abstract and sophisticated for such young people. We have studied how these children are able to acquire an articulate approach to the process of learning by taking the computer as a simplified model of certain aspects of their own minds. We have seen many cases in which this process leads to very great improvements not only in "basic skills" but in children's images of themselves as intellectual agents; and the improvement of self-image leads to improvement in learning.

Serving as a model of mind is only one of very many ways in which a computer can mediate the growth of a child's sense of intellectual power and of meaningful relationship to knowledge and technology. For a child really can master the art of computer programming and use it as a tool to accomplish personal projects of far greater complexity and ambition than anything he could do without it. But in order to make it do one's will (simulate a space flight to the moon, make music or animate one's drawings, for example) one needs to communicate with the computer in a mathematical language.

A major part of my work and that of my students and collaborators has been building "computer rich environments" in which children are motivated to communicate mathematically, often for the first time in their lives.

For example, many children who had seen mathematics as a boring and meaningful chore find themselves in an environment in which mathematical knowledge serves as a means to get something done which the child wants to do. This, for the first time, the child's perception of mathematics has something in common with what makes mathematics valuable and exciting for engineers, scientists, navigators, economists and others who actually use it.

I have used the metaphor of creating a Mathland (i.e. a place where people speak in mathematics) to convey a sense of the tremendous difference between learning mathematics in our computer rich environment and in a traditional classroom. The difference is analogous to that which separates learning French by growing up in France from

23-692 O - 71 - 11

learning French in a school room. When you learn French in France you learn it effortlessly, without a special curriculum and you learn it effectively. These things are also true when you learn mathematics as a language by conversing in it. The computer makes it possible to realize the concept of Mathland. Computers are mathematically speaking beings. At least in our LOGO environment, children get the computer to do something by "talking to it" in a computer language. This language is easy to learn and deeply mathematical in spirit. A major goal of my work has been to invent such computer languages and to find subjects about which children might like to mathematically converse with computers.

Much more research needs to be done. But even at this point, the work of our laboratory and that of Alan Kay at XEROX have shown that this approach works.

The idea of building Mathlands is not the only suggestion around about how computers could be used for enhancing mathematical learning. On the contrary, the more common suggestion is to use the computer to administer to the child perfectly traditional exercises in doing sums. In fact, I have no objection to using the computer as a teacher. But I want to clearly make the point that <u>in this particular case</u> it reflects a serious failure to understand and exploit the computer's true potential. Children who learn mathematics in a natural way in a Mathland environment do not need to have it drilled and drummed into them whether by a teacher or by a computer just as children do not have to be drilled in order to learn to speak their own native dialect. The fact that children need to be drilled in mathematics reflects that we are not using a natural learning process to teach them.

In its simplest form, my argument for how we should use the computer in the learning society is to exploit the computer's potential to create such natural learning processes. These processes tend to happen in total environments which facilitate them.

In the case of the computer, such environments need to be built, experimented with, rebuilt. Such studies, which involve building a new computer culture "from the ground up" do not correspond to the form which is expected when one files a research proposal. There is no simple variable to isolate, there is no curriculum being modified.

I have presented some images of holistic uses of the computer, uses of the computer which I believe respect the integrity of the technology, exploit it rather than constrain it. I have not done this to illustrate "success stories". These images have some common themes. They all suggest that the computer can be a cornerstone of a new learning society if our society embraces the fact that the computer offers us some radically new possibilities to truly become a learning society. We are at a turning point because social habits are pushing us into taking what could be revolutionary and making it banal by trying to assimilate computers into educational models that we developed in a pre-computer era.

When we speak about scientific progress we speak of paradigm shifts -- these are the stuff of which scientific revolutions are made. Our society needs a mandate to mobilize for such a paradigm shift in our way of looking at computers. Without it, our children will grow up in a computer culture, but one which has not been mobilized for an educational revolution.

STATEMENT OF DR. SEYMOUR PAPERT, DIRECTOR, ARTIFICIAL INTELLIGENCE LABORATORY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.

Mr. PAPERT. I would like to do that and I would like to say at the outset how important I think it is that you are holding these hearings. It will be the thrust of my testimony that we are on the verge of a real critical situation which I think deserves to be classified as a national crisis.

I believe that resources should be devoted to the study and direction of work in this area and if we fail to do this, there will be serious danger not only of a waste of an opportunity but also an aggravation of social problems within the United States and the U.S. position in the international area.

I am making very strong statements and basing them on a vision of the role of the computer in education that is much more radical and much more questioning of educational practices, in fact, much more subversive than most of what we have assumed in the past about education, than the view which is usually adopted by people in the community who are concerned with computers and education.

What I would like to do is first of all to try to convey to you a sense of how the computer presence will be able not merely to assist or improve traditional institutions like schools in teaching traditional subjects but will radically change what we teach, where we learn it, and how we learn it. And to make the point I would like to set up some analogies to use as images.

Mr. SCHEUER. Let me ask a question. You say what we teach or what we learn and where we learn. There are some people who feel that for some kids, low income, culturally deprived children who drop out of school systematically and predictably, are turned off by the public school system, the elementary and secondary school system totally and that they are almost incapable and so stultified to the learning process that it makes communication, even primitive communication between teachers and pupils, almost impossible and that probably there ought to be an alternative in that whole system.

For some kids it is not worth trying to improve and if we cannot teach them in an education-type environment, maybe we can teach them in the work environment. Maybe there ought to be release time. Maybe kids 14, 15, and 16, instead of being required to go to school should be permitted and even encouraged to get jobs and as part of that job they would have several hours per day where they would in effect learn the skills that they were not able to learn in an educational environment.

Do you think there is any validity to that point of view and is that possible? And if so, does the computer have a part to play?

Mr. PAPERT. I agree totally for many children and most children I would say that the schools do not work as a learning environment. The strategy should not be to try to fix the schools by making minor improvements in otherwise basic—they should be replaced by something very different. Now the computer can provide a viable alternative, and I'd like to describe to you how that might happen.

Mr. SCHEUER. Did I hear you say that you thought this was true for most kids in our elementary and secondary school system?

Mr. PAPERT. I believe that very, very few kids reach anything like the intellectual attainments of which they are capable.

Mr. SCHEUER. That is a horse of a different color, few adults do and few people do.

Mr. PAPERT. I think they all could.

Mr. SCHEUER. Few Congressmen operate at the level at which they are theoretically capable.

Mr. PAPERT. I think the job which the schools are trying to do succeeds only to a very small extent for almost all kids; that is, almost all kids could learn much more than they do learn and it would be under different circumstaces.

Mr. SCHEUER. And you will describe them.

Mr. PAPERT. I will describe some possible circumstances, but in describing these possible circumstances I am also submitting that part of what constitutes a crisis in this is that very little is being done by the society to study these alternatives, that it is almost impossible in the present state of funding and the present organization of the Federal agencies concerned with this problem, to get the sort of support that is necessary for the kind of experiments that need to be done and that all of us in this work constantly compromise ourselves by being forced to the kinds of experiments that you can get funding for which are very far short.

I think it will be my conclusion that Congress ought to be taking a position of leadership and giving mandates to the Nation and to the Federal agencies to do a very different kind of work in this area. But let me give an example of what I meant by a radical change.

Mr. SCHEUER. Let me clarify what I was trying to say. I think we are saying two different things and we may both be right.

You are saying that for almost all kids our present educational institutions at the elementary and secondary level, and maybe at the college and post-graduate levels too, they fail grossly to optimize their talents.

What I am saying is not inconsistent with what you are saying but it is simply quite different. For a significant number of kids the educational environment involving elementary and secondary schools is a sort of a Death Valley. It is nothing but skull and crossbones.

Mr. PAPERT. Really, I agree completely.

Mr. SCHEUER. The educational environment from the moment the kid comes into the building in the morning just totally turns him off and he is alienated and he is totally apathetic and he does not relate. There is just no possibility of a learning experience taking place for him. I do not think that is true of the majority of our kids. I do not think that is true. What you talked about may be true, that he fails to optimize his talents. But I would say for the majority of our kids in the elementary and secondary system seems to do pretty well. Certainly, for middle-class white kids it is fairly successful.

We do end up winning Pulitzer Prizes and Nobel Prizes for kids who went through this educational establishment not too long ago. For some kids it is pretty good. I have two daughters who went through school and college and through law school. My eldest daughter is working for a circuit court of appeals judge. For her the system worked pretty well. She took to it. Maybe she did not optimize her talents. Maybe she should be working for a Supreme Court Judge. But it wasn't all that bad.

But for other kids it is an unmitigated blooming disaster and for those kids we have to produce some kind of an alternative.

Mr. PAPERT. Can I talk about the kids about whom we agree that it is presently an unmitigated disaster?

Mr. SCHEUER. I don't disagree with you, but I am just trying to clarify that you and I are talking about two different groups of kids.

Mr. PAPERT. I am talking about both of them. But for the moment I will concentrate on the group you are mostly interested in.

Mr. SCHEUER. I don't say I'm mostly interested in them. I am interested in educational excellence, too. I think our college-bound kids probably could perform much better. I think in terms of a crisis in America. Maybe we have both crises, but we certainly have a crisis in turning out kids who by the time they get to be 16 or 18 are functionally illiterate, who do not have reading and writing as tools for life in a society that is fairly sophisticated and where these tools become indispensable preconditions for success in the work environment. There must be some job instruction and they must be able to perform in a world where writing is an essential form of exchange of communication. It is absolutely essential for these kids to learn to read and write.

Mr. WELLS. May I interject?

Mr. SCHEUER. By all means.

This is Bill Wells, our chief of staff.

Mr. WELLS. There is another aspect of this too, that the computer seems to be breaking down and that is the artificial barriers of the past between male and female types of education. I had occasion not too long ago to talk with the dean of the School of Engineering at the University of Virginia where my youngest daughter has just been enrolled and he is absolutely ecstatic that one-fourth of the entering engineering class this year is female versus a decade ago of 3, 4, and 5 percent.

We were talking about this and at least one element of this is the computer revolution, that females have moved into the computer field in equally, if not larger numbers than males. So I think this is certainly a big consideration.

Mr. PAPERT. Absolutely.

Mr. SCHEUER. Proceed.

Mr. PAPERT. Now I would like to think of one of these children for whom school is a complete turnoff who failed to learn even the most elementary mathematics or skills at school, who failed to learn to read or write effectively, in a sense.

Now before we decide that that kid is incapable of learning, we should look at what he did learn, and there certainly are things he did learn. For example, he learned to speak his particular dialect of his native language. He might not have learned to speak standard English but there is a very complex thing, the language that was spoken around him, which he learned very well to speak. Psychologists like Pieroget by probing more carefully have shown that there is a vast amount of learning that goes on completely unnoticed. Before the kids come to school they learn very effectively. The question I would like to ask is let's give a name to this. I will call that informal learning.

Mr. SCHEUER. The street smarts as we call them.

Mr. PAPERT. Kids learn the street smarts effectively and informally. When they come to school they fail to learn the school smarts at all.

Now using that as an analogy, I would like to talk about some research that we have done at MIT which asks whether you can set up a learning environment in which the things that are presently badly learned or not learned at all, using the school's methods of formal instruction, whether these things can be learned in the way in which the street smarts are picked up by every kid.

And we have found many ways in which this can be done.

Mr. SCHEUER. Tell us.

Mr. PAPERT. I will tell you about one that centers around the computer. I would like to pursue the analogy a little farther of using the street language, the dialect learned by the child, as effectively as the example.

If you want to talk about good learning, let us start with an example of successful learning and that is an example of very successful learning. Let us contrast the way in which you learn your own language as a child very well with the way in which you learn a foreign language like French in school, very badly. The difference is that you learn your own language by speaking in it to people who speak the same language with you and share common interests. Now can you learn mathematics in the same way?

Well, I believe those kids who turn out to be good at mathematics don't learn it in the school. They learn it because they are surrounded by adults, who, whether the adults know it or not, speak in mathematics. You might not know that you speak in mathematics, but speaking in mathematics means using certain kinds of rigor, precision and so on.

If we knew a magic way of manufacturing 1 million mathematically speaking people and distributing them in the streets, the kids might learn mathematics by speaking to them. We don't know that magical way. I'm sorry. We did not until a year ago. And there is a piece of it and there is a piece of it [indicating].

The computer is a mathematical speaking vehicle. The experiments that we are to talk about are experiments in which the child is put into an environment where he relates to the computer as a mathematical speaking vehicle.

And what we see in these environments are kids who are totally turned off from learning mathematics by reciting tables and learning things by rote. But they are totally turned on and absorbed by talking in mathematics to the computer. And they learn mathematics in the way they learned to speak their native language, without noticing that they are learning anything.

A favorite anecdote of something that happened in such a class is the following: A kid sitting there programing away. This is a kid who was right down at the bottom 5 percentile level of school before. This kid had learned to program in an experimental class we ran with support from the National Science Foundation.

There she was programing away. A very prominent math educator visited the classroom and asked the kid next door doesn't the computer make math fun. And this little girl looked up angrily and said, "Ain't nothin fun in math." And she went back to programing her computer.

I'm going to tell you about what she was doing with the computer. It was very mathematical. But for this kid the word "mathematics" had already been defined as something bad. And when she found herself doing mathematics and finding it fun she defined that is not mathematics. There is no reason to correct her. We let her go on like that, except a year later she made the discovery herself and by the end of the year she was saying, "You know, it is really quite easy. If I had not been so dumb in first grade, I wouldn't have all these troubles now."

By being dumb in first grade she didn't mean that she couldn't learn it but she refused it. Now that is typical of many, many students and anecdotes I could tell you about. I am using it as an example of how the presence of the computer does not just change the way you administer the same old lessons in mathematics. It changes the way you are teaching it by changing the relationship between the individual learning and the subject matter being learned.

Now in order to do this, of course, we had to do a lot of research and a lot of creative work. We have to set up this computer system with language that children love to learn. We had to set it up so that a child had something interesting to talk to the computer about. It is no good taking the first grade kid and saying we will talk to the computer about how to solve equations. The child doesn't want to solve equations, not yet.

So what we try to do in this project is invent things that it is fun for kids to talk with computers about. They write programs and kids learn computer languages very easily just as they learn any language very easily. They write programs to make pictures on the screen, to make the computer make music and many other things of this sort.

So this is establishing a rapport or relationship of the child with the computer by developing languages that the computer can understand and the child can learn and giving the child something to talk about with the computer, which means making graphic screens. You will see on the little computer that is drawing a picture. That is a very simple computer that is an example of the very low cost computers that are now being made for the home market and the kinds of pictures it can draw are probably not quite good enough to get the kind of involvement and engagement I'm talking about. Well, maybe they are.

But in a very small number of years there is no doubt that there will be in every home in the United States much more computer power than there is in that machine, much more computer power than the computer scientists of 1960 had. And this computer power will make it very easy for the programs of the sort I have been talking about, where the child uses a computer as a personal instrument to do things which are fun and meaningful to the child, like play music and do mathematics.

Another example. What about the written language? The same child we are talking about who learned to speak but did not learn to do mathematics also failed to learn the written language. And I think one reason—this is just taking one slice out of many—obviously, I could talk about this for a whole week, but taking one slice out of many, I would like to focus on this aspect of the written language, that it is not a communication medium for most people.

For scientists mathematics is a language, and that is why it is fun for them. And for some ordinary people, mathematics is a language but they don't know it and they learn it as a communication medium. Spoken language is a language for everybody. Written language is a language for some of us For many kids the written word is never used as a personal communication medium.

Enter the computer and the situation changes very radically. I disagree very strongly with the statement by Dr. Emery about how the electronic mails might be useful for handicapped students but wouldn't be particularly useful for the ordinary student.

I have seen situation in which children who were functionally totally illiterate, who were even thought to be incapable of reading, they were really illiterate as far as the teachers were concerned, when they got into a situation where they could communicate with the computer and they wanted it to do things, they started spelling and learning the alphabet. There were no lessons and no drill and practice any more than the baby needs these things.

There was for the first time a reason for this child to want to communicate in a condition that demanded written communication. I think the same thing is true for the electronic mails that insofar as the computer network opens up the exciting possibility of being able to be in touch with many other people and being in touch with them in different ways through a written means of expression, this transforms the written language into a personal communication.

Another example of how the computer presence just by being there—I mean not by administering lessons but by being there it can change the way in which language can be learned and perfected. In these hearings I was told by Dr. Swanson that my words are being written down. They are going to be typed up and sent to me for correction. I will have a chance to edit them and they will come back here. No doubt some staff members will edit them further.

Mr. SCHEUER. No. No. No. You will be the final word.

Mr. PAPERT. They will be printed and people will read the proofs and typos will be corrected and they will eventually go out.

What I'm trying to say is between my thoughts and the emergence of that final document there is a complex process of editing, changing, typesetting, correction, and so forth.

What I want to say is in the production of this document there is a considerable amount of structured activity mobilized and deployed in order to produce this document.

Every time I write a paper the same thing happens. I have a secretary who will write it and give me a typed version and let my make corrections and it might go through several rounds of this. This is the way in which in the end one produces good writing and the way in which we improve our skills in writing.

Now I would like to compare that situation with what would happen if I were an average sort of third grade kid—let's not take an average—let's take one of those you were talking about who is scarcely able to read and write and who is very unhappy and antagonistic and negative in the school setting.

He is told to write a little test. Very painfully and slowly he spells out these almost illiterate and illegible scrawlings on the page and he turns it in with a sign of relief. What he never does is to take what he has written and read it—he can hardly read it himself—criticize it and listen to someone else's criticisms and modify it He doesn't have the secretary or all of these technical resources that I have.

The computer can give it to him just by being there as a text editing system, provided it is set up in a way that is congenial and resonant with what seems to him personally syntonic, it matches, it kind of feels right. If it's in the right sort of feel for him, he can use this so he will write by typing at this computer. The output will be perfectly clear text. If he wants to change it, he doesn't go through this laborious process for him so slow of rewriting. He only has to tell the computer change that word.

We have seen a few experiments in which various people of different ages put into an environment where they have access to such computer editing systems, the amount of writing they do goes up enormously. But what goes up even more enormously is the amount of rewriting, because people who have never in their lives rewritten anything begin to do this all the time. They are constantly changing and correcting and editing. And as they work on this text editing it they are also editing their own abilities and improving their own abilities to do it. So there is another example in which the computer being there is able to have an impact on the way in which people learn to read and write.

Now we contrast that with a different way in which computers are being used these days to help reading and writing or to help arithmetic. Computers are being used in schools to drill the kids in spelling or to drill the kids in arithmetic. The computer says fill in the gap or which of these words is wrongly spelled or it says what is 7 plus 8 and if you give the wrong answer it says stupid. Now it seems to me that that is the most self-contradictory misuse of a technology that there has ever been, because the computer is being used to cure a disease which could have been prevented by a proper use of the computer. I think these kids are having trouble in school with arithmetic or spelling because they never became engaged in the process of natural learning of the written language and of mathematics.

Now what the computer should do is give them that and we would not need to drum and drill them in the schools. Why have we adopted this more primitive use of the computer? I would end this by raising an important kind of social warning. This is why it is a national crisis. The pattern of social appropriation of any technology works like this that the first piece of the technology you have is very primitive. You don't know how to use it so what you do to it is the same old things you have done before, but slightly different.

The first ancestor of the automobile was a horseless carriage and it really was that, a carriage with an engine attached. The predecessor of cinema was when they made the movie camera they put the camera in front of the stage and acted a play. It took a whole generation before we really understood that cinema could be used in a much more creative way than doing the old kind of acting. There were new things you could do with it. I see what has been done up to now with computers in education as like the horseless carriage and like the cinema movie camera before movies were invented, before Hollywood happened.

One reason why that should be so, of course, is that is the natural thing to do first. Another reason is that up to now computers have been a scarce and expensive resource. One has had to justify the buying of an expensive computer to use in an educational setting. This is changing rapidly. It is changing not because of the leadership given by the education community or even by Congress—and I hope this will change—it is changing because the leadership which has come from industry which has committed itself to a task of miniaturizing and lowering the cost and bringing the computer into the lives of the people.

There is a process afoot, which quite independently of the decisions of educators, is going to put into the hands of every child in every home this tremendous computing power.

Mr. SCHEUER. When you say in the home, how is it going to get in the homes in southeast Washington or in Harlem or Bedford-Stuyvesant?

Mr. PAPERT. I believe by the end of the 1980's you ought to be able to buy a television set that is not a part of a computer complex. I believe that the cost of a computer is going to be so small that people will buy computers as toys for their children. This will be cheaper than buying a balloon. I exaggerate. It will be cheaper than buying the average sort of toy that is now bought for Christmas, even in Harlem.

Mr. SCHEUER. Bill Wells, who is our staff director, says you can go into the barrios of San Juan and in every home, even if they don't have running water, they will have a television set. I was explaining to him that in New York's Harlem and Bedford-Stuyvesant and the South Bronx and the worst of the slums that you can go into an apartment and it not only has a television set but more likely than not it will have a big console of television and record player and the whole schmeer worth $700 or $800.

Mr. PAPERT. That is the way the computer will come into the homes. It is going to come into the homes as part of the desire of people for what you might call entertainment, if you want to be disparaging.

Mr. SCHEUER. How are these kids going to learn how to orchestrate this computer so that they have fun and relate to it? Where will they learn it?

Mr. PAPERT. I would hope they would learn it—that the official education system would do something about helping them to learn it. But I think there are a number of scenarios and I don't know which will be the way it will play out. I think computers, much more than anything else, can be selfteaching.

Mr. SCHEUER. Will there be televisions shows like Sesame Street that will show the kid how to use the computer?

Mr. PAPERT. Absolutely, there will be. But I think that is only one of the possible channels. Let me repeat The kids learn to speak without anybody really showing them how to speak. They learn to speak because they are surrounded by people who are speaking. I think they will learn to use the computer because they are surrounded by computers in much the same way. I think this needs research.

And what a lot of our research has been devot[illegible] is creating things to do with the computers have what we call no threshold. For example, in order to learn to program that computer you have to spend at least 5 minutes and if you are an illiterate child you might have to spend an hour.

Mr. SCHEUER. How much time would a Congressman have to spend?

Be very careful. [Laughter.]

Mr. PAPERT. We have set things up and we have tried to create languages for toying with the computer and things to do with them so that in the first minute, even if you are illiterate, or even if you are a 3- or a 5-year-old child, in the first minute you can do something.

Mr. SCHEUER. I'm willing to try it.

Mr. PAPERT. I'm afraid Eastern Airlines shook up our computer and it is not going to work. You are welcome to come to MIT and we are willing to bring it down again.

Mr. SCHEUER. I would like to have you bring it down again.

Mr. PAPERT. Well, maybe the point hardly needs to be emphasized, but I think I would like to end on optimism and with a cautionary statement. The optimistic statement is that computers are going to be there. We don't have to worry about how to get them into people's lives. What we do have to worry about is the cautionary side which is how we can influence the way in which they are used and what the relationship is between the computer and the evolution of the public school system. I think the presence of the computer both in the way I have been talking about of replacing formal learning by informal learning but also insofar as the computer itself can be a teacher and can maybe come to do formal instruction very effectively. I think the computer raises or puts into question the public school system by, for the first time, offering a viable alternative to it. I hope that the public school system is going to be able to adapt itself.

Mr. SCHEUER. In other words, you are saying it can either be integrated into a more enlightened and more sensitive public school environment or it could be a substitute for the public school.

If it is a substitute, where are the kids going to go for the substitute? What kind of place will it be? Is it at home?

Mr. PAPERT. I believe a lot will happen at home. I also believe that there will be social contacts across computer networks. I believe also that new kinds of organizations will start off as sort of clubs and things like that. There is the home group computer club in California that is a fantastic and novel kind of organization of computer hobbyists.

Mr. SCHEUER. Are these really sophisticated kids who are making it at school and who have thereby become computer mavens?

Mr. PAPERT. Let me say that we don't know very much about how to answer those questions. I think we don't know very much how to answer those questions and I think that the study of who gets caught by the computer under what conditions and who gets stimulated and challenged is a complex question of psychology and sociology which is getting almost a negligible amount of attention although it should be one of the major questions confronting our society.

Dr. SWANSON. Since we are talking about exposing rather young children to a high powered technology, I wonder if there are any studies to document its effects. Does your own experience indicate that there may be harmful psychological side effects with young children working with computers?

Mr. PAPERT. It is very clear that the close, intimate interaction with computers has a powerful effect on the mental life of some individuals. We know cases where that effect seems to be negative. It makes people antisocial and draws them into such close relationships with the machines that they are cut off from other people. We know other cases where it is invigorating and stimulating and brings the kid out of the depths of depression, out of even autism in one well-documented case.

So both of these things can happen. Where urgent research is necessary is studying under what conditions which of these things happened to what people. I think this has to be recognized. One of the things this committee can do is to give recognition to the urgency of this kind of issue as a national crisis.

One of the recommendations I would make is that a very high level committee be created on the educational and psychological uses of the computer. My answer is that it can go in all sorts of directions and there is no point in guessing or speculating about which way it will go. What there is least point at all in doing is simply trying to turn a blind eye to it and put one's head in the sand and say ban the computer.

Mr. SCHEUER. Has anybody said that?

Mr. PAPERT. Indeed.

Mr. SCHEUER. What does the teacher's union say?

Mr. PAPERT. A lot of teachers are terrified about the computer and the reason they are terrified about the computer is that they see it as an alien and threatening thing. They don't see it in the spirit in which I'm talking where it is a very humanizing thing where the use of the computer which children use, learning mathematics by talking to the computer in mathematics, such children are much easier to teach, because they want to learn. So the role of the teacher is facilitated.

For many teachers the computer is seen as something that will displace or substitute for them or make their job harder.

Mr. SCHEUER. We will send you the transcript of testimony given last week at the first one of these hearings by a superintendent of schools from my congressional district in Brooklyn, Dr. Harvey Garner, who has been carrying out a computer program and he detailed for us how about 2 years ago when they started that teachers as well as the parents were extremely skeptical of the computer both in terms of its management potential and its learning potential. And now the teachers are overwhelmingly enthusiastic in support of the computer because they think the computer enables them to do their job better.

Mr. WELLS. You might mention Mr. Shanker.

Mr. SCHEUER. Yes; and Al Shanker himself, the president of the teacher's union in New York, supports the computer, because he is convinced, too, that it enhances the role of the teacher and enables her to be very much more cost effective, enables her to relate better to the kid and it creates a much more positive environment in which all of the participants can function.

Bill?

Mr. WELLS. Dr. Papert, you mentioned the virtual absence of any significant work in the social sciences regarding the implications of some of the things that you see on the horizon. How best do you see this being formulated, an approach being formulated? Does the computer industry which is spearheading this have a responsibility to try to hook up with the social scientist or do the social scientists have to barge in and say what the hell is going on here?

You mentioned some types of conditions now. Are you thinking of something along the lines of the Kennedy-Johnson Commission on Automation Technology in the Economy which took place in the midsixties because of alleged rising unemployment because of automation? Is this the kind of thing you perceive?

Mr. PAPERT. I think we need a multipronged approach and need to do many things. That is one of them. I certainly don't think that the burden should be placed entirely on industry. I think there are some aspects of it that industry can, should, and in some cases, does perform very well. But there are some aspects which are not inside their scope. I would like to mention one or two others that I mentioned in the paper you have as to the institutional answers to it. I think one of them is setting up some such commision.

I think other people have a better expertise than I do in deciding what kind of commission or committee it should be. I think it is very important for the few suitable universities to create academic centers of excellence in the area which we call computers and people, the psychological aspects of the computer.

I imagine that the faculty and research staff of such a center would include both computer scientists, sociologists, psychologists, and educators. I think there is going to be a very desperate need in a few years time for expertise in the society.

I think not only do we need research to be done, but we need to train the professionals who are going to serve these functions and the only way we can do that is by setting up university programs. So I think that ought to be done and, of course, I think that the funding agencies like NSF and NIE should be given not only more money but more especially a mandate to use it in a way that is better matched to the requirements of this growing field.

Dr. SWANSON. Does that mean that currently you feel there is a lack of direction and purpose on the part of the executive agencies as well as limtied funding in this area? Also a lack of recognition of the so-called crisis that you are talking about?

Mr. PAPERT. Yes; indeed. In the paper I made the distinction between the incremental local improvements in an ongoing system and wholistic, global rethinking of the problem. The way in which education research is being funded and the way in fact it is being done in the education research places is much more geared toward the incremental local improvement than toward the wholistic redesign. And this is because until right now there has not been the technological base for making any wholistic redesign. So wholistic redesigns have simply been up-in-the-air talk and so people became disillusioned by them and naturally they don't——

Mr. SCHEUER. Have you ever done any thinking or writing on the subject of what an alternative system would be? Would it be a social club or a day care center? Would it be a place of employment for kids 14 to 18? Or maybe we need a lot of options.

Mr. PAPERT. I was going to say all of the above, but I think what we need most urgently is for some people to be able to set up today or next year simulations of the way it will be in 5 years' time. We should not wait until the computers are everywhere and these new clubs and ways of operating come into being spontaneously and they worry about whether it is being done effectively. I think what we need to do right now is some experiments or pilot studies in which many of those options can be explored by creating preliminary models, creating envirionments in which those things can be carried out.

I have given a lot of thought to how one might do such pilot studies. What I have given more thought to and have been more frustrated by is how on earth one can ever get the money to be able to do such a thing.

Dr. SWANSON. One question that logically raises is in fact it seems like you are trying to bootstrap the whole effort. If you are talking about demonstration projects in several locations next year, what is to say there is not a paucity of researchers with the kind of vision you are articulating to staff those centers?

You are saying two things, that we have to create centers to train the people and we want to have an ongoing research project. What is the solution?

Mr. PAPERT. I think that question needs very careful thought and one has to do it in a well-considered and well-planned way, but we have to do it and we have to make the best of what we can with the resources available, try to channelize them into reasonabl large-scale critical mass projects. I think the way in which work is going in this area, like a lot of others is like if you have a 1,000-foot canyon and the way you jump over it is to line up 1,000 people each of whom can jump one foot and say "jump."

Mr. SCHEUER. That is something I can understand. [Laughter.]

Mr. PAPERT. I can give an example of just that. Let's take this area of an even more extreme case of where we know how to apply the technology rather than the dropout kids in the elementary school, let's go to the area of the very severely mentally handicapped. Let me, to be specific, concentrate on physically handicapped because I have had some experience myself in the area of cerebral palsy.

Mr. SCHEUER. Is that a mental handicap as well as a physical handicap?

Mr. PAPERT. Let me tell the story. This is just where there is a problem.

Mr. SCHEUER. Are you talking about learning disabled children?

Mr. PAPERT. I had the opportunity of working last year for about 20 hours with an adolescent who had reached that age without ever having manipulated an object. He does not have enough control of his hands to pick anything up and move it. He has no speech. He cannot walk. He has lived in wheelchairs, a life of total dependency. He doesn't express himself very well. Everybody thought he was retarded. The reason they thought he was retarded was such things as the following: The way he communicates his elementary needs uses a method that is very widespread.

He has a stick on his head and he can move his head a little bit and his hands. He has this thing called headstick and a big thing called a word board on which symbols or words like bathroom and hungry are located. He communicates by pointing at it. Now many kids with his degree of ability to move their head very painfully and slowly learn to type by poking at the typewriter. This kid had never learned to type, nor several other things. This had caused him to be classified as mentally retarded. Now the reason was very different, as I can prove in this particular case. The reason was that learning to type was not worthwhile for him. What's the payoff in learning to type if you do it so badly and you still have to rely on somebody putting the paper in.

You are even more dependent on other people. Who wants it? Now by connecting the typewriter to a computer so that this kid by poking those keys could cause pictures to be drawn on the computer screen, could instruct the computer to print out the pictures on a printing machine so that this kid could for the first time in his life draw, not only draw but make an object with a drawing on it, which is the first gift ever made by him and given to anybody, which he sent home to his parents, or caused to go home to them.

It made sense now to learn to poke at a keyboard and within a few weeks he was typing as well because it was worth his while to learn to type with the computer. I have seldom had such a moving experience.

But I would like to say the other side of it that is grotesque that comes I think almost close to a national violation of civil rights of these people. When we have tried and expended a great deal of effort in trying to get funded a project to do what I'm going to describe for these people, and we cannot because of the fragmented policy of lining up—for example, right now the Bureau for the Education of the Handicapped has just issued a call for proposals. It has $3 million for a program of research, development, and demonstration of technological devices for the handicapped; $3 million is little enough, but it could actually be used except that there are 1,000 people on the side of the canyon phenomenon. The call for proposals explains that the policy—although there is no limit to the amount you can ask for—but in the past money has been given for $80,000 or $100,000 grants. I claim that giving $80,000 puts a researcher in a position to say make a little electric typewriter so that somebody can poke at it. But it is not enough to make much difference in the life of this individual.

Mr. SCHEUER. You are talking about the critical mass problem.

Mr. PAPERT. I believe if we had critical mass we could, by linking this person more effectively to the computer than having him poke at a typewriter, the door to learning and culture and self-sufficiency and independence and a career could be opened to him.

A concept which I have been trying to label informational prosthetics means that with the computer this person can learn, this person who is being completely isolated and dependent can manipulate information and can do any job in the world which primarily involves manipulation of information. Like your job primarily is manipulation of information, or that of a writer or musician or scientists. I believe with this technology if we had critical mass we could bring a person like that to a position where in 3 year's time he could be earning a living and earning a living by entering into a field with open possibilities where he could settle for a routine job, if he wanted but where there is a challenge for more creative careers open in front of him. We are not doing that and we are not doing it largely because of such policies as fragmentation of research and the fact that people in the education community and especially in the care of handicapped tend to be rather antitechnological in their outlook and largely because of a self-enforcing policy.

In the past technology has been disappointing. The technologists are limited to making tiny steps which confirms the belief that technology doesn't do much good. Many studies have concluded recently that technology is not cost effective in education. Look carefully. I say that the reason is that they have tested out a technology which is subcritical. It would be as if when the refrigerator was invented you said, "Ha, we're only going to be able to allow people to make refrigerators that drop the temperature by 1 degree and we'll see if that does some good first." And if people like that, we will make refrigerators that drop the temperature by 20 or 50 degrees. When we put out these refrigerators that drop the temperature by 1 degree and everybody says the food goes rotten just as much as without the refrigerator, it does no good, it does harm, because it reinforces false expectations and a negative attitude toward technology.

I think the story of technology and education is very analogous to my story of the 1 degree refrigerator and the thousand people on the side of the precipice.

My story of the handicapped is just one example. I said it because it was a dramatic example and one where I hope Congress can and should see it as a legal and constitutional responsibility.

Mr. SCHEUER. You know in the last year that the courts have said that education is a constitutional right of educationally handicapped kids and that the State cannot say that this child is ineducable and do nothing for him. There is a constitutional mandate for the State to have appropriate education for all kids, educationally handicapped and even kids that we have up to now described as ineducable have constitutional rights to education and constitutional rights for the State to make extraordinary efforts to design education programs relevant and sensitive to them.

Mr. PAPERT. The problem is what is appropriate. You see, all the school systems in the country are doing what they consider to be appropriate, but the perspective on these technological possibilities that is distributed in the education community is very far behind what can be done so that what they consider to be appropriate is very different from what is appropriate and there is the problem.

It is all very well for the courts to rule that you must do something, but if the people who have to decide what to do are profoundly out of touch with the spirit and pace and possibilities of the only technology that can be effective, well the court ruling has been carried out in a legalistic sense but in a real human sense, it hasn't.

I think we possibly need to change the legislation in order to make what is legal become more matched to what is real.

Mr. SCHEUER. I agree.

Mr. WELLS. We might mention to Dr. Papert that we are holding joint hearings a week from today with the Education and Labor Subcommittee that deals with the handicapped and vocational rehabilitation.

Mr. GALLAGHER. Just one question. It was mentioned as to the possibility of some adverse reaction by teachers and unions, and so forth, and that some examples show that they welcome the educational computer to complement their work. But with the home computer it seems to me there is a lack of control that a teacher has over a classroom situation. At home the student could be getting answers to social science questions that are completely different from what he is being taught at school, which could cause a problem.

Second, many teachers are fearful now that the homework is not being properly done by the student because of outside influences; namely, television. I am just wondering if you would want to comment on this?

Mr. PAPERT. The problem you are raising is real and serious. You recall that I said earlier I see the future of the computer in the home as a serious challenge to the public school system. I think it is not inconceivable that the public school system can collapse if it fails to make adequate responses to this challenge. I think the problems are very serious and have to be taken very seriously.

I don't think that any encapsulated answer I could give in a few sentences would deal with the questions you are asking except to say that those questions need deep, serious, and large-scale study with adequate resources of people and the possibility of experiment and simulation and setting up models and pilot studies where we can see that sort of thing happening as early as possible so as to anticipate as best we can what it is going to do and what it is going to deal with.

I think nobody knows enough to give an expert answer to what is going to happen in those respects. I can tell you my guesses but they are only guesses. I think we have seen little examples in this sort of thing where the educational community has abdicated the responsibility of leadership. An example is the story of the little hand-lead calculator. I don't think its impact is so enormous that it may turn into a national problem. It is not nearly as potent in its ability to affect people as the computer. But it is a little forewarning of what is to come.

As a statement of the problem, let us review a little of the history of that. You see, the hand calculator was the product of industry and industry produced it and put it out. The first reaction of the education world to the hand calculator was to say let us do studies to see whether this is good for the kids and whether it is good for the kids to have calculators and how can we incorporate them into the classroom.

They started with a slow pace of little studies here and there. Long before they were answering their questions through their slow paced studies everybody had these calculators and calculators were everywhere.

Mr. SCHEUER. The kids had them?

Mr. PAPERT. Yes. The most successful teaching machine is a little calculator called the Little Prof which is a little Texas Instrument calculator where you can punch into it and ask yourself little arithmetic questions and get answers. It is really fascinating to see how the kids like it. Why do they like it? I think they like it because it gives them a way of doing arithmetic in the quiet privacy of being alone without anybody looking over their shoulders, neither a teacher nor another kid.

There is something about the relationship between this machine and the individual and in taking account of his whole way of thinking and what makes numbers and what they are to him that explains how this little machine is so catchy for these little kids. So I think Texas Instrument did a good job. They did one of the most significant pieces of educational research that we have seen in this decade, significant except there were not the resources and expertise to watch what was happening.

The school systems were doing their experiments inside their classroom. They didn't realize that what was happening outside the classroom and what was happening in a child's bedroom when he takes this thing to bed with him and punches in, it is something he communicates with. But the school systems weren't watching that and that's where the action is. What I'm trying to say is because of certain narrowness of vision of the whole education establishment and its way of thinking that it is failing to collect the data and develop perspectives on what is really a social movement.

Mr. GALLAGHER. Speaking of that, if it is adapted to television, how will dad watch the world series when the kid is working on the calculator?

Mr. PAPERT. Well, there you go. I think we need to take these things very seriously. We need to see that there are built in structural aspects of the features, the structure of the official education somehow seems to keep it from taking the leadership and doing the right things.

Mr. SCHEUER. What would you like to see come out of this hearing? If you were chairman of this subcommittee or staff director, what kind of report would you like to write and who would you urge to do what?

Mr. PAPERT. First of all, I think something is done just by having the hearings. I think that acknowledging this as a major and important area for thinking and study and concern is perhaps the most important thing to do. I think it should go further than such hearings as this so some sort of committee, commission or planning organization should be set up.

Mr. SCHEUER. Could the executive branch and legislative branch outside the public sector, is this an intercorporate group? Is this something that Brookings or a Ford Foundation or the Rockefeller Foundation should do? Should Joe Califano set this up? Should there be a White House conference on computers and learning?

Mr. PAPERT. I think it should happen in whichever way can mobilize deep-thinking, responsible people with influence to be able to confront these issues and to engage them on a sufficiently deep level not to be making superficial judgments that express prejudice. Whatever method of organization best achieves that and gives large scale national prominence and clout to what gets discussed there, that is what is needed. I would say that is one thing.

Two, as I said before, I think mandates and funding for the agencies which can do something about projects should be given. I think the conditions for setting up some sort of academic centers of excellence of the sort I mentioned should be given great priority. Those are the steps I would take at this state if I were you.

Mr. SCHEUER. You have been extremely stimulating and thought provoking. As you can see, we have sat here for a long time.

Dr. Papert, thank you very much. We have enjoyed and been stimulated by your remarks.

Dr. John Seely Brown of the Computer Science Division of Bolt, Beranek, and Newman, Inc., of Cambridge, Mass.

As I have told all of the witnesses, your testimony will be printed in the record at this point in its entirety and will you chat with us informally as the two preceding witnesses have done?

[The prepared statement of Dr. Brown follows:]

Notes for Addressing the House Science and Technology Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation

regarding

Computers in a Learning Society

Presented by

Dr. John Seely Brown
Bolt Beranek and Newman
50 Moulton Street
Cambridge, Ma.

Prepared by

Dr. John Seely Brown
Bolt Beranek and Newman
50 Moulton Street
Cambridge, Ma.

and

Professor Ira Goldstein
Massachusetts Institute of Technology
Cambridge, Ma. 02139

October 12, 1977

Notes for Addressing the ... and Technology Subcommittee on Domestic and Internati... Planning, Analysis, and Cooperation

regard ... in a Learning Society

I wish to thank the subc... owing me to address it today.

We are at the beginning of an Inform... olution.

I believe that a revolution is po... le over the next decade that will transform learning in our society, altering both the methods and the content of education. This revolution can occur by harnessing powerful computer technology to serve as <u>intelligent instructional ...stems</u>.

It is clear to those who follow ... cost projections that powerful personal computers will become widespread over the next decade. However, it is beyond the vision of many that these computers can serve as intelligent, sensitive tutors for a wide variety of subject matter.

No one would debate that computers can be page turners or rote drill and practice monitors. But it may seem impossible that they can be insightful tutors, responding appropriately to a wide range of unanticipated situations.

A new paradigm, however, is now emerging. In my laboratory and in the laboratory of my colleague, Professor Ira Goldstein of MIT, we have focussed on providing computers with an ability to <u>understand the learner</u> -- that is, understanding his strengths and weaknesses as well as his style of learning. This enterprise, the design of Intelligent Instructional Systems, treats as central -- first, representing expertise within the computer, thereby escaping the limitations of traditional, frame-based CAI; second, building structural models of the learner's skills. thereby being responsive to the needs of individual; and third. communicating in restricted English, thereby escaping the straightjacket of computer jargon.

These are difficult problems that raise deep questions about the very nature of learning. But they are problems that we can approach through an interdisciplinary effort of psychologists, educators, and computer scientists. From this effort is arising a theory for bridging the gap between a learner's needs and the machine's capabilities; a theory that will make the computer a truly personal tool.

Since 1970 we have been exploring the computer as intelligent instructional agent. We embarked on this endeavor because we saw the 1970's as prelude to a massive dissemination of computer technology with truly incredible capabilities. We believed that while others were successfully nurturing the growth of this technology, there remained a pressing need to understand the cognitive issues involved in its use.

This need was not being met by classical computer aided instruction, whose vision of the computer was largely shaped by the capabilities of technology of the 1960's. In contrast, we foresee a computer-based learning environment radically different from the traditional classroom situation -- an environment based on a guided "learning-by-doing" both in the home and in the school.

Prototypes of the future must be created today.

Let me now introduce you to three prototypes which manifest some of the capabilities that could be realized in tomorrow's learning environments. The first prototype explores a potential transformation of technical education through the computer acting as consultant; the second explores the potential for a fundamental change in educational evaluation through the computer acting as assistant; and the third explores the potential for a renaissance of education in the home through the computer acting as coach.

Computers can serve as consultants.

My first example explores the dramatic impact intelligent instructional systems can have on technical education. Training competent technicians to repair the everchanging number of devices and technologies on which our society depends is an important educational goal. The mass dissemination of tomorrow's powerful computers makes possible the widespread use of simulations in technical training. Just as flight simulators have long been important in training pilots, we believe that electronic simulations, for example, will be equally basic to technical training. These simulations provide inexpensive and safe opportunities for students to explore the complexities of a device.

The critical contribution of the intelligent instructional system is to monitor and critique simulated tests and repairs made by the student. We have designed a prototype of such a system called Sophie for a limited part of the electronics domain. Sophie presents the user with a simulated circuit to be fixed. The user can make any measurements he wishes, replace any parts. Sophie observes these measurements and employs a deep understanding of electronics to decide whether a given measurement is needed or a given part replacement justified. Its tutorial function is to discuss these observations with the novice technician. In essence, it is a troubleshooting consultant. The student can explore the device with no possibility of harm, in a private setting.

The availability of such consultants also solves another critical educational problem: that of continuing education. A technician faces the difficulty that the devices he is expected to repair are constantly changing. Written material is a clumsy means to document these changes, for it is a difficult medium in which to describe the dynamic nature of repair procedures. We envision Sophie-like consultants as being the basic medium by which technicans receive ongoing education. They are dynamic, they are organized around experience, yet they are easily modified to serve as an educational environment for a changing technology.

There is still another role such consultants can play. We believe the citizen himself can employ them to reduce the alienation engendered by modern technology. Sophie-like environments are fun: it is quite enjoyable to take apart a simulated TV set to see how it works. The embedded computer consultant can provide a guided tour of the device by embodying a deep theory of the domain along with a cognitive theory of what constitutes common sense understanding. While the citizen will probably never actually repair his TV set, he has gained a sense of command, of personal power through a better understanding of the devices which he employs.

Indeed our vision extends beyond consultants for technical repair to simulations and coaches for a vast number of activities in our culture including flying a plane, sailing a boat, building a bridge, and even piloting a moon shuttle. Moreover we are designing a consultant for the task of programming itself, to avoid the computer becoming a source of mystery and alienation.

Our culture has grown so complex that many feel it is beyond their understanding. Through the simulated world of the computer, with the advice and aid of an embedded consultant, a dramatic and beneficial improvement can occur in our understanding of the world around us.

Computers can serve as assistants.

Our second example concerns an intelligent instructional system capable of diagnosing the underlying cause of errors in a student's basic arithmetic skills.

Below is a set of problems a young student, Johnny, was given in an actual classroom. All of the additions are wrong. Not surprisingly, the teacher concluded that Johnny could not add.

87	365	679	923	27,493	797
+93	+574	+794	+481	+1,509	+48,632
---	----	----	----	------	-------
11	819	111	114	28,991	48,119

But the teacher was not correct. For Johnny had a perfectly reasonable procedure for addition; it just had one small bug. When adding two digits with a carry, he wrote down the carry and threw away the units digit. Johnny was only one small step away from a correct procedure, a fact that the teacher failed to observe for most of the school year. The failing grade produced by traditional evaluation neither diagnosed the nature of Johnny's misunderstanding nor helped him to debug it.

Recently we have designed a prototype diagnostic assistant called BUGGY that can construct procedural models of students' arithmetic skills. BUGGY examines a student's answers and grows a diagnostic model that best explains the observed errors. In a recent experiment, BUGGY analyzed over 10,000 problems done by 1300 students. The results were procedural models for each student, identifying the bugs in that student's arithmetic skills. In the case of our young student Johnny, BUGGY would have inferred why Johnny can't add.

The consequences for standardized tests of the 1980's are enormous. It is entirely reasonable to conceive of the current national tests being replaced by student interaction with systems like BUGGY. The result would be evaluations less susceptible to the uninformative yes/no quality of statistical scoring, and far more useful to the educator and to the student.

In concluding my discussion of this example, let me stress that before BUGGY could be built we needed to have both a deep procedural theory of the basic skills of arithmetic as well as a set of diagnostic heuristics. Before such systems could be built for significantly more complicated domains--such as reading comprehension--equivalent theories must be constructed for those domains. In other words, dramatic advances in computer technology alone will not suffice.

Computers can serve as coaches.

My third example is perhaps the most fundamental of the three, for it envisions a renaissance of learning in the home.

I will set the stage with this radical statement: I see the TV set, as we know it, disappearing in ten years. It will disappear by becoming a part of the home computer installation. Of course, the TV/Computer will continue to receive commercial programs. But this will no longer be its central role. With far more frequency, the American family of the 1980's will be using its TV/Computer to play games; to watch interactive films in which the viewer can effect the outcome; and, most important of all, to access the treasure house of human knowledge that will be stored in the memory banks of these computers.

We believe that the TV/Computer will revolutionize learning in the home by uniting recreation with education into a single self-motivated enterprise. To explore this possibility, we are investigating how intelligent instructional systems can make computer games into arenas for acquiring basic intellectual skills. We are looking at computer games because they will probably be the single most popular use of the home computer. Hence, they provide a crucial point of educational leverage.

The idea is this: some TV games provide a challenging and active educational environment. However, as with any game, the player can reach a skill plateau. Good coaching is then required to move the student off the plateau. This is the function of the intelligent instructional system. It provides this coaching by embodying expertise for the game, modelling the player's skills, diagnosing plateaus, and supplying appropriate advice to help him surmount his current difficulty.

A representative TV game for which we have constructed a Basic Skills coach is a modern day version of Theseus and the Minotaur. Play occurs in a maze of caves, in which various dangers reside. To play well, one must employ knowledge of logic, probability and geometry to determine the best move. Thus, the game is designed to exercise basic reasoning skills.

Clearly it is important that these games are an environment that is active, that captures children and adults, and that exercises important intellectual skills. But their revolutionary impact derives from our ability to add a cognitive component to these systems, a personal coach serving to advise the player.

To illustrate our prototype coach, suppose Mary, a young player, has reached a skill plateau. For example, she is not understanding the common sense heuristic that multiple evidence carries more weight than single evidence for competing hypotheses. Our prototype coach can observe whether Mary is consistently failing to apply this heuristic in her play. If so, the coach waits for an appropriate situation and offers advice. For instance, the coach might say:

> *Mary, it isn't necessary to take such large risks with the Minotaur. You have multiple evidence that the Minotaur is in cave 14 (where you want to go) which makes it quite likely that the beast is there. It is less likely that cave 0 contains the Minotaur. Hence, Mary, we might want to explore cave 0 instead.*

In the absence of such advice, Mary might be long delayed in acquiring this heuristic and the other basic skills exercised by the game. In a natural way, the computer coach marries education to recreation.

Of course, a human coach could also perform this function. But this is not practical when one realizes that these games will be in the home, played as recreation by any member of the family at any time.

Naturally, there are many subtleties in creating a successful computor coach: the coach must not interrupt too often, it must not give explanations that are too lengthy, and it must retain a rapport with the student. To this end, we are constructing a procedural theory of the teacher that takes account of such considerations. It is a difficult enterprise and much work remains to be done. But it offers the possibility of making the computer the ultimate in congenial tools, one that is sensitive and responsive to its user.

Now MINOTAUR is only one game among many that we could have discussed. For example, we have constructed computer coaches for the PLATO project's arithmetic game "How the West was Won" and the math educator's game of "Attribute Blocks". Rather than relying on canned responses, all of those coaches embody an ability to construct diagnostic models of the strengths and weaknesses of the student's play, and techniques for generating explanations for any situation that may arise in the game.

The potential here is enormous. Imagine, for a moment, ten thousand computer activities -- all intellectually challenging, all different. Now imagine tens of millions of citizens engaging in these activities as recreation. And finally, add to this vision the availability of coaches. Explicitly, the coaches provide advice to improve play; they serve a recreational purpose. But, implicitly, an educational purpose of the most profound kind is being served. In essonse, we are creating a new environment for learning, centered in the home and equipped with personal tutors available on demand. This environment is activity-based and is ideal for reaching that segment of the population for which the classical schoolroom situation has failed.

A new science of learning is emerging.

Let us now step back from these examples of intelligent instructional systems. We have organized our discussion around them to give a concrete feel for the future we envision. But such an organization conveys only implicitly the most important characteristic of this enterprise, which is that we believe a new science of learning and of teaching is emerging from this research. It goes beyond traditional psychology in its pervasive use of the procedural metaphor, beyond traditional education in its employment of new learning environments, and beyond traditional computer science in its focus on the personal computing. Already it holds the promise of transforming educational evaluation, of reformulating technical curricula, and of diminishing the difference between recreation and education.

Its fundamental contribution it to develop the concept of building a procedural model of the skills of the learner. It is this model that guided the repair advice of our technical consultant, the diagnoses of BUGGY, and the choice of explanations made by our computer game coach. The form and structure of procedural models of the learning process can have impact as much on the content of education as on the development of a new computer-based methodology. Thus, the deepest significance of intelligent instructional systems in a learning society is that it not only revolutionizes the methods of education, but its very content.

A new sociology of learning is emerging as well.

I have described the revolutionary impact of p· ·sonal computing on the methods and content of education. Now let me tı to still another area of fundamental change. We believe that personal computing will have an equally revolutionary impact on the sociology of learning. It is our belief that the home will assume a new importance as a center of education. We see the intelligent instructional system as a household appliance, as useful to mom and dad as to the kids. Surely our neighbors in California will be using such personal learning environments to understand the latest results in earthquake prediction, while we New Englanders will be studying with equal interest the latest advances in solar heating technology.

This is as it should be. Given the dramatic pace of progress in our society, education must be a lifelong experience. But for an adult, the classroom, where one sits among 20 to 30 other students, receiving limited personal attention, surely is not acceptable. The home-based intelligent instructional system is an attractive alternative. Learning again becomes centered in the home; an activity for all family members; motivated by interest, not arbitrary school room demands.

Places of excellence to explore this future must be created.

Now I will turn to the question of what issues of public policy are raised by this coming explosion of computing power. Considering the potential impact of the computer revolution on the student, the schools and the family itself, we believe it is urgent for Congress to establish a major program for research into the theory and technology of computers in a learning society.

Currently, the major source of support for this research is the Department of Defense (see note 1) where it has been correctly perceived that powerful computing can serve a critical function in military manpower training and augmentation. But if we are to consider this imminent revolution from the perspective of its impact on the schools and on the family, a new civilian program must be established.

Small projects have been funded by NSF and NIE, but they are below critical mass. We believe centers of excellence should be established where the full possibilities of 1980's technology can be explored today. (See note 2).

Such centers will be expensive, for they will require the most advanced technology. Less expensive, but less powerful prototypes are pointless, for they will not reflect the resources available to the average home even five years from today.

To some, this might suggest that we wait until the 1980's to pursue this research, when the technology is inexpensive. But while hardware is getting cheaper, the basic breakthroughs in cognitive understanding are not being made. We can wait, and risk a vast wasteland of home computing. Or we can understand the issues now. The cost is insignificant compared to the national investment soon to be made in these home computers. The cost is also insignificant compared to the change that will occur in the educational, recreational, and professional lives of our citizens.

A frontier of the mind is being opened.

In closing, let me stress that the revolutionary transformation of learning in our society that we see as possible for the 1980's is not simply a consequence of the incredible computer technology that will be available then. It would not revolutionize education, for example, to place the Encyclopedia Britannica within the memory banks of every home computer. While this is worthwhile, it would not be qualitatively different from placing the books themselves in the home, only cheaper.

The unique quality of the computer that does make possible a revolution is that it can serve as a cognitive tool. It can be an active agent -- a servant, assistant, consultant or coach -- in a way that books and television cannot. With vision, with planning, with dedicated research, our citizens can be employing this tool to open a new frontier of the mind within a decade.

References:

On intelligent instructional systems:

Brown, J.S., "Uses of Artificial Intelligence and Advanced Computer Technology in Education", in Computers and Communications--Implications of Education, Academic Press 77.

Goldstein, I.P. "The Computer as Coach: an Athletic Paradigm for Intellectual Education", Proceedings of the Fall Conference of the Association for Computing Machinery, October 1977.

On computer coaches:

Burton, R. & J. S. Brown, "A Tutoring and Student Modelling Paradigm for Gaming Environments", in R. Coleman and P. Lorton, Jr. (Eds.), Computer Science and Education, SIGCSE Bulletin, Vol. 8, No. 1, Feb. 1976, pp. 236-246.

On computer consultants:

Brown, J.S. & R. Burton, "Multiple Representations of Knowledge for Tutorial Reasoning", in D. Bobrow & A. Collins (Eds.), Representations and Understanding Studies in Cognitive Science, New York: Academic Press, 1975.

On computer assistants:

Brown, J. S. & R. Burton, "Diagnostic Models for Procedural Bugs in Basic Mathematical Skills", Bolt, Beranek and Newman, August, 1977.

Note 1:

Defense department agencies that have funded research on embedding a cognitive capability in computers to serve as tutor or consultant are: the Advanced Research Projects Agency, the Office of Naval Research, the Air Force Human Resources Laboratory, the Army Research Institute for Behavioral and Social Sciences, and the Navy Personnel Research and Development Center.

Note 2:

NIE has recently established a center for cognitive studies related to reading comprehension. While its mandate is to explore the marriage of advanced technology and intelligent instructional systems, it is producing theoretical

34-652 O - 78 - 20

studies that will be of use in this endeavor.

Note 3: The History of Intelligent Instructional Systems

Intelligent instructional systems represent a new generation of *learner-based computer aided instruction*, preceded in time by the original *frame-based systems* and an intervening generation of *expert-based CAI*. The following table characterizes the history of CAI in terms of these three generations.

FRAME-BASED CAI	EXPERT-BASED CAI		LEARNER-BASED CAI
	ABLOCKS-I	--->	ABLOCKS-II
	SCHOLAR	--->	WHY
PLATO	SOPHIE	--->	SOPHIE-III
TICCIT	EXCHECK		
	CAMPUS	--->	MINOTAUR
	BIP	--->	BIP-II
			WEST

The *Frame-based Period* occupied most of the sixties and even today remains the dominant paradigm outside the research environment. Programs developed within this era were typically organized as a decision tree of multiple choice questions, with the student's responses determining which path in the tree is taken. These CAI programs were the first explorations of the computer as an educational tool. They were in some cases able to provide interesting learning environments, for example the fruit fly simulation of PLATO [Bitzer *et al.* 1972], but were ultimately limited by an inadequate understanding of the problem domain being taught, and inadequate models of the teaching and learning processes. The paradigm of this period was to develop tutor languages to facilitate the design of scripts by teachers for their domains. Such an approach to CAI remains useful in certain contexts, but to achieve a new plateau of performance, a new design philosophy is necessary.

The *Expert-based Period* represents the shift to a new paradigm in which the goal is to embed genuine domain expertise in the CAI program. Three benchmark efforts in this category, each concerned with a very different kind of expertise, are the Logic and Set Theory tutors constructed by Suppes *et al.*; the geography tutor of Carbonell and Collins; and the electronics troubleshooting tutor of Brown *et al.*

* Suppes has been involved with CAI since its inception, and hence his work spans all three generations. One of his long standing goals has been the development of a proof checker capable of understanding the validity of a student's proof. With the gradual evolution of machine intelligence techniques, he and his colleagues have been able to evolve successively more powerful proof checkers [Goldberg and Suppes 1972, Smith *et al.* 1975]. Thus, in this case, the research represents an evolutionary rather than revolutionary transition from frame-based to expert-based CAI.
* Carbonell designed Scholar around 1970 as a CAI system for geography that could answer as well as ask questions. The basic theoretical improvement was the use of a semantic net to represent domain knowledge. Since that time, Scholar has evolved as a result of the later work by Carbonell, Collins and others [Carbonell & Collins 1973, Collins *et al.* 1975].
* Brown and Burton's SOPHIE system for tutoring electronic troubleshooting is impressive in terms of its level of domain expertise [Brown *et al.* 1975]. The program is capable of simulating the internal behavior of a power supply, and hence can answer most student questions regarding the state of the device.

These programs made possible a new level of performance. Such CAI tutors are not limited to comprehension of a highly restricted set of student responses; but, through an embedded domain Expert, are able to comprehend a much wider set of interactions.

Recently, a third phase in CAI research has begun, characterized by the inclusion of expertise in the tutor regarding *the student's learning behavior and possible tutorial strategies*. In the above table, this generation is referred to as *Learner-based CAI* to emphasize the use of AI techniques in the modelling and tutoring components as well as in the Expert module. Within this context, Collins [1976] has investigated computational models for Socratic tutoring strategies. Burton and Brown [1976] in a tutoring program called WEST have introduced issue oriented models of the student's knowledge, rather than simple records of right and wrong answers. Atkinson and others at the Institute for Mathematical Studies in the Social Sciences have examined the representation of domain expertise as a network in which tasks and their requisite skills are represented [Barr, Beard & Atkinson 1975]. In this research, the BIP system for tutoring the computer langage BASIC, a model is maintained of the student's familiarity with various skills, and the next task posed to the student is done on the basis of which skills are currently known.

The intelligent instructional systems describe in these notes are examples of this new generation and represent an integrated investigation into tutoring and modelling.

References for this Brief Historical Perspective

Barr, A., M. Beard and R. C. Atkinson, The Computer as a Tutorial Laboratory: The Stanford BIP Project, Technical Report No. 260, Psychology and Education Series, Institute for Mathematical Studies in the Social Sciences, 1975.

Bitzer, D.L., B.A. Sherwood and P. Tenczar, Computer-based Science Education, Computer-based Education Research Laboratory, U. of Ill., Urbana, Report X-37, 1972.

Brown, J.S., "Uses of Artificial Intelligence and Advanced Computer Technology in Education", to appear in Proceedings of a Conference on the Impact of Computers on Education, A Ten Year Forecast, Washington, D.C., forthcoming 1976.

Brown, J.S., R. Burton, & A. Bell, "SOPHIE: A Step Toward Creating a Reactive Learning Environment", International Journal of Man-Machine Studies, Vol. 7, 1975, pp. 675-696.

Burton, R. & J. S. Brown, "A Tutoring and Student Modelling Paradigm for Gaming Environments", in R. Coleman and P. Lorton, Jr. (Eds.), Computer Science and Education, SIGCSE Bulletin, Vol. 8, No. 1, Feb. 1976, pp. 236-246.

Carbonell, J., "AI in CAI: An Artificial-Intelligence Approach to Computer-Assisted Instruction", IEEE Transactions on Man-Machine Systems, Vol. MMS-

11, No. 4, December 1970.

Collins, A. & M. Grignetti, Intelligent CAI, BBN Report No. 3181, Bolt, Beranek & Newman, Inc, Cambridge, MA. 1975.

Collins, A., E. Warnock, N. Aiello, & M. Miller, "Reasoning from Incomplete Knowledge", in D. Bobrow and A. Collins (Eds.), Representation and Understanding Studies in Cognitive Science, New York: Academic Press, 1975.

Goldberg, A. & P. Suppes. "A Computer-Assisted Instruction Program for Exercises on Finding Axioms", Educational Studies in Mathematics, 1972, 4, 429-449.

Smith, R. L., H. Graves, L.H. Blaine, & V.G. Marinov, "Computer-Assisted Axiomatic Mathematics: Informal Rigor," in O. Lecareme & R. Lewis (eds.), Computers in Education Part 1: IFIP, Amsterdam: North Holland, 1975.

Stansfield, J., B. Carr, & I. Goldstein, Wumpus Advisor I: A First Implementation of a Program that Tutors Logical and Probabilistic Reasoning Skills, MIT Artificial Intelligence Laboratory Memo No. 381, Sept. 1976.

STATEMENT OF DR. JOHN SEELY BROWN, COMPUTER SCIENCE DIVISION, BOLT, BERANEK & NEWMAN, INC., CAMBRIDGE, MASS.

Mr. BROWN. Dr. Papert has spoken very powerfully about the sociological and educational implications of technology.

What I want to talk about this morning are some paradigms based on not machines like those he described but machines maybe 10 to 100 times more powerful than that, and that are clearly coming. A new paradigm is possible with such technology.

Mr. SCHEUER. A new what?

Mr. BROWN. Educational paradigm.

In my laboratory and in the laboratory of my colleague, Ira Goldstein of MIT, we are focusing on providing computers with an ability to understand the learner, that is, to understand his strengths and weaknesses as well as his style of learning. This enterprise, the design of Intelligent Instructional Systems, takes as central first, representing true problem solving expertise within the computer and second, good diagnostic and modeling capabilities of the particular student that the system is engaged with.

Let me introduce you to three prototypes which manifest some of the capabilities that could be realized in tomorrow's learning technology. The first prototype explores a potential transformation of technical education through the computer acting as a consultant. The second explores the potential for a fundamental change in educational evaluation through the computer acting as an assistant.

The third explores the potential for a renaissance of education in the home, as we have heard today, through the computer acting as coach or a kibitzer.

My first example explores the dramatic impact intelligent instructional systems can have on technical education. Training competent technicians to repair the everchanging number of devices and technologies on which our society depends is an important educational goal. The mass dissemination of tomorrow's powerful computers makes possible the widespread use of simulations in technical training.

Just as flight simulators have long been important in training pilots, we believe that electronic simulations, for example, will be equally basic to technical training. These simulations provide inexpensive and safe opportunities for students to explore the complexities of a device.

The critical contribution of the intelligent instructional system is to monitor and critique simulated tests and repairs made by the student. We have designed a prototype of such a system called SOPHIE for a limited part of the electronics domain.

SOPHIE presents the user with a simulated circuit to be fixed. The user can make any measurements he wishes, replace any parts. SOPHIE observes these measurements and employs a deep understanding of electronics to decide whether a given measurement is needed or a given part replacement justified. Its tutorial function is to discuss these observations with the novice technician. In essence, it is a troubleshooting consultant. The student can explore the device with no possibility of harm, in a private setting.

There is another role such consultants can play. We believe citizens themselves can employ such computer-based consultants to reduce the alienation engendered by modern technology. It is quite enjoyable to take apart a simulated TV set to see how it works. The embedded computer consultant can provide a guided tour of the device by embodying a deep theory of the domain along with a cognitives theory of what constitutes commonsense understanding of a piece of technology.

While most citizens will probably never actually repair their TV sets, they have gained a sense of command, of personal power through a better understanding of the devices that they employ.

Our culture has grown so complex that many feel it is beyond their understanding. Through the simulated world of the computer, with the advice and aid of an embedded consultant, a dramatic and beneficial improvement can occur in our understanding of the world around us.

Our second example concerns an intelligent instructional system capable of diagnosing the underlying cause of errors in a student's basic arithmetic skills. Those of you who have the paper before you have an example of the problems that a young student, Johnny, was given on a screening test.

My first example was what can happen by having a consultant embedded in the computer along with the simulators so that people can play with a simulated system in order to get a better understanding of how and why it works.

My second example embodies the idea of embedding very real intelligence into a computer and using that intelligence to diagnose the underlying causes of student's problems. This provides us with a chance to evaluate what has been happening inside a student's head. We have examples of an automatic system that can look at a student taking a screening test, look at all of the answers and find out what is actually wrong in that student's understanding of the material.

I have a dramatic example.

Mr. SCHEUER. What do you mean by a screening test?

Mr. BROWN. When you enter fourth, fifth, or sixth grade, kids are given tests to assess their level of understanding. We have an example where a kid got every single problem wrong. He failed the screening exam, got a very, very low score, and the problem was that there was only one mistake, one simple mistake in his algorithm for doing addition.

Mr. SCHEUER. There was only one thing wrong with his what?

Mr. BROWN. His procedures and basic skills to actually perform arithmetic computations. There was one thing wrong. It was a very small thing but it permeated throughout his whole knowledge network and caused him to get everything wrong on the exam. The problem was that this little bug or mistake that he had in his understanding was so deep down in his knowledge network that his teacher could not diagnose what was wrong.

So in some sense he got scored as if everything were wrong, but in fact he only had one small mistake and the results of this test did not help the teacher in any way figure out what was wrong with this student and it did not help the student at all.

Mr. SCHEUER. The computer could identify what the teacher could not?

Mr. BROWN. Yes, now it could do that by embodying a deep cognitive theory of what the skills are to carry out arithmetic computations. This country has been interested in back-to-basics, yet it seems very strange to me that we really don't know what is all of the tacit knowledge and what is all of the underlying knowledge required to actually do mathematics. We are actually using the computer system as an experimental device to try to build a theory of this tacit knowledge in order to see what goes into doing mathematics. One of the byproducts of this research is that with this kind of theory we can step back and use it to provide a technique to evaluate a particular student's behavior to find out what is wrong, what his underlying misconceptions are that lead to the symptoms or the errors on tests. The potential for this in terms of a national evaluation program could be quite astounding.

No longer do we have to count on mechanized scoring techniques that just look at the right and wrong answers but we can find out how many fundamental misconceptions he does have.

Mr. SCHEUER. So examinations and tests can be used as tools in the teaching process rather than just measurements of the level of achievement.

Mr. BROWN. Right. In fact, now such a system has thrown open to question what is meant by a score on a test. We don't care about the number of right and wrong answers, but we want to know what his fundamental misconceptions are. If we can identify those, the number of right and wrong answers he gets is not too meaningful or useful, because now we can take an articulation of his misconceptions and use that either in a computer-based system or a human-based system to help remediate the student's underlying misconceptions.

This is just one example of how embedding intelligence about the domain itself into a machine leads to qualitative changes: Qualitative changes not only in the notion of evaluation, but changes in the way we test our own ideas. For example: What does it really mean to understand, not understand the theory of mathematics, but understand how to do mathematics? It is very strange to me that we are concerned about getting back-to-basics in mathematics without first knowing that. We know from new math what the theory is but that theory is useless sometimes. The question is what is the knowledge to do mathematics. It is hard to get at. It is hard to build a cognitive theory of that knowledge.

By taking a machine and embedding that theory into the machine we have a new kind of rigorous standard to see whether we can get a machine to do the kind of problem solving activities in a way that we think the students should do them. It is an interesting new idea of how to combine a cognitive theory with a tecknological theory.

Mr. WELLS. In a sense, you are driving towards conversions of the work in artificial intelligence.

Mr. BROWN. Yes; there are many ways this can have a serious and profound impact in even 2 or 3 years. Right now the types of theories we are building reside in complex and large computers. But in fact these machines will soon become 10 to 100 times more powerful and also be in the home. It gives us the chance for the first time to imbed this kind of intelligence in the machine.

I am suggesting just one way of using intelligence in a machine. The second way I want to talk about using intelligence, Which addresses a lot of the questions brought up already today, involves the notion of what's really fun about having the computer in the home. Having a computer in the home is fun; I can guarantee you that. It's fun because there are lots of activity based games on the machine. Some of these games in fact exercise basic reasoning skills in logic, probability, geometry, and mathematics, basic thinking skills.

Kids want to play these sexy games. They get taken into them. But the problem is, so what? They play these games or maybe they want to learn how to program the machine so they can actually do something else with it.

But what we're really missing is what I think of as a cognitive component that its on top of these games—a coach or a kibitzer, a kind of personalized tutor that can take the kid's enthusiasm about a particular educational game and point out to him at critical times what he's doing right or wrong and what is educationally or intellectually significant about the particular situation he is currently confronting.

Very often if you put a kid in front of a computer and have him play a probability game or anything like this, you will find he gets stuck pretty quickly. He zeroes in on a plateau of his skills. He doesn't see the real challenge and that, in fact, the particular game situation he confronts is an illustration or instance of some abstract idea he has been taught in school. He has been taught abstract things, but he has seldom been provided with a concrete realization of these abstract concepts.

Our cognitive component or computer based consultant or coach sitting on top of these games can look at what he is doing and point out to him. "Hey, isn't this an interesting situation or example of something you may have learned at such and such a time," giving him his own personal experience and a concrete example of important material. This provides an activity-based hands-on-learning environment which we think has some very profound implications which can shift education from the school to the home.

It gets around the problem that learning in the home must be textbook type instruction. We can use this cognitive component in the home to get the student to do something, a hands-on experience, and then step back and point out what is significant or how he has gotten locked into a suboptimal rut while, say, solving some problem—homework or whatever.

Mr. SWANSON. Can you give us an example of the type of game or type of advice the machine might provide?

Mr. BROWN. Yes; we have two or three games now running on our computer-based systems that have this type cognitive components on them. One of them which you might have seen last week when Dr. Bitzer was talking is the classic game of "How the West Was Won" which exercises basic arithmetic skills. You have a game board in which you are trying to beat the computer getting from here to there by making arithmetic expressions out of a set of numbers. Did Dr. Bitzer show it to you?

Mr. SWANSON. I have seen it.

Mr. BROWN. That's a fun game. However, if you look carefully at what is happening, students get almost nothing out of it because they have locked in on only one rote way of playing that game. They don't exercise the potential of that environment. We have actually built an automated laboratory instructor or coach to monitor that game. This system, called WEST, is now being tried out at one of the school systems in Cambridge. It watches over the kid as he is playing and can automatically figure out what his strengths and weaknesses are. It can then choose appropriate moments in which to break in and point out something to him: Why he has gotten locked into a suboptimal strategy or why he is constantly losing games—expand his horizon but in a context that matters to him.

Mr. SWANSON. It seems to me you are saying that the kibitzer explains to the student how he learned to play the game and he can reflect on how he is learning to learn?

Mr. BROWN. Yes, it could.

Mr. SWANSON. What are the implications of that? Is that a subject that is normally covered in schools today?

Mr. BROWN. It is very clear that it is missed, because in some sense we don't even have the appropriate cognitive theories of how to understand understanding. Those theories are what these machines really have to embody as well as deep tutoring theories.

Let me give you a simple example of the latter. I give you a really neat game and let you play with it on the system. Now suppose that every time you did something wrong, a coach or kibitzer threw its fist down and started hassling you, saying that move was dumb, and why did you do that, and here's how you should have done it—the sociology of that learning environment is hostile. The problem in building an intelligent instructional system is to develop a good enough cognitive theory to figure out what's going wrong in the kid's head, and to develop a cognitive theory of what comprises good personal tutoring, so that this coach or kibitzer comes in only when it sees a critical moment to provide tutoring.

If the coach comes in all the time, the kid will either punch out the computer terminal or get up and walk away saying, "You spoiled my fun game and I don't want to play it any more." When that happens you have really lost a good educational opportunity.

On the other hand, if you let a kid work in a basically open ended environment and you never can critique what he's doing, you lose a great deal of the real educational opportunity inherent in that environment. What we are trying to do is to provide good personal tutoring on top of a fun, open ended game situation, letting the student get something educationally significant out at the same time he's having some personal, hands-on experience.

This thrust to intelligent instructional systems is one of the types of evolutions that we see will be made possible by tapping the almost incredible capabilities of tomorrow's technology. It will bring about a qualitatively new kind of learning environment, a learning environment that Dr. Papert was talking about earlier, that we think may be ideally suited for people who have already dropped out of school because this environment is basically one of learning by doing.

I think that such systems will be possible in the next 5 years, but to make that happen, we have to realize that technology by itself is not sufficient. It is all too common to hear people in educational technology talk about technology. They say by god if I had a machine 10 times more powerful. I could do wonderful things. Well, by and large, that's not true. I think people in the educational technology overlook the most difficult issue: Developing the cognitive science necessary to understand how to exploit that technology.

Unless we have good theories as to what comprises understanding or tutoring or learning, we won't be able to make much of an advance over the limited kinds of deployment of technology that we see today. In terms of major new research projects, the issue is not technology per se but more a question of adding what I call a cognitive component, a cognitive understanding or a psychological theory about how to use the capabilities that are going to be offered to us by tomorrow's technology.

Mr. WELLS. I would like to suggest that we don't have a field that is barren of information or theoretical work in this area. I recall as long as a decade ago that Jerome Bruner at Harvard was doing a great deal of work in cognitive psychology dealing with 5-, 6-, and 7-year-olds and successfully developing the means to teach them rather advanced concepts in physics without ever using the terminology. These kids were understanding very advanced concepts and it seems to me there is a lot of knowledge that somehow has to be linked with the types of things you are talking about. What's going on here.

Mr. BROWN. I couldn't agree with you more. Dr. Bruner and Dr. Papert have made profound contributions to this effort, but it is just scratching a very complex surface.

Let me give you two examples of areas that haven't been explored. A kid has been working on a problem. He gets stuck and so he takes to the tutor his partial solution, and now the tutor has to give him some advice or some hints. Have you seen anywhere a formal theory of how one goes about giving hints, of how one can look at what a kid has done already and figure out how he has attempted to solve that problem, what is wrong with his plan and how to suggest revising it? This issue must be tackled to bring into being the kind of personal computing I am talking about.

The second example: I am perplexed by the question of what it means to understand a basic skill, say a basic skill in mathematics. I can learn the subtraction algorithm or the long division algorithm, but what does it mean to understand how to add fractions in any way other than the rote procedure I have memorized? What does it mean to understand fractions in such a way that the concepts are hung on some kind of a framework that is useful and makes sense. We really don't understand that very well.

Mr. WELLS. Rather than just a long chain of discrete steps.

Mr. BROWN. Yes. Another example can be found in the area of reading comprehension. It is very strange, but we are just now beginning to realize that for years we have been designing tests for reading comprehension without any good theory of what comprises comprehension. How the hell can we test comprehension if we don't know what comprehension means and if we don't know the skills of comprehension as opposed to the skills of decoding words into sentences?

What is this magic process that enables us to devise a meaning for a paragraph? We must understand that if we want to be able to design meaningful diagnostic tests.

Mr. SWANSON. I think everybody has amply documented the importance of research in this area. I was wondering if you could give us some comments on the line of what you would like to see come out of these hearings, especially in terms of alteration of Federal policy.

Mr. BROWN. I think Dr. Papert answered that question in a way perhaps better than I can. I believe that some major centers of excellence have to be established that have the critical mass phenomenon of bringing together cognitive scientists, educators, computer scientists, and technologists into one setting in which some kind of synergism can be brought about where each of us can help the other understand what new paradigms are needed and how to make use of them.

I think that has to happen. I think we have to seriously consider the problem of critical mass.

Mr. SWANSON. Is there a scarce resource not in terms of avaialble Federal funds but in terms of people who can do this kind of work?

Mr. BROWN. Of course, well-trained people are a scarce resource. But one of the purposes of such a center is to provide a place to train graduate students and a new generation of scholars and scientists who really understand the issues and paradigms we are talking about. When I, a computer scientist and somewhat of a cognitive scientist, talk to other computer scientists, they often think I'm crazy when I talk about cognitive science issues. They don't understand why these issues are relevant. For example, use any computer system today and you realize it has to be designed by an idiot in terms of its friendliness or ease of use.

That is an issue that has not been raised in any serious way before. It's absolutely imperative that we start understanding what it means to make a computer system friendly.

Mr. SCHEUER. What do you mean friendly? You mean to sort of eliminate the deadly hand of that adversary feeling that the kid gets when he walks into the elementary school?

Mr. BROWN. You walk over here—I don't know this particular system, but I would imagine that if you sat down and started trying to program it—if I tried to program it—we would find horrible things happening, asinine comments coming back to us. That kind of unfriendliness is something we don't have to tolerate today. How can we get around it?

I think an issue that will be brought up later is the whole question of computer literacy—what does it mean to feel comfortable using computer technology. I happen to work with secretaries who are required to use complex computer-based systems—more than just word processing systems—filing systems and electronic mail, and so on.

I worry about training these people because they have to be able to understand. One of the things I have found out is that half of the people we try to train collapse into a twitching heap after about the first month. They can't take it. And they hate it.

The problem, as we have diagnosed it, is that they don't have enough of a common sense understanding of that piece of technology that they can't begin to envision what is happening well enough to be able to feel comfortable using it.

Mr. SCHEUER. You are terrific.

Thank you very, very much.

The last witness is Dr. Arthur Luehrmann of the Lawrence Hall of Science, University of California at Berkeley.

[The prepared statement and a biographical sketch of Dr. Luehrmann follows:]

PREPARED STATEMENT ON RESEARCH, DEVELOPMENT AND PLANNING FOR COMPUTERS AND THE LEARNING SOCIETY BY DR. ARTHUR W. LUEHRMANN, ASSOCIATE DIRECTOR, LAWRENCE HALL OF SCIENCE, UNIVERSITY OF CALIFORNIA BERKELEY, CALIFORNIA

This statement is intended for the October 12, 1977 hearings of the U.S. House of Representatives Science and Technology Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation, which is conducting a four-day oversight review of "Computers and the Learning Society."

INTRODUCTION

The bare bones of my testimony today can be put in five sentences. I will first enumerate those sentences. Then I will amplify each one and attempt to convince you that it is factually accurate. Finally, I will point out the research, development, and planning implications that follow from these facts. Here are the statements.

1. The United States is the world leader in manufacturing microelectronic hardware.
2. That technology makes it possible today to deliver powerful personal computers to millions of individuals.
3. The biggest single impediment to the further growth of this industry is the fact that the vast majority of Americans are uneducated in the use of a computer.
4. To carry out the educational task ahead will require a substantial investment in research, development, planning, and delivery.
5. The private sector is not organized to make significant investments in the education of the public.

WHAT IS "EDUCATION IN COMPUTER USE"?

The key idea in these statements is contained in the phrase "education in computer use." Before going on, I want to clarify what I mean by it and to distinguish my concerns clearly from the concerns of the witnesses who appeared here during the first two days of these hearings. They were concerned mainly with the form of education. I will be emphasizing the contents.

They focussed during the first day on computer management of instructional resources and, the second day, on computer delivery of instruction. In both cases the instruction thus managed and thus delivered was in traditional subjects, such as reading and mathematics. Their focus, therefore, was on the computer as a medium on instruction. My focus today will be on the computer as an object of instruction—not a thing to be taught with, but a thing to be taught about. Not a means, but an end.

Proper questions for the Subcommittee to ask about the computer as a medium of instruction are (1) whether it is better and (2) whether it is cheaper than conventional ways of managing and delivering instruction. But the appropriate questions to ask about the computer as an object of study are quite different—(1) Is it more important to learn to use a computer than to learn subjects now being taught? (2) Can computer use be taught effectively to a broad spectrum of students? Negative answers to one set of questions must not prejudice the answers to the other set. The cost effectiveness of a CAI math course tells us nothing about whether children can or should be taught to write computer programs.

I am not quarrelling with CAI or CMI; both will improve instruction in traditional subjects. My point here today is that neither CAI nor CMI will teach people to use the powerful personal computers which American technology is now capable of delivering to our citizenry. While it is true that a person taking a CAI lesson will learn rudimentary typing skills and rules about interacting with a computer, he or she will not learn how to write interesting computer programs, or how to structure a problem for computer solutions or how to evaluate other people's programs. When I use the phrase "education in computer use," I am referring to the development of these latter skills and abilities—programming, structural thinking, and critical evaluation of computer applications. It is these skills that are presently lacking in the public and are needed if the public is to benefit from the personal computer.

BACK TO THE MAIN ARGUMENT

Now I want to return to those five bare bones of my testimony and to flesh them out.

1. "The United States is the world leader in manufacturing microelectronic hardware." Basic research in solid state physics in the 1950s led to the invention of the transistor at Bell Laboratories. Since that time the U.S. has led the world in the technology of miniaturizing electronic circuits on silicon crystals. A 1977 study by Arthur D. Little, Inc. forecasts a $4 billion U.S. microelectronic industry in 1980, growing to $10 billion in 1985. This growth is occurring at a time when other "native industries," such as autor ›bile manufacture, are losing ground against world competition.

2. "Microelectronic technology make- t possible today to deliver powerful personal computers to millions of individuals." Already two companies with national distribution are marketing $600 personal computers complete with TV screens, keyboards, and magnetic tape unit for recording programs and data. These are the Tandy TRS-80, marketed through Radio Shack, and the Commodore P.E.T., marketed by independent stores. Vastly more powerful machines, now available for several thousand dollars, are expected to follow the steep cost-decline curve well known in the microelectronic field. In a few years they too will be about costly as a color TV set. Texas Instruments, Timex, and Sears are reported to be entering the field. *Time* magazine (September 5, 1977) reports a Dallas microcomputer retailer as saying, "Some day soon every home will have a computer. It will be as standard as a toilet."

3. "The biggest single impediment to the further growth of this industry is the fact that the vast majority of Americans are uneducated in the use of a computer." The technology, in short, is far ahead of our ability to make use of it. The same *Time* article points out that "even though prices have dropped, microcomputers remain complicate ddevices that require long hours of study to use properly."

There is a striking analogy between the situation today with regard to computers and the situation in Germany in 1492 when the Gutenberg printing press was developed. A new technology had vastly reduced the cost of delivering books directly to masses of people. The people, however, were illiterate. To them the book was also a "complicated device that requires long hours of study to use properly." Computer technology today is entering a world populated by computer illiterates—those who have not yet learned to use a computer. Our Dallas dealer, therefore, should restrain his enthusiasm. Most of us have already mastered the flush toilet. Not so, the computer.

4. "To carry out the educational task ahead will require a substantial investment in research, development, planning and delivery." Preliminary R&D projects, such as the ones reported on today by Drs. Kay, Papert, and Brown, give strong evidence that a knowledge of computer use can be a powerful aid to the intellectual development of children. My twelve-year experience at Dartmouth College and now at the Lawrence Hall of Science convinces me that many if not most people enjoy learning to use a computer and that they succeed at it. More important, I have observed that a student who is able to structure a problem for solution by computer nearly always has a better understanding of the problem than he or she got from a purely verbal or purely mathematical description. In a very real sense, there is an intellectual dimension to computer problem solving. Some research projects reports that computer users develop what amounts to a new language for expressing their ideas. I will not elaborate this point because the testimony you have already heard today has dealt almost exclusively with research into the educational value of learning to use a computer.

A great deal of additional work needs to be done before mass computer literacy is achieved, however. Several fundamental research questions need to be answered. For example, what sorts of logical structures should be contained in the computer languages we teach? What grade level is best for classroom instruction in computer use? How should emphasis be balanced between teaching the grammatical rule of programming and teaching meaningful problem solving by computer?

While that research is in progress, several pilot courses in computer use need to be developed, tested, evaluated, and improved. Teachers need to be trained, or retrained, to conduct the courses.

As computer courses become viable and are recognized as valuable additions to the curriculum, the schools must engage in planning activities. The schools must find ways and means of introducing the new courses, and of supporting their continuing costs in the future.

If these research, development, and planning activities do not occur, then the majority of the public will remain illiterate in computer use. Furthermore, those who do become skilled users are likely to come from affluent families who can afford a home computer and can teach themselves to use it.

The analogy with books comes to mind again. The people who benefitted most from the printing press were those who were already educationally advantaged. Mass literacy was not achieved until public education entered the scene and developed a reading and writing curriculum for everyone.

5. "The private sector is not organized to make significant investments in the education of the public." While it is true that manufacturers of personal computers have much to gain from mass computer literacy, it does not follow that they will invest in education. This is true because the individual manufacturer would thereby benefit its competitor as much as itself. The analogy with books comes to mind again. Why doesn't the Random House publishing company invest in teaching people to read? Because the people might well go out and read Scribners and Doubleday books. And so reading is taught in schools. For the same reason, computer use must be taught in schools.

SUMMARY

In summary, then, it seems clear to me that we have both good news and bad news about personal computing. The good news is that U.S. technology is ready today to deliver powerful personal computers to our citizenry. The bad news is that our citizenry is illiterate in the use of computers. Unless the public is educated in computer use, two bad things will happen: (1) a leading U.S. industry will be denied a mass markets, and (2) the public will be denied the personal and occupational benefits of knowing how to use a computer.

RECOMMENDATIONS

1. Mass computer literacy should be identified as a goal of our educational system.

2. Although the ongoing costs of such an educational program must be borne by the states and the local schools, federal funds are needed for research and development activities required to initiate the program.

3. Among the topics for which research funds are needed are these:

(a) The role of computer education in the cognitive development of children.

(b) Types of logical structures needed in the computer languages which are to be taught.

(c) The role of computer graphics in improving communication between man and machine.

(d) The age level at which computer use can be taught most effectively.

(e) A set of performance objectives and corresponding achievement tests for education in computer use.

4. Funds are required to develop, test, and improve several model courses in computer use. The usual arguments against national curriculum development are inoperative here. If federal funds are not available for curriculum developments in computer education, then there will be no curriculum in that subject. That is obviously not the case for existing subjects, such as chemistry and biology. The stigma of a federally imposed computer curriculum can and should be avoided, however, by supporting several independent development projects. Local schools would then have a range of choices.

BIOGRAPHICAL SKETCH

DR. ARTHUR W. LUEHRMANN, ASSOCIATE DIRECTOR, LAWRENCE HALL OF SCIENCE, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

Dr. Luehrmann was born in New Orleans in 1931, received his AB and PhD degrees in physics at the University of Chicago, and joined the Physics Department faculty of Dartmouth College in 1965. His growing interest in computers and education led in 1971 to a joint appointment in the Kiewit Computation Center at Dartmouth, where he was Assistant Director for Education. During the years 1968–1977 he directed several educational computing projects funded by NSF and Exxon Education Foundation. In August, 1977, he became Associate Director of the Lawrence Hall of Science, University of California, Berkeley, where he is now in charge of computer operations and education. He is experienced in many aspects of educational computing, having written CAI lessons in physics, a computerized management system for self-paced instruction, and text materials incorporating computer programming. Dr. Luehrmann has published numerous articles and delivered papers here and abroad on educational computer use, computer graphics, and the principle of free student access to university computers. His military service in 1952–54 was spent in the U.S. Army, most of the time in the Canal Zone.

STATEMENT OF DR. ARTHUR LUEHRMANN, LAWRENCE HALL OF SCIENCE, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIF.

Mr. SCHEUER. What is the Lawrence Hall of Science.

Mr. LUEHRMANN. The Lawrence Hall of Science is a unit of the University of California at Berkeley. It is a science center, something between a science museum and a research center on informal learning in science. It conducts research projects as well as offering exhibits for people coming to the hall to enjoy and hopefully learn a little bit about science. The hall has pioneered in educating a broad public—about 170,000 visitors per year—in the use of computers.

First of all, I would like to thank you for inviting me here. This is a very important hearing and I hope that good things come out of it. I expect they will.

Mr. SCHEUER. From our point of view it has been extraordinarily productive and stimulating. I want to reiterate my thanks to the preceding witnesses. It has been a marvelous morning. So please proceed.

Mr. LUEHRMANN. I will summarize my point of view very briefly and spend most of my time responding to questions. I think that would be more useful to you than presenting a formal position at this point.

The entire point I want to make can be put into five statements and that is the only part of my prepared statement I will read. It is quite concise.

After I make those statements, I would like to reinforce what has been going on here today and distinguish sharply between the kind of computer use that is envisioned here and the kind you heard about during the first 2 days of testimony before this subcommittee.

The statements are these:

First, the United States is the world leader in manufacturing microelectronic hardware. No other country has come close to the advance state of our technology.

Second, that technology makes it possible right now to deliver powerful personal computers to millions of individuals. You see on the table at my left an example of a machine that people can afford today.

The third point is that the biggest single impediment to the further growth of this industry is the fact that the vast majority of Americans are uneducated in making use of the computer. They just don't know how.

The fourth point is that in order to carry out the educational task ahead, it will require substantial investment of funds into research and development and planning and, finally, delivery.

The fifth point is crucial. The private sector simply is not organized to make significant investments in the education of the public on such a broad scale.

Mr. SCHEUER. What population groups do you think this computer era will be most useful for? Is there anything in it for the elderly who are homebound with the television set as their only companion, or is it teaching kids, or will it be of use to people in their middle years, the parents of growing families, in their producing years, or is it all of these?

Mr. LUEHRMANN. The answer is yes all of these. Computer use in my judgment, is a basic skill. All can profit from it. There is a separate question, and that is, "How do we bring about that state where everyone can use the computer?"

If we were talking about an ongoing educational program, the best place to begin is with young people. But the computer is new on the scene. What about all the people who don't know how to use it and who are no longer in grade school or secondary school? How will they learn? And, indeed, I can imagine senior citizen centers having a computer facility and learning to use the computer for good purposes.

Mr. SCHEUR. How about for the elderly, the elderly homebound with their television set in the corner? Presumably, the computer will be an integral part of that television set.

Mr. LUEHRMANN. I believe that is true.

Mr. SCHEUER. What does this hold for improvement in the lives of the elderly, this whole computer area?

Mr. LUEHRMANN. When one interacts with a computer, one is interacting with intelligence, one is forced to communicate what one wants to do to the computer. And the very process of communication is something that people find interesting to do. It is an intellectual skill. I don't mean that it is only for intellectuals. It is a basic skill, and people who do it find it satisfying personally. There is personal satisfaction in communicating with a computer.

Mr. SCHEUER. And the prior witness talked about people perceiving of the computer as a friend. And there is sort of a friendly relationship there.

Mr. LUEHRMANN. They perceive it to be a friend if they feel they are in control of the situation, and they perceive it to be an enemy if they feel like they are the subject.

Mr. SCHEUER. Is this skill of relating to that computer and sort of manipulating it something that kids can grab onto almost immediately like a new language, as the professor said, but that which elderly people in their sixties and above have difficulty being comfortable with?

Mr. LUEHRMANN. It depends a great deal on the sociological setting. Kids are able to make mistakes in public without feeling too bad about it. Older people have trouble making mistakes in public. And typically, computers have been located in visible, public areas. People have not had them at home. When that happens, I think everyone will learn to use computers comfortably without feeling threatened.

23-082 O - 78 - 21

Mr. SCHEUER. Excuse me for interrupting, but we have a rollcall vote on, and I will have to leave after the next bells which is about 5 or 6 minutes. So I did take the occasion of getting some of my questions answered. After I leave, my colleagues here will ask you some of the questions we have prepared. I did want to take the opportunity of asking some of those questions. Please forgive me if I have to leave shortly. I apologize, and we have thoroughly enjoyed your testimony.

Mr. LUEHRMANN. I referred earlier to an important distinction that I want you to keep in mind. Witnesses last week told about using the computer to teach some subject matter (CAI) or to manage the instructional program of a school district (CMI). I want you to keep that in mind as just one possible application of a computer. In that role, the computer may or may not be a cost-effective solution to the educational problems that the country faces. But on the other hand, I want you to keep in mind that a kid can be taught to use the computer, and that the process of using the computer is different for the kid than the process of being taught by the computer. It seems to me that it is this second activity, the teaching of the kid to use the computer, which is at issue today. That is what the witnesses here have stressed today. There is something important about people learning how to interact with machines. That is the point here. It may be that the CAI programs are effective, and it may be that they are beneficial or they may not be. But that has nothing to do with the question of whether or not it is a good idea for people to learn to use computers.

Now, what do I mean by learning to use a computer? What I want, and what the other speakers today stressed, is for people to be able not merely to learn a programing language. That is an occupational skill with certain benefits. The important thing, however, is to learn to structure their thinking so that it can be communicated to a computer; structure a problem in such a way that it can be presented to a computer for a solution.

Now, that process of thinking through a problem in an abstract way and representing it very concretely by writing it down as a computer program, that process has an intellectual dimension that is terribly important. It gives the person another language for representing problems, another way of thinking about problems.

What tools does a person usually use to think about a problem? There are just a few—logic, mathematics, natural language (English in this country). One writes words about a problem. One may be able to express a problem as a set of mathematical equations. One certainly uses logic. A computer program is yet another way of representing one's understanding of a problem. One can write the problem down as a set of procedures—go through this process and repeat it some number of times; then do this process; then test to see if a certain variable has reached a certain value. If so, go do this. If not, do that.

It's a different kind of way of describing a problem. And the person who has another way of describing a problem has another way of thinking about it. It is this "thinking dimension" which is so important to stress here. The reason we want to teach people to use the computers is because it will make them think better. At least, that's what we believe. Not enough research has been done to prove that point absolutely. But there is clear evidence from the few research projects that have gone on with real students that such is the case.

There is an analogy that I stress in my prepared statement and I would like to repeat it here. It is the analogy between the current state of development of computer technology and the situation of when the printing press was first created. When the printing press was first developed most people were illiterate. Reading a book must have seemed terribly complex and learning to read must have seemed an enormously expensive task for society to undertake. In fact, society did not undertake it. The chief beneficiaries of the printing press were people who were already affluent and literate and already powerful. The case may be the same with computing. If there is not a public program to instruct people in the use of computers and computing—the intelligent use of computers and computing—then the people who can afford to buy machines like that one on the table are people who have incomes for which such an expenditure may seem small. They will have had solid educational backgrounds that encourage them to go and learn these new skills, and they will be thereby further advantaged over the people who do not go out and buy these machines and do not go out and spend the time it will take to instruct themselves in the intelligent use of computers.

So I believe that if no public program exists to teach people to use computers, then there will be private programs. But they will be socially distorted programs, and the public at large will not learn the basic skill. A few members of the public will learn something of value to themselves.

Dr. SWANSON. It is my understanding that some of the remarks of Dr. Brown implied that in fact we could create a computer coach that could train the person almost from ground zero to program his own personal computer. Is it not possible to conceive of a cassette to plug into your home computer that would take you from an initial starting point to becoming a fairly sophisticated programer so that this teaching process of computer programing could be decentralized into the person's home and there would be no real need to have this done in a school location.

Mr. LUEHRMANN. That is an interesting question. Can computer education go on independently of the school system? It can be approached as a resarch question and it should be. We should find out what can be done in centers other than schools to teach various topics, including the use of computers.

However, I don't think we should write off the schools themselves. The schools have been effective over the past centuries in making the public literate. Certainly there are failings and one wishes the public were more literate than it is. There's no question about that.

On the other hand, most of us went through schools and most people can read a newspaper, or they could a few years ago anyway. I believe that the schools are still a vehicle worth trying. How do you do that?

Well, you have to actually put something into the curriculum called "computing."

Dr. SWANSON. Won't students actually learn how to program the computer as they go through the type of training routine advocated by Dr. Papert?

Mr. LUEHRMANN. Let me clear that up. I was not trying to distinguish my testimony from Professor Papert's. I was trying to distinguish my testimony today from that which went on last week, which described classical CIA and CMI. CAI and CMI are applications, of technology to teaching English and teaching math, not to teaching computing itself.

What we have been talking about here today has been teaching people to use computers for their own purposes.

Dr. SWANSON. So you use the broad term computer literacy to cover everything we have talked about today?

Mr. LUEHRMANN. Yes; that's the point.

Dr. SWANSON. Could you provide us a general description of the kind of structural mechanism that is required to teach computer literacy as well as some of the different institutions that would carry that out and the kinds of costs that might be associated with such a program?

Mr. LUEHRMANN. Yes; I will answer that, but bear in mind that I answer it primarily so that we may have something specific to talk about and not because I am totally wedded to the model I propose here. In fact, my strongest recommendation is that what is needed is more funds to support the development of alternative models for teaching computer literacy. I have no question but that a goal of our educational system should be to teach computer literacy to all people. That ought to be adopted as a national goal. The means of achieving that goal are debatable. Whether computer education should go on in the home, or schools, or by television,or by using public centers is not clear at all, and there should be opportunities to try out many different methods.

But I will propose one particular way, a recognizable structure, in which computer literacy might be taught. Imagine a half year course at the ninth-grade level. I don't think we know yet whether the 9th-grade level is proper or the 3rd-grade level or the 10th-grade level. I can see some advantages of inserting such a course in the ninth-grade level because there are curricular inadequacies at that level at the present time.

But let me pass on. Suppose it were a ninth-grade course and suppose it took half a year to teach. The content would be determined by the objective of teaching kids to solve problems by computer. One would have to teach some rules for programing, the grammar of computing, so to speak. But grammar itself is not very interesting. I know what a subject is, and a verb, and an object, and so I can make a sentence; but that doesn't mean that I can say anything meaningful. So the rules for programing are a minimal requirement and not intrinsically interesting—merely a means.

The student would learn a protocol for interacting with the computer: Who types, when, and what does the computer say, and how do I end my communication with the computer? That is rather trivial but essential information. But most important, the course would contain sets of interesting problems that were appropriate for solution by computers, starting with small problems that are well defined and concise and ending up with somewhat larger ones that put the pieces together into more interesting problems.

A simple task might be the following: Given a list of words, how do you sort them into alphabetical order? This is a nonnumeric task, which is nice because it doesn't look like numbers and people afraid of math would not be scared off. The teacher could talk about strategies for putting words in order and then about strategies for finding words once they are in order. The point is not to learn to do those things in particular, but to learn how to communicate that problem to a computer so that the computer can be a tool, a magnifier of one's own skills.

So the course would have that kind of content. It would be aimed at problem solving, using problems that students understand and learning how to express those problems in the language that the computer will be able to understand.

That is the kind of course I have in mind. It could be introduced into every high school in the country right now. Bear in mind that it is a half-year course out of a 4-year high school curriculum, which consists of about 40 half-year courses. So we are talking about no more than a 3 percent change in the high school curriculum to introduce such a course, I would consider that a minimal first step toward computer literacy. As time went on, one would want to see how computer uses could be inserted in traditional courses like mathematics and sciences and language. But as a baseline, in order to insure a standard competency in computer usage, one might be able to get away with a half-year course at that level.

What would it cost? Here's one way to say it. It would cost quite a bit less than having a library in secondary schools. The equipment and teacher costs would be less than the staff costs and the purchase costs associated with a library. I arrive at a figure of about 50 percent of the cost of having libraries in secondary schools is what it would cost to provide basic computer literacy education of this type within the school setting. Now I should point out that of that amount more than half is staff cost. Less than half is equipment cost. But the staff used for the computer courses should come from the present teaching staff. That should not be a new cost. If that is the case, then the remaining equipment costs are perhaps of the order of a quarter of the cost of having a library in the high school.

As to the equipment cost, I am using a very generous figure for the price of computers. Within 5 years these figures will be laughable, but today they are right. The course I've described should be based on computers with more capability than the $6,000 home computer available today. I have used a figure of about $6,000 because I know of equipment one can buy off the shelf which has approximately that capability which is needed. My equipment figures are high because I have assumed today's price for a more powerful machine.

Dr. SWANSON. Just to get a handle on how-fast that is going down, today's $6,000 computer, when will that cost $6,00?

Mr. LUEHRMANN. In about 5 years. It's funny how these things go. That particular model won't fall very fast, but it will be replaced by other ones.

Dr. SWANSON. What will an equivalent size to that computer cost?

Mr. LUEHRMANN. I would think within 5 years it could be had for certainly under $1,000 and perhaps as little as $600. The color TV set seems to be a target price for all things for the home market. I would think something in that neighborhood would be feasible on a 5-year time scale. It would have a greatly improved graphic capability and much more memory.

For my cost calculations I have used the figure of three students per computer in the classroom. That is not optimal. It would be better to have one apiece, but at $5,000 to $6,000 apiece that seems like a luxury. If the price went down fast enough the number could be brought up.

I have also tried to write equipment purchases off in 3 years, which may be a little fast. So my figures are also high for that reason.

Mr. GALLAGHER. I have touched on this point somewhat before and I would like to hear your views on it. Point 5 on your testimony, page 5, you say that the private sector is not organized to make significant advancements in the education of the public.

Mr. LUEHRMANN. Yes.

Mr. GALLAGHER. I would like to go back for a moment to one of our previous witnesses, Dr. Papert, who had this statement:

> A computational revolution is certain to happen. It is driven by industry rather than by the educational community. It will take place in the home whether or not the schools accept it.

Your point here is that significant investments are needed. I assume you are referring to R. & D. seed money.

Mr. LUEHRMANN. Yes.

Mr. GALLAGHER. Preferably from the Federal Government. Well, I think there's a profit motive here and if industry sees it they will move on it and it will come about whether or not the Federal Government likes it or sees it, et cetera.

Mr. LUEHRMANN. Yes; I agree with you that there looks to be a contradiction here, but I don't think there is. I agree that there is a profit motive and a strong incentive for the manufacturers of equipment to go out and sell that equipment and to tell people whatever is necessary to make as many sales as possible. I agree with that point. If there were no research and development funds available for the kinds of research and development projects that I think need to be done and which we have talked about here, something would happen anyway. The question is whether what happens will be good for the public. I think the arguments are very strongly in the negative. I don't think that what will happen will be for the good of the public.

First of all, people will learn to use computers anyway. Some people. Who? The people for whom a $600 expenditure is not very much. I have touched on that already. There will be a tremendous distortion in the distribution of computer literacy within the society. That seems to me to be inappropriate.

Second, computer manufacturers have no interest in teaching skills which are transferrable from their machine to some other machine. They have a much greater interest in hooking you into some idiosyncrasy of their equipment. They are not trying to teach you literacy. They are trying to teach you the virtues of using their machine rather than their competitor's machine.

In the process they will contribute to some literacy, of course.

Mr. GALLAGHER. You did bring out an analogy there: "Why doesn't Random House Publishing Co. invest in teaching people to read? People might go out and read Doubleday books."

Mr. LUEHRMANN. Exactly.

Mr. GALLAGHER. Will that analogy hold water because you have Westinghouse and Zenith selling television sets which have a different segment of industry, namely the service industry and Madison Avenue putting in programs.

Mr. LUEHRMANN. Yes.

Mr. GALLAGHER. Why couldn't it happen in this area too?

Mr. LUEHRMANN. It will and that's just the point. What will develop is an industry which is marketing applications that will run on the home computer. It will not, however, teach people to write their own applications. It will only sell canned programs that help them with their income tax or the decision about how much of a house they can afford to buy.

Mr. GALLAGHER. Are you saying if Federal money is put in that this won't happen?

Mr. LUEHRMAN. I'm not saying that at all.

Mr. GALLAGHER. You are saying if Federal money does not go in the programing material itself would be suspect.

Mr. LUEHRMANN: I'm not saying that either. I think those are interesting programs and I expect such an applications industry will develop, I'm confident it will. I am saying that there will be no conscious program to teach the public how to use a computer themselves. Some will learn by hook or crook but in a way that is not optimal and not transferable and highly distribted within the society, favoring the affluent. Basic literacy in using the computer will not be taught by any industry that I know of in the private sector. It is not in their interest. It is in their interest to sell hardware and applications. It is not in their interest to teach people how to write programs or how to solve problems by means of a computer. Do you see the difference I am making here?

Another very important thing is that it's important in the model I propose that teachers be taught how to do this and you can be sure that the private sector is not going to engage in a program of retraining teachers to teach students how to use the computer. It seems unlikely to me, anyway. It may be possible that a giant in the computer industry which has more to benefit from mass literacy and anybody else could see it as being within its interest to conduct such programs. It may be that that is true, but I think that is highly unlikely.

And, finally, the schools are unlikely to have equipment on which to teach the use of computers without some planning by the local communities for acquisition planning which is supported by Federal or State funds. I do not think the on-going cost of such a program should be supported by the Federal Government. Since computer use is a basic skill, the local community should support the on-going cost of teaching it.

But I think Federal funds can be very helpful in the research, development, and planning stages.

Mr. GALLAGHER. But it should go to the educational community?

Mr. LUEHRMANN. I think it is an educational task, yes. Research needs to be carried out at the university level, at institutions that deal with the public, science centers, and science museums. Other models for teaching computer literacy should be tested besides the one I have proposed.

Mr. GALLAGHER. Somewhere along the line there has to be a marriage with industry just for the equipment. Who is going to produce the equipment?

Mr. LUEHRMANN. I think the equipment that is going to be marketed in general is adequate to the task. I do not think special new equipment will have to be developed for teaching computer use.

Mr. GALLAGHER. It has to be interlinked.

Mr. LUEHRMANN. Industry certainly has to be a participant in the the planning, all the way through. It would be nice if industry were willing to come forward with funds to support research. But I think we would be wrong to expect it at this point. The experience is not there to give one much confidence that funds will be forthcoming.

Mr. WELLS. Isn't there a parallel between what happened with the automobile industry and the construction of the vast road network throughout the United States? It was not really until six decades after the technology arrived on the scene that we began to think of the social consequences.

Mr. LUEHRMANN. Rational planning did not occur because it was not of central concern. People made independent decisions.

Mr. WELLS. It is probably not unreasonable to expect industry to participate in what Mr. Gallagher is suggesting. I see no reason why industry should not be interested in participating in some of the things Dr. Papert suggested.

Mr. LUEHRMANN. I think certainly in any planning activities there should be industrial representation. It is very important for those who are going to be involved in educating the public in the use of equipment to be in very close communications with the suppliers and other communities as well: Researchers who are working on problems in learning and people who are working in computer science. All of these people should be represented at the planning level.

Mr. SCHEUER. I would like to thank Dr. Luehrmann and Dr. Emery and Dr. Pepert and Dr. Brown for appearing today. I think the session was highly productive and I think your remarks are well taken.

We hope that the endeavors of the subcommittee and the staff will reflect the high level of testimony that we have had today.

Thank you very much for coming.

[Whereupon, at 12:50 p.m., the subcommittee was adjourned to reconvene at 10 a.m. on Thursday, October 13, 1977.]

COMPUTERS AND THE LEARNING SOCIETY

THURSDAY, OCTOBER 13, 1977

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON DOMESTIC AND
INTERNATIONAL SCIENTIFIC PLANNING,
ANALYSIS AND COOPERATION,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:10 a.m., in room 2325, Rayburn House Office Building, Hon. Robert S. Walker, presiding.

Mr. WALKER. This is the fourth day of the Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation's hearings on "Computers and the Learning Society."

Today we have asked representatives of our various Federal agencies concerned with funding research, development, and demonstrations in the field to appear. They will explain to us their current programs and policies.

We are happy to have this opportunity, especially in light of what we have found in our 3 previous days of testimony on computer managed instruction, computer assisted instruction and research plans for the future.

Having said that, I would like to call first Dr. F. James Rutherford, Special Assistant to the Director of the National Science Foundation.

Dr. Rutherford, we will enter your remarks into the record. If you want to go through them that is fine and if you want to paraphrase them, that will be fine too.

[The complete prepared statement of Dr. Rutherford is as follows:]

STATEMENT OF DR. F. JAMES RUTHERFORD
ASSISTANT DIRECTOR FOR SCIENCE EDUCATION
NATIONAL SCIENCE FOUNDATION
BEFORE THE
SUBCOMMITTEE ON DOMESTIC AND INTERNATIONAL SCIENTIFIC
PLANNING, ANALYSIS & COOPERATION
COMMITTEE ON SCIENCE & TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
OCTOBER 13, 1977

Mr. Chairman and Members of the Committee:

Today, I am pleased to describe for you the National Science Foundation's (NSF) programs directed at computers in science education.

1. National Science Foundation Goals and Policies in Computer Education

In his Health and Education message to Congress on February 28, 1967, the President specifically directed the National Science Foundation to work with the U.S. Office of Education in establishing an experimental program for developing effective methods for utilizing computers at all levels of education. After action by both Houses of Congress, NSF was authorized to foster and support the development and use of computers and other scientific methods and techniques for research and education in the sciences. Since then, the National Science Foundation has supported a wide variety of programs designed to stimulate the innovative applications of computers in science education. This has included support for the development of: computer technology and techniques for instruction; computer applications in science and courseware for selected scientific disciplines; new instructional concepts based upon the availability of computers; and organizational mechanisms to facilitate the widespread use of computer products and concepts. It has also carried out tests of alternative computer-assisted instruction systems and provided training programs for faculty.

In the development of computers for science, the National Science Foundation has taken steps to assure that it does not merely duplicate the efforts of business and industry. From the beginning, the Foundation has worked closely with both the commercial sector and academic institutions to develop alternative systems for meeting diversified instructional needs in science and mathematics. Much of the NSF effort has been aimed at "proof-of-concept" experiments and field tests. These are needed to reduce uncertainty for the commercial sector and to offer evidence to members of the academic community on the advantages and limitations of various models of computer use. The operating premises are that the user is the best judge of the usefulness of instructional materials and systems and that the commercial sector provides the best avenue for their distribution.

In addition to computer oriented science education activities, the NSF has administered science information programs. These include: support for activities to improve the use of scientific and technical information and to conduct research in the information sciences in order to better understand the fundamental process of information transfer. Some research projects seek more effective ways of applying new technologies to the problem of information access and use. Other projects seek to improve the transfer of scientific information from originators to users by providing computerized abstracting and indexing services to scientific and technical literature. The Foundation participates in bilateral international science information activities, and thus, to a limited degree provides a Federal focus for international science and technology activities.

2. National Science Foundation Programs for Computer-Related Support

a. History

In 1968, in response to a Presidential directive, the National Science Foundation established a special office for computer research support. The Office of Computing Activities (OCA) was created to provide a suitable framework for meeting the special needs for computers in education and research. In addition to supporting research in computer science, a special Computer Innovation in Education (CIE) program was launched to support cutting-edge, high-risk projects with potential for high pay-off.

In fiscal year 1972, the Computer Innovation in Education Program of OCA was transferred to and integrated into our Science Education programs and renamed the Technological Innovation in Education program. In 1977 the TIE program was discontinued and many of its functions were absorbed in other programs. During the nine-year period from fiscal year 1969 to 1977 the Computer Innovation in Education Program (including TIE) spent an estimated $51,976,000 on computer uses in science education.

b. Current Programs

In fiscal year 1977 our Science Education Development and Research (SEDR) and Science Education Resources Improvement (SERI) divisions supported 192 computer-related projects for an estimated total of 9.7 million dollars.* In addition to providing support for research and development for computer-related projects in science education, programs in those two divisions have been particularly responsive to providing instructional support for the

* See Appendix for a description of programs and expenditures.

improvement of science education at a variety of institutions. The relatively large number of computer-related proposals received and projects supported is indicative of the proposal pressure from institutions to initiate and upgrade the use of computers in science education.

3. Overview of General Results of Projects and Research Efforts

The accomplishments of NSF programs have been many.

(a) Regional Instructional Computing Networks

NSF helped pioneer the development of thirty regional networks which include 300 institutions of higher education and many secondary schools. Most of these networks are self-sustaining and have continued to operate without additional federal funds.

(b) Systems. Experiments with and demonstrations of computer-assisted instruction systems have been encouraged and supported by NSF. Several are now commercially available. A student computer-based career guidance and information system has been field-tested and evaluated. Support has been provided for the development and evaluation of a computer-assisted instruction system for arithmetic and reading in elementary-secondary schools.

(c) Curriculum. Computer-based curricular materials have been developed for chemistry, mathematics, physics, social sciences, biology, statistics, and computer science. Research efforts have been made to evaluate and restructure science curriculum based upon the availability of a computer.

(d) Computer Languages. New computer languages, LOGO and PLANIT, have been developed for computer-assisted instruction.

(e) Surveys and Studies. In order to monitor development of computers in education, national surveys have been conducted in higher education and secondary education. Studies have been supported to identify exemplary uses of computers and to identify the barriers to widespread use.

4. Problems in Current Government Policy

Current Federal policy and the provisions of the National Science Foundation Charter allow us ample latitude and freedom to support significant developments in computer-based education. If there are any constraints, they are the financial limitations for discretionary funds for research and development in science education and the support of special high quality institutional projects.

5. Future Directions in Computer-based Education of Special Interest to the NSF

Due to the limitation of funds, the Foundation intends to concentrate its resources on those areas which hold the greatest potential for fundamental and lasting changes in the educational process. These include the following:

(a) Fundamental Research and Development. In the last five years computers have undergone an order of magnitude improvement. Current CAI and problem-solving techniques are grossly inadequate for today's computer systems. Researchers are moving away from the development of systems that simply teach facts and skills to the study of knowledge based systems. Advanced, smart or intelligent CAI systems are beginning to appear, and hence, there is a need for fundamental research on such questions as "How do people learn?" "What is knowledge?" and "How can machines augment human learning and knowledge?"

(b) Curriculum Revision and Development. Existing curricula need analysis in the light of the widespread availability of low-cost computers. Current research tends to indicate that with the aid of a computer elementary school children are capable of solving complex problems which they are not traditionally exposed to until high school or even college. Careful exploration is needed to determine to what extent today's courses can be made more efficient through the imaginative use of computer technology. But modification of existing curricula may not be sufficient. Research is needed to examine whole new curricular possibilities. That is, support should be given for the experimental development of entirely new instructional materials and approaches that from the outset presuppose the existence, and local availability, of inexpensive computers. Simultaneously, computer involved courses need to be invented for various levels and subjects in which the computer itself is an object of study.

(c) Faculty Training. In the early years of Federal support for computers in education, workshops were provided for faculty development. With the ever increasing numbers of new acquisitions of computers, renewed efforts for faculty training are needed. It is clear that in order to obtain optimum utilization of new instructional technology and high quality materials, there must be concomitant faculty training.

(d) Microcomputers. Low-cost microcomputers offer an exciting development for science and science education. The development of special machines for a wide variety of applications is an urgent problem. The combination of video disc and microcomputers promises to make available powerful, personal, computer systems which can combine the versatility of television with the power of the computer.

The computer has become a symbol that in many ways represents science and technology in the public eye. That is not surprising, since it is a versatile tool that has affected not only every field of science, but also has come rapidly into common household use.

The computer permeates many aspects of our society and impacts significantly on the daily lives of most people. Educated citizens need to know enough about computers to be able to both capitalize on and control their use. In the context of these hearings, I wish to emphasize that computers offer a unique opportunity to improve the quality of education while enabling us to advance our state of knowledge in science and education. Computer technology should allow us to better prepare all of our citizens for successful lives in the real world of today and tomorrow.

APPENDIX

Science Education Programs

and

Computer Related Activities (FY '77)

23-082 O - 78 - 22

SCIENCE EDUCATION PROGRAMS AND CURRENT COMPUTER RELATED ACTIVITIES (FY '77)

Programs	Total Funding*	Funds Spent on Computer-related Projects*	Total Number of Projects	Number of Computer-related Projects
		SCIENCE EDUCATION RESOURCES IMPROVEMENT		
CAUSE	10.8	3.5	69	20
LOCI	2.2	.7	122	61
ISEP	2.86	.6	296	80
RIAS	4.3	.462	30	3
MISIP	5.2	.452	32	10
	25.36	5.714	549	174
		SCIENCE EDUCATION RESEARCH AND DEVELOPMENT		
RISE	2.5	.75	24	4
DISE	9.0	3.26	89	14
	11.5	4.01	113	18
	36.86	9.724	662	192

- - - - -

*Millions of dollars.

Science Education Resources Improvement Programs and Computer-Related Projects

INSTITUTIONAL SUPPORT

The institutional support programs of the Science Education Directorate are designed to strengthen the capabilities of schools, colleges and universities for science education and research training. They range from programs aimed at institution-wide improvement in the sciences to highly focused projects dealing with a single component of an individual course.

RIAS

The Research Initiation and Support (RIAS) Program supports such activities as exploratory research and the acquisition of instruments, equipment, and facilities for research training. This is designed to help institutions to upgrade their programs for young scientists at the graduate and postdoctoral levels and faculty with recently completed graduate training.

Of the 30 awards granted through RIAS, three were computer-oriented. For example, Wayne State University received an award so that young scientists in chemistry and psychology can receive training and research experience in the computer-control of scientific experiments. Ability to use computers to control research is important now and will become even more important in the near future. The young investigators will receive their training on a computer network in which a number of microprocessors control individual experiments while sharing a single set of expensive peripheral devices attached to a communications computer.

ISEP

The Instructional Scientific Equipment Program (ISEP) is designed to improve the quality of undergraduate science instruction by supporting the acquisition of scientific equipment required for undergraduate instruction in the sciences. Approximately 30 of the 287 projects supported by ISEP were computer-oriented. One of the projects, for example, involved supporting equipment purchases at Washington and Lee University which will be used in developing a new course in microcomputers for students without previous electronic experience.

LOCI

The faculty-oriented projects are supported under the Local Course Improvement (LOCI) Program. This program is designed to 1) encourage the introduction of new scientific and educational concepts to undergraduate students, and 2) enhance the teaching capability of science faculty.

Of the 129 LOCI awards, 61 were computer-related. For example, California State University, Sacramento, received an award to develop interactive CAI techniques to use in teaching undergraduate students in chemistry how to acquire and interpret data from laboratory instruments. This project addresses one of the most important teaching objectives in a laboratory science.

MISIP

The Minority Institutions Science Improvement Program (MISIP) provides support to effect long-range improvement in the basic scientific strength of post-secondary institutions whose enrollments are composed predominantly of Black, Native-American Indian, Spanish-Speaking or other disadvantaged ethnic minorities underrepresented in science.

Ten of the 32 awards granted in FY '77 by MISIP were computer-related. For example, an award was approved for the Atlanta University Center to conduct a project designed to establish computer technology as an integral component of the science program. This will be accomplished through training faculty in the use and development of computer courseware for science instruction, by providing remote instructional computing capabilities to the Center institutions, and by providing technical support services. Atlanta University, Clark College, Morehouse College, Morris Brown College and Spelman comprise the five Center institutions. The program will impact at least 3,000 minority students. It's anticipated that through this program, students will improve their academic performance in science and math courses, and more students will be motivated to study science and choose science careers.

In order to accommodate the growing need in the area of computer technology, greater funding is indicated. Primary emphasis would be placed on:

° providing students enrolled in minority institutions with an opportunity to learn the use of computer technology

- enabling faculty at minority institutions to incorporate computer techniques into their courses
- removing the barriers of poor mathematics and science preparation of entering students through the use of computer assisted instruction techniques
- enhancing the research capability at minority institutions with computer facilities.

OTHER MINORITY ACTIVITIES

Few proposals submitted to other NSF programs for small developing institutions, in particular minority institutions, involve computer technology. If these institutions are unaware of the value of the computer as a tool in education and research, computers certainly will not be among the top items on their priority lists of needs. In attempting to ameliorate this deficiency, the Foundation has supported three 4-day intensive workshops on Educational Computing in Minority Institutions (ECMI). The computer literary workshops were funded at approximately $906K and involved some 1,000 faculty and 100 presidents of minority colleges. An evaluation of these activities is currently being planned to determine if the ECMI workshop model is a cost-effective way to assist in accomplishing the goal of improving computer literacy among the faculty at these institutions and, subsequently, improving minority institutions capabilities in this area. Other mechanisms also need to be researched to determine their feasibility, effectiveness and cost-efficiency.

CAUSE

The major objective of the CAUSE program is to strengthen the science education capabilities of predominantly undergraduate institutions, departments, or groups of departments. The program addresses the needs of those institutions--large and small, public and private--that have experienced a decline in undergraduate science education standards over the past decade. In particular, attention is given to the large number of institutions heretofore uninvolved in the science education activities of the Foundation.

This fiscal year 69 awards were made by CAUSE totaling $10.8 million. Recipients included 19 two-year colleges, 28 four-year non-Ph.D. degree-granting institutions, 16 Ph.D. institutions, and 6 consortia.

As in FY 1976, over half of all proposals submitted in FY 1977 involved computing. Twenty of the 69 funded projects were computer oriented. Suffolk Community College, for example, received an award to develop a program designed to incorporate computers into a wide variety of courses covering six academic areas. The concerned departments are Mathematics, Physics, Chemistry, Earth and Space Sciences, Engineering and Economics. When in full operation, the program will affect as many as 10,000 students per year, by exposing them to the computer as both a learning device and an exceptionally valuable tool for problem solving. The mode of computer usage, be it as a computational tool, a simulator for models, or CAI, will depend on the specific courses.

Science Education Development and Research Programs Computer-Related Projects FY '77

The Division of Science Education Development and Research (SEDR) spent 11.5 million dollars in FY '77; of these monies 4 million was spent on 18 computer-related activities.

RISE

The Research in Science Education (RISE) program supports research on a variety of topics, one of which is "technology in the classroom." Projects supported are:

° The impact of calculators in elementary school mathematics (G. Wheatley, Purdue University),

° Computer literacy in science education (D. Klassen, Minnesota Educational Computing Consortium),

° The importance of gaming in acquiring mathematical and scientific knowledge (I. Goldstein, M.I.T.), and

° An assessment of a children's computer laboratory (S. Papert, M.I.T.).

DISE

The Development in Science Education (DISE) program supports research in several areas, one of which is "technology in science education." Fourteen technology projects were supported.

Several projects concern the development of courseware and improved dissemination of materials. Melvin Novick, at the University of Iowa, is continuing work on a system to analyze data using Bayesian statistics. David Parnas, at the University of North Carolina, Chapel Hill, will prepare software to facilitate the teaching of structured programming, a new approach that promises to improve programmer productivity. David Merrill, of Courseward, Inc., will investigate learner-controlled instructional strategies. Wallace Feurzeig, at Bolt, Beranek and Newman, will create a transportable version of the LOGO language which has been used effectively in a variety of educational environments, most notably with Seymour Papert's TURTLE. Gary Breneman, at East Washington State College, is writing courseware for use in undergraduate chemistry classes. The CONDUIT project, which has offices on five campuses and over 100 colleges and universities as members, is continuing to facilitate the distribution of courseware by establishing language standards and testing existing courseware at other test sites before it is made available generally.

Two projects are concerned with speech output in computer-based instruction. Jonathan Allen at M.I.T. is continuing development of a speech synthesis system. Patrick Suppes at Stanford is developing lessons which incorporate speech output as well as developing courseware in logic.

The remaining six projects are:

° Science career awareness for elementary school children (A. Korotkin, Richard A. Gibboney Associates, Inc.),

° Study on courses in computer literacy and the impact of computers on society (R. Austing, Association for Computing Machinery),

° Assessing the impact, benefits, limitations and costs of computer innovations in education (R. Seidel, Human Resources Research Organization),

° Educational applications of intelligent videodisc systems (A. Bork, U. of California),

° Computer conferencing system for peer evaluation and commentary on essay tests (J. Woolpy, Earlham College), and

° Guidebook for the use of computer graphics in undergraduate mathematics (G. Porter, U. of Pennsylvania).

STATEMENT OF DR. JAMES RUTHERFORD, NATIONAL SCIENCE FOUNDATION, WASHINGTON, D.C.

Mr. RUTHERFORD. I would prefer to submit the report and talk to you about some of my interests and concerns. I am sorry that Dr. Atkinson cannot be here. He wanted to be here, but he is out of the country.

As you know, he has a great interest in computers not only because he is director of the Foundation but because he himself has done substantial and outstanding research on learning using computer technology.

I should also like to point out to you from the start that I am not a computer specialist. My interest during my professional life has always been in the learning of science by students at all levels. I have taught in high schools, I have been a university professor, and I have developed physics curriculums. I regard my job as science education director in a similar way.

My only interest in computers, really, except as an individual, is in the extent to which they can contribute in a positive and imaginative way to better learning for all young people. So I will not speak to the details of computer technology.

In the report you will find some history of the contributions of the National Science Foundation. As I began to learn about that I was impressed by the record at how early the Foundation discovered that the computer was something more than a research instrument, something more than a device for making business happen more efficiently. But the record is clear and you can read it. In fact, the hearings you have been holding are testimony to the effectiveness of the National Science Foundation. I think most of the people you have had here at one time or another have received some support or encouragement from NSF.

When one looks at the role of computers in learning, in education, in helping children learn science and learn how to deal with the world, I tend to be skeptical. I think modern technology at best cannot be a substitute for good teaching, for the skill and decisionmaking ability of the teacher in a classroom.

But even more than that it is the fact that the history of the use of technology in education is not bright. Visit schools and colleges and you will see that many instructors still have difficulty getting a 16 millimeter projector to contribute in a useful fashion to learning.

Television and radio early on were corrupted at least in an educational sense and have not been exploited. The early working computers seemed to place them out of the range of use in schools—too expensive, too large, and too frightening in a psychological sense. We did not know enough about them. So I had some skepticism, but I must say that my thinking changed and without exception I think we are now facing a new situation in which computer technology has a good chance, if properly exploited, to make important contributions to the learning of the entire spectrum of young people in our schools and colleges.

The economic barriers have just about disappeared and are on the way out. The sizes have gone down and no longer is there a frightening machine either in place or off in some distant place, but it is something you can lift and see and deal with like a typewriter.

People are going to be around them and become used to them so that they will be looked upon in a neutral way as say a television machine or a radio, no longer exotic. The question, therefore, is—I think they are going to be used but the question is how and for what purposes and how can we learn to do it correctly?

I would like to suggest that we are now at the point that we should first of all undertake a vigorous and renewed research and development effort to learn better how these freestanding, independent, small computers can affect learning in real classrooms. That could not happen before.

In a New York City project attempting to improve science for junior high school students, we found that students and teachers responded well to the use of these small machines. But more than that, the machines provided a way of beginning to look at students differently and learn more about how they learn. I think that research and development is the overriding need right now, not to support schools or colleges to buy equipment, not to underwrite the development of programed instruction, but to finding out with these machines how learning occurs, how scientific concepts are developed, and how quantitative notions grow, the relationships between numbers and real world quantity. That is a 10- to 20-year line of research that is opening up now that I think will be enormously powerful.

The second thing I think we are in a position to do now is to think of this instrument in relation to science and mathematics curriculum. To do this I think we should look at the computer as an entirely different device from an information-dispensing apparatus. Motion picture projectors dispense information and other projectors do that and books do that and radios and televisions. The computer can do that, too, but I think that is not its power. Its power is that it is a device or tool for manipulating information, for helping people to think. Now that is what school is about, learning to think and manipulating information for yourself in order to make decisions.

So I think we must now begin the task of reexamining all of our curriculums, especially in science and mathematics, to see in what ways this tool can be used to make the instruction more powerful, more germane, and more open to more students.

Third, in the line of things I think we are now ready to do, is to examine in a research-and-development way the computer as an object of instruction. Ten years from now, in order to get by in the world, we are building for ourselves, for better or worse, a citizen is going to need to know how to deal with computational devices and something more than a handheld calculator.

Notions such as modeling, how to project your decisionmaking, how to use instruments that can now bring you information, help you organize it and make decisions are going to be in our world. Therefore, our schools should undertake the process of learning how to do this, how to prepare our students to enter and be effective in such a world. That is different from using it as a tool to improve science instruction itself.

Those, I think, are the main directions in the future. The National Science Foundation, particularly the education directorate, I think, is in an extraordinarily strong position to undertake the promotion and support of such research. We have had now a couple of decades of first-rate research. And everything that has happened, whether or not you can find it in schools or colleges, has provided a base.

I would suggest respectfully to this committee that as it explores the connections between computers and learning that it think of the computer first of all as a preeminent research device for learning more about learning and, second, as a tool for reexamining all of our school and college curriculums, especially in the sciences and mathematics, and finally as something to be taught about itself.

I would be pleased to answer any questions you might have.

Mr. WALKER. Thank you very much, Dr. Rutherford, for your statement. Counsel has brought to my attention here an article called "Science for Urban Junior Highs" which I think backs up some of the things you were just stating.

Looking at the article and taking testimony you have given here, it strikes me that one of the things that might be important in determining where we go in the future of education is where do you begin applying the computers for use in the educational community. You are talking about junior high school age here. We have had some people testifying here who seem to be indicating that they are applying computer technology to the elementary schools.

I guess what I am concerned about is, is there a danger along the way that we begin to teach more about the computer than we teach about the basic skills and the basic information needed to assess what a computer can and cannot do? And when do you begin introducing the computer as being not just a tool but a basic part of one's life and how much basic education should there be in front of that?

Mr. RUTHERFORD. I suppose there is a danger in the use of any new technology in education. It would be more of a danger if educators were better able to apply technology than in fact they are. But I think the point is well taken. My own bias as an educator now is that in the elementary school the computer's role in the school should be solely as a tool, not as an object of instruction. And if it can help children learn fundamental thinking, logic, and use of numbers, how to express ideas, how to sort information, that is contributing basic education, and that is its role.

I would say up through the junior high school level, up through high school, the main function of the computer ought to be to help one get a deeper understanding of subject matter.

As you get into secondary school, however, I think you are beginning to reach the point at which it becomes possible and important to think of the computer as something itself to be understood. Because, after all, half of our children do not go to college and probably one-eighth or more never finish high school; thus high school is the last chance for many to learn about computers.

So if we want them to understand the instrument, to know its limitations and know what to expect of it, then I think something needs to be done at the secondary level on the computer itself.

Mr. WALKER. I can see that there are some dangers both ways on the thing. That is what I'm trying to clarify here. No. 1, it seems to be absolutely essential that people have the basic information needed before we get into the computer. But at the outset of your statement you speak about the intimidating factor of computers. Isn't it also possible that if we don't start teaching computers at a very early age and teaching people to utilize them as a part of their informational network that when we finally do introduce them at the junior high school or high school level you are introducing then an intimidating factor in terms of the child.

Mr. RUTHERFORD. I think my response probably wasn't very clear. What I meant was the computer should probably be used from the earliest grades but for the purpose of helping children learn the fundamental intellectual skills and knowledge about the world.

Mr. WALKER. But the problem there it seems to me is do you teach them to become dependent upon the computer for those skills without developing the skills separate from the computer? Here a couple of years ago the teachers were saying that we should not have a math class without having all the kids there with little pocket calculators. But it seems to me that somewhere along the line they ought to get the basic skills without the reliance on the machinery before you introduce the machinery.

Mr. RUTHERFORD. I don't know. I personally have not that fear, although I consider it to be a researchable question as to what unwanted dependencies might develop from the use of technology in earlier years.

Mr. WALKER. I would hate to think that if we had another blackout in New York City that we would not have anybody who could add if they didn't have a computer or calculator.

Mr. RUTHERFORD. I am not well informed on the outcome of work that has been done. There has been a considerable amount of work on the use of computers in fundamental learning, things related particularly to rote, (learning.)

My understanding is that what they did was not teach the children simply how to use the computer to get an answer to a problem but rather used the computer to teach children how to use numbers. So, used in one way, the computer can make you independent of it, while I suppose, used in a different way, it could also build in a dependency.

Some dependencies may be useful and others not. The automobile is one that we are probably overly dependent on. On the other hand, no one is arguing that we can really get by without it. There is a danger if one willy-nilly introduces new technologies into the schools. If they are injected in a way that desregards the purposes of school at every level, there is a danger.

Mr. SCHEUER. What are the purposes of school?

Mr. RUTHERFORD. They are to help all of our young people get the kinds of intellectual skills and knowledge that it takes to be able to operate in the real world, to understand the world and enrich their lives and have opportunities to get the kinds of jobs or careers that they might be interested in.

Mr. SCHEUER. To make them better functioning citizens. That's a pretty broad mandate. I don't see how you would have a problem with that mandate. You said computers are used for the educational system to help children learn counting and math and arithmetic. Can't the computer also be used to sort of open their minds and key their interest on the whole business of learning, the whole business of communication, and the whole business of absorbing ideas and solving problems?

Mr. RUTHERFORD. I think, Mr. Chairman, my remarks before you arrived were in part to that point, that the real power of the computer in the classroom is as a device that will help youngsters learn how to sort information, restructure it and think about the world. As an information-dispensing device, I'm not terribly interested in it. We have lots of ways of drowning students in information. What they need is not more information but knowledge of how to use it.

Mr. SCHEUER. If they are not receiving the information, you are not drowning them with it. You may be sending it, but if they are not receiving it, there is some kind of a barrier.

Mr. RUTHERFORD. Surely.

Mr. SCHEUER. If through the computer you can deliver it to them in a form they find attractive and interesting and stimulating and acceptable you may be giving them information in a fashion that the regular school establishment is not giving it to them.

Mr. RUTHERFORD. Perhaps so.

Mr. SCHEUER. Nobody is drowned in information, unless he is receiving it. It is the old thing of if a tree falls down in the middle of the forest and there's nobody there to hear it, is there noise?

Mr. RUTHERFORD. But I still have considerable skepticism about the power of the computer to motivate students for a long period of time to simply receive more information. It can do that for some students.

Mr. SCHEUER. There is no point in trying to prove that. The question is can the computer do lots of things.

Mr. RUTHERFORD. That's the point.

Mr. SCHEUER. It shouldn't be judged on whether it can just do one thing for a long period of time and probably the least interesting or significant thing of all the things you have mentioned that it is potentially capable of doing.

Has NSF funded any longitudinal studies of how the computer can be used say for this group of kids in our society that we are having trouble turning on and for whom the public school system, as an institution, doesn't seem to work very well?

The kids are predictably coming out of school from their 11th and 12th year almost functionally illiterate, if not completely functionally illiterate, without reading and writing and counting as everyday tools of life. Have there been any longitudinal studies of the kind of roles that the computer can play in turning on these kids?

Mr. RUTHERFORD. There have been some studies that have gone on for a long time. I am personally not aware whether there have been longitudinal studies. There are staff members here whom I would be happy to ask and who would know.

Mr. MOLNAR. I am Dr. Andrew Molnar of the National Science Foundation. One of the major difficulties in this area is that most of the activities have been of a research nature such that the curriculum created is for a small specific experiment.

And the lack of curriculum from, say, 6 through 12 precludes a long-term, longitudinal study. There is one being conducted on a limited basis.

Arthur Melmed of the National Institute of Education which is supporting a longitudinal study in Los Angeles, can probably give you more details on that, since they are supporting it.

But there have been studies which demonstrate that computer-assisted instruction does work for disadvantaged students; that is, that we are able to demonstrate significant improvements in performance at the elementary and secondary levels. At the higher educational level, computer-assisted instruction is a little more inconclusive in terms of results in that it appears that it teaches as well as an instructor; that is, a computer-assisted instruction program can substitute for a high-quality teacher and present materials in a consistent manner over time.

Mr. SCHEUER. That is a significant statement.

Mr. MOLNAR. It is.

Mr. RUTHERFORD. One response to that: I must say that in education in general, we have conducted very few longitudinal studies. It is sad because it is one of the few ways you can determine the real impact of what is happening in the schools. It is probably in part a consequence of the way funding happens annually. It is hard to keep studies going for 12, 15, or 18 years.

The test of education is what happens to the youngsters when they become members of society, adults, and have responsibilities. If that is related to education, we ought to be making such studies, the computer included. But there are other things we claim have useful effects, but we don't go about measuring them properly.

I think that should be promoted more by the education agencies.

Mr. SCHEUER. Let me zero in on particularly this group that we seem not to be able to cope with very well, the group of low-income, culturally disadvantaged kids, whom we expose to the educational system and shove them through the pipeline and they come out after 12 years virtually unaffected by it all. They have really resisted it, the efforts of pretty decent and sincere people. Maybe it is because we dish it up in a form that is totally irrelevant to them as they perceive it. It offers no rewards to them and it doesn't relate to their life and what goes on in their homes, et cetera. There are many reasons why they perceive it as irrelevant, but the fact is that they do manage to get shoved through the pipeline and emerge after 12 years of education really quite functionally illiterate.

The question is, has the computer proven, or are there indications that the computer can turn these kids on? It seems strange to talk of a computer relating to a kid, but we have heard some testimony that the computer can be programed so that the kid in effect has the computer under his or her control and there seems to be actually a symbiotic relationship, a "friendly" relationship between the kid and the computer and the kid feels he can manipulate the computer and does in such a fashion that learning becomes attractive and fun.

Mr. RUTHERFORD. I think there is evidence that that is the case. Not all students, but a large number of them, are able to interact with computers and enjoy it and will be enthusiastic about learning in the computer mode when they are turned off by other aspects of school. I think we know that. What we do not know now is how to capitalize on that. Now that we have them at the computer, so what? What is it we want to teach them?

Mr. WALKER. Have we evaluated which kids? I don't know enough about it to judge, but is it just kids that have kind of a mechanical bent anyhow that like to use the computer or how long would that kind of thing last? When I was learning to type I liked to mess with the typewriter too. When do we get to the point that it's just as boring for the child to sit there and punch things into the computer as it is to sit in the classroom and be entertained by a teacher?

Mr. RUTHERFORD. In the first place about the spectrum, I think there is evidence that both the very bright and the academically slow student respond and can learn, so it cuts across. As to when one gets tired of it all——

Mr. WALKER. That doesn't necessarily relate to the aptitude I was talking about. For instance, you could have a bright student with mechanical aptitude and also a slow learner.

Mr. RUTHERFORD. I think it is not a question of mechanical aptitude. I think there are other psychological reasons why the computer is so fascinating for so many people. Now there is a question of will one finally get bored with that, just as with everything else. I think the answer to that is how clever and imaginative we become in continuing to think of material to go with the computer.

If it isn't doing anything for you any more, you will lose interest. You get tired of just playing with it, so what has to happen is that it has to continually serve the student and he has to know it. One of the things about the computer that is nice is that it almost always provides sort of an instant feedback on how well he is doing. But there has to be substance. Machines by themselves are of no special interest. I think we have not developed enough substance. So my guess is that boredom will set in unless we go beyond the drill and memory aspects, the aspects that involve getting an answer to a question or getting information. It will become more interesting and more powerful and they will stay with it longer when we start using it to handle information, to sort and pair and aid in the thinking process.

Mr. WALKER. You mentioned as part of your statement the social science curriculum could be used. Now as a former social science teacher I always thought that one of the goals we were trying to reach or get across was conceptual information, that the idea of certain knowledge was not as important as the concepts which we developed in the students we were teaching, whether it was in Government while I was teaching that, or sociology, or whatever. Is that what you are saying then? Is that where the computer could be applicable to social science, that we can use it to evaluate information and teach concepts.

Mr. RUTHERFORD. I would think that—I am not a social science teacher, but I would say that a more important use in that context would be to handle the kinds of information that are associated with public decision making. I guess that is what happens in social science classes. People are inundated, for example, these days with statistical statements, numbers. Charts appear in the paper. Now with a computer in the social studies classroom students could learn how to query information, how to sort it and how not to be fooled when somebody says the average is something.

Mr. WALKER. You could destroy a lot of political campaigns here. [Laughter.]

Mr. RUTHERFORD. That use of the computer as an analytical tool to help people become analytical and thoughtful about our society would be something that I would think would be possible.

Mr. WELLS. Mr. Walker?

Mr. WALKER. Yes.

Mr. WELLS. Following up a point that Mr. Walker was pursuing a few moments ago about the prospect of rapid boredom or at least reaching a level where they are no longer concerned, there were two major points raised in our testimony yesterday that might be worthy of asking you to comment on. One was that there was an analogy of the introduction of computers into business and the Government worlds. Initially they were looked on as a replacement for clerks, handling inventories and payrolls, et cetera, fairly trivial kinds of operations.

Now a decade or two later we are beginning to understand and apply computers in much more sophisticated ways and we are using computers as part of the decision process and as aids in complicated heuristic types of processes. The analogy was drawn that we are at the payroll substitution stage in the education area. Do you agree with this very rough analogy?

Mr. RUTHERFORD. I believe so, and that is why I think it is now time to move on from the payroll level to the level of conceptualization and analytical use of computers.

Mr. WELLS. A second point was that with the widespread movement and calls throughout the country for back to basics education—I believe Dr. Brown made the point very eloquently yesterday that back to basics has a very simplistic ring to it but it is a very complicated concept when one begins to think about it, because we have a very difficult time understanding exactly what the basics are and secondly how do we get to these basics in terms of fundamental understanding and fundamental processes. It is his contention that in this back to basics movement the computer can serve a very useful diagnostic function in helping understand these processes of getting back to basics and helping a child and a teacher diagnose what is the learning disfunction that any child may have. Do you agree with that concept?

Mr. RUTHERFORD. I agree that in time it might serve that function. I think it is not at all close now because we simply lack information on the learning process. For many years in the schools it has been claimed that what a good teacher should do is diagnose the learning disabilities of each child and then apply some remedy. I can't imagine that anybody who has ever taught school would think much of that idea.

Mr. WALKER. And you start with the premise of a good teacher, how you measure a good teacher, that's a big problem too.

Mr. RUTHERFORD. The thing is even if you could diagnose the problem you would not know what to do about it in each individual case. The child is more complicated than that. I think that is a goal one should strive for and that is why I think the computer will have enormous use in helping us understand the learning process, learning how to diagnose difficulties, learning how to repair them when we do see them. But that's decades of effort. It is not a simple matter. We have one advantage now. There has been a great deal of good research on cognition and learning already, but it is a complicated problem.

The advantage now is that we can have free-standing computers, inexpensive, in the classroom and there can be, I think, a much greater critical mass of learning studies going on that will gradually get us there.

Dr. SWANSON. You said the three major thrusts of the research you see in the future are first, learning how students learn which has just been talked about; second, computers related to curriculum; and third, preparing the students for a computerized role. I realize you have just come onboard at NSF, but how would you characterize the previous research thrust? It is not clear to me how these three goals will differ from what has gone on in the past. Is this really a new departure and if so how does it build on or differ from the past?

Mr. RUTHERFORD. I think this is building on the past. My view of the previous program, a not terribly well-informed view, is that it was primarily the beginnings of research, the pioneer work, the notion of a relatively few people that here was a new technology and we have to learn how to use it for research purposes and for educational purposes. But that was just the foundation. What I am suggesting is that we now build on that and we are in a position to do so.

Dr. SWANSON. Within the NSF could you describe a little of how you envision the organization responding to these three goals and what the approximate level of funding you are thinking about might be, in terms of a yearly basis?

Mr. RUTHERFORD. The first part of your question, we are in the process now of trying to plot out our research and development activities for the next decade on the assumption that there will not be enough resources to do all the good kinds of research and development that can be done in science education. We feel we have to pick certain basic tasks that will have a major payoff and stay with them, and get the researchers out in the field working on these particular problems over time. There will be a small number of research thrusts, one of which will be essentially computer learning, but it won't stand alone. It will stand alongside other research efforts relating to problems of, for example, motivation and self-confidence to conceptualize learning and some others.

So we perceive it no longer as it was, say, a decade ago, as a separate group from our other research activities but as one of the major lines.

As to what form that will take and how much it will cost I have not a good estimate yet. We are in the process of trying to put it together. I would think that in general it is time for the Federal Government to undertake, for perhaps a decade or so now, a rather substantial investment in computers applied to learning through our agency and others which may have an interest.

But what the number is I don't know.

Dr. SWANSON. Over the past 3 days of hearings we have had countless witnesses who have emphasized that whether we like it or not the impact of computers will be widespread on our society and if we are going to have wise social planning the major consideration in a lot of our research ought to be how to take advantage of this computer technology that is being created by the private sector.

I was wondering if you could comment a little on what you see as the need in terms of research. It seems to me it is not really included in these three goals you have articulated. Several witnesses have emphasized that in the public sector we have to create the courseware or as Dr. Brown put it, artificial coaches that could be piggybacked onto the computer games that are going to be coming out. We are being flooded with this stuff by the private sector, so a lot of the learning will occur outside the normal school curriculum. I wonder if you can amplify on that?

Mr. RUTHERFORD. If the point is that the computer is likely to be trivialized, I think that that is a danger. It can go the way of some of our other technologies and be misused if it is left solely to the private sector.

I think what the public sector can do is to develop models, and to test ideas and mechanisms. For example, one is the very problem of how can the private and public sectors work together to disseminate the learning that is developed. Right now, programs are hard to transfer from one instrument to another, so a great deal of good work is not being properly used. It is not even known about. But that is a researchable question. What are the variety of ways? In fact, the National Science Foundation right now has two different models it is testing to try and set up a network in other communications modes.

It is a difficult problem. I am convinced that both sectors are crucial, that the private sector is the only way we have really to efficiently distribute the kinds of materials and devices that will end up in schools and colleges. On the other hand, I do not think they are in a position to develop high-risk ideas, to develop model kinds of materials, to test them sufficiently or distribute them widely.

Therefore, the Federal Government should support research and development, and somehow make a pool from which private industry can then draw in its efforts to get things into schools and colleges.

Mr. WALKER. Are there any further questions?

Mr. GALLAGHER. I have one, which I think Mr. Walker will be interested in.

Taking off on what the chairman said about the computer being a friend, as one witness said, we had a witness here whose testimony I would have to characterize somewhat is miraculous. In fact, I told him so. He was from Whittier, and they had computerized education there for several years. He was not talking about quantitative but qualitative changes in the students. They reversed a 16-year downward trend in test scores. He said the interplay between the students—these were the disadvantaged students, Chicanos and blacks—he said that the interplay was actually making a change on the student himself. He had been put down all his life, at home and in school and by the establishment, and now for the first time he was developing some confidence and become more resourceful, a self-starter. He was now internally controlling his own life. He could work with that computer and slow it down, something he could not do in a classroom situation. It was not only a friend but more than that. It had some astounding byproducts, he said. Absenteeism had gone down and vandalism had gone down and a number of other secondary things. I personally don't know how to evaluate that. He made a terrific case, not just for teaching of students to become more knowledgeable, et cetera, but almost a personality change resulting from this interplay between the machine and the kid.

Mr. RUTHERFORD. I think that is possible. I would simply evaluate such testimony with reserve. In the education business I, myself, and my colleagues over the years tended at the early stages to overstate the case, to make judgments based on our own work or individual studies.

The statements you made about the behavior of the students, I have seen almost those same descriptions made in relation to other experiments not related to the computer, and I believe them, too, but the job of bringing about a large-scale change in education is the one of taking these potential things that we have developed and turning them to the general usefulness.

So I would be impressed by the potential. I would not say that therefore we can simply load computers into classrooms and have that happen in general. We can get there, but educational problems are severe. They are complex. They are social, cultural, and psychological. Decades of work of a variety of sorts are needed to make headway. The computer, I think, stands a chance of doing that. Its value that you mention, however, I think there needs to be some care that it be looked at as a friend because it can help the youngster learn to think and do things and not the anthropomorphic sense. I am not much impressed with the early days where they had computers talk back to you like they were your friend. I don't think that. It's a piece of machinery.

Mr. GALLAGHER. I almost had the feeling that he was putting life in the machine.

Mr. RUTHERFORD. That is not something one wants to do, I think. It's your friend if it helps you think and learn and make your way better in the world. But just remember in back of every one of those instruments is the human mind. I am more and more impressed—one cannot fail to be impressed by the power of a computer. But that power was devised and developed by researchers, by people. They are the real friends of students, and we have to be careful about banking on warm feelings toward computers. Computers are useful only if they help us intellectually.

And it doesn't matter, as a matter of fact, whether they are really all that friendly. Some of the great teachers in history as human beings were not always warm, cheerful people. And yet in fact there seems to have been some learning going on. You have to be a little careful.

Mr. WELLS. Some of the warm, cheery people who developed the automobile now could be advised that it kills us at the rate of 60,000 per year.

Mr. WALKER. Thank you very much, Dr. Rutherford. Your testimony has been very helpful and we thank you for coming this morning.

Next we would like to call Dr. Arthur Melmed, associate director, finance and productivity group of the National Institute of Education and Dr. Tom Sticht, associate director of the basic skills group of the National Institute of Education.

[The statements of Dr. Melmed and Dr. Sticht are as follows:]

STATEMENT OF ARTHUR S. MELMED, ASSOCIATE DIRECTOR FOR FINANCE AND PRODUCTIVITY AND THOMAS G. STICHT, ASSOCIATE DIRECTOR FOR BASIC SKILLS, NATIONAL INSTITUTE OF EDUCATION BEFORE THE HOUSE SCIENCE AND TECHNOLOGY SUBCOMMITTEE ON DOMESTIC AND INTERNATIONAL PLANNING, ANALYSIS, AND COOPERATION, OCTOBER 13, 1977

Mr. Chairman, we are pleased to have this opportunity to present the views and experience of the National Institute of Education on "Computers and the Learning Society."

The National Institute of Education was established by Congress in 1972 with the general mission of helping to improve American education through research and development and dissemination, and a specific mission, one of several, to strengthen the scientific and technological foundations of education.

We regard the computer as very important both because of its potential for improving education and because of its effects on the society from which students come and for which they are being educated to become adult participants. We think of computers as part of a larger body of rapidly evolving information technologies that include, as well, broadcast and cable TV, video recordings and computer-generated visual images. As members of this committee are aware, the price of computer capability is falling rapidly. What would have cost $20,000,000 fifteen years ago now costs roughly $1,000, and this may drop to $100 by the middle of the next decade. We are promised soon video recordings providing about 50,000 individually accessible video images on a disc similar in size and cost to an LP record, designed for display singly, or as a motion picture, on a home television set with a player costing about $500.

We agree with Eric Ashby's view that this electronic information handling explosion is the fourth in a series of revolutions in education. The first three are frequently identified as the invention of the school, the adoption of the written word as a tool in education, and the invention of printing and the subsequent wide availability of books. This fourth revolution is already strongly manifested by the virtually universal availability of television in American homes and the estimate that most children ... watched 3-4,000 hours of TV before they start school and by the end of high school will have spent more hours before the TV set than in school. The effect of the computer is less strong so far. However, the first wave has arrived with the $5-10 handheld calculator capable of performing with perfect accuracy most of the arithmetical calculations which confront children in elementary schools.

The computer is proving also to be a useful aid in exploring the ways in which human beings take in new information from books or other sources and attack problems and draw conclusions. Psychologists and computer scientists have combined forces to simulate human thinking processes with a computer, thereby advancing our knowledge both of thinking and what can be done with computers.

In a program budget of $57M appropriated by the U.S. Congress for the Agency in FY [illegible] the amount expended on activities related to computer and education was approximately $1.5 million. The choice of these activities was guided by Agency objectives to:

(1) improve the effective and efficient delivery of educational services;

(2) improve our understanding of human learning, through use of information processing models; and

(3) improve our understanding of social behavior in a computer-centered learning society.

These are rather broad objectives. Narrower intermediate objectives, and specific programs of activities were selected by broad consultation with both researchers and educational practitioners.

Activities we wish to highlight today follow a natural line of development:

(1) the evaluation of existing technologies for computer-managed education, computer-assisted instruction, and mathematics instruction;

(2) exploratory research and development of educational applications of the new, low-cost technologies;

(3) research and development of software to create a new generation of "smart" computers; and

(4) studies on the impact of computers on the individual and society.

One of the earliest developed uses of the computer in elementary-secondary education has been for administrative and managerial purposes. However, potential adopters of such systems have only little systematic information on the impact of such use on school costs and practices.

The Minnesota Educational Computing Consortium (MECC) operates one of the oldest and most extensive administrative and management data processing systems in the country -- called TIES -- involving 45 suburban Minneapolis school districts. In 1976, MECC was selected by the National Institute of Education for an evaluation of the patterns of use, and both observed consequences and perceived outcomes of computing services on school district management. Eleven of the 45 districts were selected for in-depth study. The study is not complete, but the following interim results are available.

Administrative Use of Computing

The TIES administrative computing system includes eight systems or services; Personnel/Payroll System, Finance/Budget Accounting System, Attendance System, Census System, Mark Reporting System, Class Scheduling System, Student Information System, Research Services.

Among the eleven districts studied, 61 specific applications of the above eight systems were in use.

Costs

The average Total cost for a TIES-member district (including salaries, equipment, membership charges, and all other computer related support costs) for obtaining instructional and administrative computer services is less than 0.75 percent of the district's total operating costs.

Impact of Administrative Computer Use on School Districts

To date in the NIE Computer Impact Study, a number of impacts of administrative computer use on school district operations can be noted.

Computer use in the financial accounting and budgeting area enables districts to implement program budgeting concepts and to decentralize budgetary development and control. This is accomplished by allowing a district to greatly increase the number of line items in its chart of accounts (often from 200 to 2000 line items), by enabling it to easily obtain information sorted in several ways, and by providing the district with up-to-date, detailed, and accurate budget information. In addition, the computer service simplifies the districts reporting responsibilities to other governmental agencies.

The computer scheduling service enables the schools (secondary) to offer students a greater choice of courses which can be rescheduled several times during the school year. Without use of a computer, the school administrators would be able to schedule only once a year and offer a more limited and restrictive curricular program.

Computer use in the census area enables a district to develop accurate and timely data concerning the district residents. The ability of the computer programs to sort the data according to variables such as place of residence, type of family dwelling unit, and numbers of children at various ages, has provided districts with valuable enrollment projections and other trend information. In many of the districts, the enrollment projections have proved to be a valuable aid as the administrators plan their responses to declining student enrollments. For example, the information has often been the key ingredient to significant district decisions concerning school closings or construction, teacher hiring or layoffs, and boundary shifts within districts.

The primary impact in the Personnel/Payroll area is that of time-savings in processing payroll and maintaining records. Also, several districts are finding that the capability of sorting data in many ways is proving to be valuable when reports are made to State and federal agencies.

Finally, many of the districts make use of a computer program that allows them to simulate a multitude of possible salary schedules for the teaching staff. The impact in several districts has been that the parties to negotiations can more quickly and thoroughly investigate alternative pay proposals both before and during the negotiations process.

Research Services have allowed several districts to begin to conduct research on their operations. Changes in programs have often occurred as a result of the research findings.

In addition to the impacts noted above, several other general impacts should be noted.

1. More relevant information for both short-range and long-range decision making is available to, and used by, district managers.
2. The information is more likely to be available at the time that it is needed.
3. Time is freed from recordkeeping and clerical duties (administrative) so that more time can be spent on duties that are more closely related to the main educational functions of the districts.

* * * * *

Also in the domain of existing technologies, the National Institute of Education is currently supporting a four-year longitudinal study of the effectiveness of computer-assisted drill and practice in improving the skills of disadvantaged elementary school students in the areas of computational mathematics, reading and language arts. The computerized curriculum being used is the result of over a decade of developmental work, mostly centered at Stanford University. The exercises supplement regular classroom instruction with individualized drill of from 5-20 minutes per day on a cathode-ray tube computer terminal. The intricately designed computer program assesses each student's skill level and presents appropriate exercises on their individual cathode-ray tube consol. Students type in answers and are immediately informed on the screen if their answer is correct or incorrect. When a mistake is made, the correct answer is displayed, accompanied by a demonstration of the correct procedures where appropriate. The classroom teacher receives regular printouts displaying the placement and progress for each student in specific skill areas.

Previous controlled studies of the mathematics program have achieved statistically significant gains for students over the course of a single year. The current research is exploring the pattern of student gains with differing amounts of time on the computer over the course of several elementary school years, and will include a followup of student progress into the junior high school after computer drill and practice has stopped. The Los Angeles Unified School District is providing the site for the study, and the research is being conducted by the Educational Testing Service with the assistance of a panel of research and instructional specialists. The per pupil cost of the instruction is well within the amount -- in excess of $300 -- budgeted under Title I for each eligible child in Los Angeles.

The computer-assisted instruction (CAI) was introduced into the participating schools only in March 1977, and the only data now available to us was obtained in the course of debugging the system and settling student and school personnel down into its use. The available data suggest that all three CAI curriculums -- mathematics, reading, and language arts -- have a positive effect on student performance. However, our research is designed to inform us on the amount of effect for different amounts of CAI, and how this varies with students over a four-year period. The data to answer these questions will become available only in future years.

* * * * *

In the area of educational uses of the handheld calculator, selected activities include:

(1) Establishment of a Calculator Information Center at the Ohio State University. The two primary functions of the Center are gathering information through searches of journals, guides and through direct contacts with professional organizations, manufacturers and publishers, and generating a variety of documents for disseminating the information to interested school audiences.

(2) Several awards for the development of prototypic mathematics curriculums which creatively involve the use of handheld calculators.

* * * * *

A program of activities to explore the educational applications of the new, low-cost technologies is just getting underway. A scheduled conference involving researchers and practitioners is planned to assist the National Institute of Education design the broad parameters for this program.

There have been various attempts in modern times to use technology to improve the delivery of educational services. With some exceptions in the military and private sectors, these attempts can be described broadly as failures. Numerous reasons have been advanced to explain the failure by our schools to adopt technology. These include cost, reliability, lack of curriculums, and institutional and cultural barriers. The new video-disc and microprocessor technologies hold the promise of lower levels of cost and higher levels of reliability than ever before. The purpose of the planned conference is to examine alternative strategies for educational R&D to advance the optimal use of these technologies in the schools.

* * * * *

The activities above are of an applied and developmental character. The National Institute of Education also supports work of a more theoretical and conceptual nature. In this category is R&D of software to create a new generation of "smart" computers. Current project activities include:

(a) Center for the Study of Reading at the University of Illinois and Bolt Beranek and Newman Inc. This project investigated comprehension skills involved in oral and written language. Much of this work is conducted by cognitive scientists who are investigating ways to represent knowledge which will permit computers to comprehend and product language in a highly interactive manner. Such research is fundamental to the development of "smart" computers. To date, Drs. Allan M. Collins and

John Seely Brown, both of Bolt Beranek and Newman Inc. have created computer programs which will carry on "dialogues" in sophisticated, though limited, ways. This, and other research on comprehension at the Center for the Study of Reading encourages the continued support of research in this area.

(b) Institute for Research on Teaching at the Michigan State University. Researchers at this NIE funded Institute are developing computer programs for helping reading clinicians develop better diagnostic skills. Computer simulation programs are being studied which will be utilized to train teachers to think differently about reading problems, to more accurately diagnose problems in their classrooms and prescribe remediation. This work is based largely on previous work in the field of medical practice by Drs. Arthur Elstein, John Vinsonhaler, and Lee Shulman, who is co-Director of the Institute for Research on Teaching. It is anticipated that the success with computer diagnostic training found in training medical doctors will also be found in the training of reading specialists.

(c) Independent Grants. A number of smaller grants to independent researchers are permitting the study of various comprehension processes such as the drawing of inferences, understanding figural language, and the analysis of different language structures (sentences, paragraphs, stories). These studies are basic to the development of software for "smart" computers.

* * * * *

Finally, we have initiated in FY 77 some in-house research to understand the effects of the written language technologies on people's learning and thinking processes, and the implications of this for society. Additionally, some small contracts were let to obtain planning papers in this problem area.

The study of the written language technologies lays the groundwork for studying other media and technologies. For instance, before one can fully understand what the complete consequences are of long hours of television viewing on literacy skills, one needs to fully understand what literacy skills are. Our research to date has indicated that the skills developed over 12 to 16 years of schooling which stresses the reading and study of books, graphs, maps, charts, tables, and other printed media are not well understood. For this reason, it is not exactly clear as to how we might determine the effects of electronic media on such skills. We have learned that the oral language skills of literate persons differ from those of non-literates. There is reason to speculate that children from better educated homes acquire oral language skills more like the language of the textbooks and teachers they will encounter in school. This may account, in part, for why children from less well educated homes do more poorly in school in the fourth grade and beyond where the language of the textbooks differs greatly from natural spoken language.

Such findings suggest questions about other media and technologies: Will computers develop special ways of thinking which will be transmitted from one generation to another in the same manner as the aspects of the written language are transmitted via the spoken language to the child, which hence renders him or her capable of more easily learning the written language? Such inter-generational cycles of transmission of thinking skills are poorly understood. Thus we expect to conduct planning efforts in FY 78 to lead to a thoughtful and coherent program of research on media and technology in FY 79 and beyond.

* * * * *

This concludes our highlights of NIE activities. In summary, we regard the role of computers in society an important topic for R&D. Our efforts so far have been concentrated on the role of computers in elementary-secondary education. A basic element in our R&D strategy has been and will continue to depend for feasible and economical computer hardware on the private sector and high-technology R&D agencies in the public sector. Our program plans for FY 1978 and 1979 will continue to give emphasis to:

(1) exploratory research and development of educational applications of new, low-cost technologies;

(2) research and development of software to create a new generation of "smart" computers; and

(3) studies on the impact of the computer on individual learning and social behavior.

We do not plan, during these two fiscal years, to launch either the demonstration and evaluation of large-scale prototypes, or broad curriculum (courseware) development efforts.

We would be pleased to answer questions about our programs and our plans.

Statement of Thomas G. Sticht,* Associate Director for Basic Skills, National Institute of Education, before the House Science & Technology Subcommittee on Domestic & International Scientific Planning, Analysis & Cooperation, Washington, D.C., October 13, 1977.

Mr. Chairman and members of the Committee, it is a pleasure to appear today to discuss the very important topic of "Computers and the Learning Society".

As my associate Mr. Melmed has noted, the National Institute of Education is committed to improving the quality of education in the nation, and in strengthening the scientific foundations of education.

Learning is, of course, the object of education and this includes both the formal education of the schools and the non-formal education of the home and society at large. The NIE conducts research to understand the nature of teaching and learning as it occurs both in- and out-of-school, and seeks ways to improve the effectiveness and efficiency of teaching and learning for all citizens. In various research activities we are attempting to understand who learns what and how. We are attempting to understand what competencies are useful and/or necessary for participating in our society.

To understand what skills and knowledges are developed in our society, we need to understand the various media and technologies which seem to most directly affect our basic human capacities for reasoning, communicating and designing new tools and environments. We expect research on media and technologies to guide us in the determination of what should be taught in schools to permit citizens to develop the skills made possible by various technologies.

In Mr. Melmed's presentation, he has discussed some of the NIE research which uses media and computers for the delivery of instruction. This research makes direct impact on student's learning of subject matter areas, and represents the use of computers for direct instruction.

The research I wish to discuss differs from that discussed by Mr. Melmed in that it focuses on the role of media and technology in changing language and thinking processes in indirect ways, and by that I refer to indirect learning that results from the use of a particular technology. I will illustrate what I am talking about by discussing a major program of research at NIE which is concerned with understanding the impact of an older technology – the written language – on our basic reasoning and communication skills. The importance of this work in the present discussion is that it provides techniques for comparative studies of other technologies.

It may seem surprising, in view of the large amount of public and private monies spent on teaching people how to read and write, to discover that only a very few people working in recent times have paid much attention to what the consequences for a society are when it becomes a literate

*This paper was prepared in collaboration with Kent Viehoever of NIE.

society. A most succinct and concise summary of much of this thought is provided by Professor David Olsen, of the Ontario Institute for Studies in Education, in the Proceedings of the National Academy of Education, vol. 2, 1975 (review of a book entitled "Toward a Literate Society). I will not review all of the points he makes; rather, one point is of signal importance and that is that the most fundamental effect of writing is on the writer, and eventually on literate societies. Because of the permanent nature of the written language it can be studied. Inconsistencies between writers can be detected, and the resolution of such inconsistencies can be sought. Such activities make possible the development of <u>history</u> and <u>science</u> from the earlier <u>mythology</u>, which is founded in the spoken language. The permanence of the printed language, in contrast to the ephemeral nature of the spoken language, makes it possible to formulate extensive arguments and to check their internal consistency and to derive their implications.

By serving as a sort of external memory, the written language has dramatically extended the natural human capacities for logical reasoning, and has made possible the reasoning needed to develop the complex electronic technologies which are the concerns of this Committee.

A most important, and only recently made discovery, is that people who become literate, who use pen and paper for reasoning, and who study written knowledge extensively, develop the ability to take hypothetical viewpoints and reason hypothetically in a wider array of problems than do non-literates. Professors Michael Cole, Sylvia Scribner, Steven Rieder and associates at Rockefeller University have found this in their studies of literates and non-literates in several groups in Africa. Professor Olsen also points out that the use of the written language for extended reasoning requires that the writer learn to think in a way that is less bound than spoken language is by a particular context. This is because spoken language usually takes place in face-to-face settings where there is opportunity to ask for clarifications, to point directly to things and to make use of the particular contexts the speakers are in.

My point in this extended discussion of written language is that the development of the technology of printing, and the wide spread expectations that all should read and write has had a profound impact on Western thought. And there was no intention on the part of the inventors of the alphabet (we must suppose) that the permanent nature of the medium would lead to such profound changes in wh[illegible]ren spend more than 12 years of their lives mastering the written [illegible]e, developing the study skills for using the written language, and lea[illegible]ng from printed language. Changes in which the spoken language skills go almost unnoticed, left to the society outside of the school system for development. Our focus on the written language as an external memory has led to the abandonment of earlier developed techniques for controlling the memory in spoken language; many topics in rhetoric, such as memory systems, declamation, are almost completely ignored in our book oriented schools. We have traded off much training to develop skills in the spoken language in favor of the skills made possible by the printed language; skills drawing not so much upon the fact that the printed language is a tool for communication, though it certainly is, as is the spoken language; rather, the skills of the literate person are those made possible because the printed language extends our natural capacities for memory, and the visual medium permits us to spread the language around in visual space. Hence we can create additional analytic tools such as complex tables, directories of information arranged in lists; labeled graphs; maps; and even the labeled flow charts made so ubiquitous by the intersection of the printed language with the technology of computers.

Our continued study of the printed language will, we believe, lead to a better understanding of just what has happened to us as a literate society. It may also reveal basic misunderstandings about what we can use various media for. For instance, studies on who uses printed media and electronic media strongly suggest that people who get information from printed sources remember the information better than people who get the information from electronic broadcast media. Other studies show that the less well educated remember less from T.V. and radio newscasts than the more highly educated. These studies, if confirmed by further research, imply that we cannot achieve educational equity goals willy-nilly by broadcasting information to the poor and less well educated and expecting them to develop the useful store of knowledge that the more highly educated will develop from both the printed and electronic media.

We must be concerned that in the rapid development of computer technology we do not further increase the gap between the haves and the have nots in our society. We must also try to understand what we might be trading off by using computer technology as extensively as we presently use printed technology.

<u>The Computer Technology Revolution</u>

One critical feature of the literacy revolution is that its many ramifications were neither predicted ahead of time nor, in large parts, recognized while they were happening. Another critical fact about the literacy revolution is that its effects took place over the course of several centuries. Yet today, partly as a result of that revolution and partly as a result of the new media and technologies, the rate of societal change has speeded up tremendously and promises to accelerate even more. The effects of the next revolution may permeate our civilization without our recognizing what is happening, just as did the effects of the literacy revolution, but they will <u>not</u> take centuries.

What are some of the implications we can draw from this?

o In the first place, such revolutionary effects <u>will</u> occur, whether we do anything about it or not. In large part, also, we will <u>not</u> be able to control them -- we can only anticipate them and try to prepare our capabilities to be able to handle them.

- Secondly, just as mechanical tools have extended our physical capacities the print media have extended our memory capabilities and our capacity for extended logical reasoning. The computer which has greatly extended our processing speed, further extends our capacity for reasoning. The newer interactive computer, with capacities for displaying graphics, music, and other symbol systems will extend human capabilities such as our ability for creative design and composition. The effects of this extension are not easily predictable without further work on basic human processes and how they interface with the "smart" computers soon forthcoming.

- The increasing rapidity of technological change -- which even today dictates that the camera, recorder, television, or computer that you buy tomorrow will be out of date within several years — means that schools will not be able to amortize new computerized equipments as long-term investments, but must be prepared for continued re-investment every few years. The increasing rate of change also means that we can no longer afford to invest the brunt of our research funds on studies whose conclusions are premised on specific equipments, which may be outmoded before our findings can be widely implemented. The teaching and learning variables frequently employed in studies of CAI and programmed learning may have only a pedestrian relevance to the technology of tomorrow.

- CAI and Educational TV, in their present form, may well be outmoded in 10 years or less. As A. W. Luehrman aptly pointed out in his 1972 presentation to the Spring Joint Computer Conference, if the invention of writing had been frozen into something called "Writing-Assisted-Instruction" carried out only in special "WAI" labs, the revolutionary effects of mass literacy might never have happened. We anticipate that within a dozen years or so a sizeable number of homes may have their own interactive telecomputers, and it is quite possible that there will be cooperative arrangements for shared educational responsibilities between home and school.

<u>Implications for NIE-Funded Research on Computers and Basic Skills</u>

If the above predictions are reasonable:

1) We cannot restrict our concern to instruction in formalized classrooms, but will include learning in various contexts.

2) The importance of the teacher will not be diminished, but there will be new support and technological roles within the teaching profession, and the classroom teacher will become in part an "orchestrator" of the child's various learning experiences. Thus we will continue our concern for improving the effectiveness of the teaching process.

3) The types of research variables which we will emphasize will be those which transcend highly specific equipment or media configurations.

4) We will continue our concern for basic reading, writing, and mathematics processes, but give special emphasis to the way in which these skills relate to new media and technologies.

5) We will be concerned with some primary cognitive skill dimensions and with the relationships between these and new media and technology. We will be particularly interested in how the new technology can augment human capabilities of inductive reasoning and creative design.

6) We will be concerned with the social implications of new media and technologies to discover which groups of citizens are taking advantage of the new tools for thought, and to discover what skills may be being modified in these groups as a result of the use of new media and technologies.

Mr. WALKER. Your statements have been considered a part of the record and you may feel free to read, paraphrase them or just talk to us in an informal way, if you care to do that.

STATEMENT OF DR. ARTHUR MELMED AND DR. TOM STICHT, NATIONAL INSTITUTE OF EDUCATION, WASHINGTON, D.C.

Mr. MELMED. Thank you very much, Mr. Chairman.

I would like to paraphrase some remarks that I have here in writing, and Dr. Sticht will choose his own style for proceeding. We are pleased to have the opportunity to appear before you today.

The National Institute of Education (NIE) was established in 1972.

I have attended much of the hearings thus far. I think an issue that has not been taken up is the issue of evaluation and dissemination.

We know quite a good deal from research and development. You heard yesterday that we know quite a good deal about the potential of computers for education and society. You heard yesterday about the world of the future. But beyond research and development, NIE is responsible for evaluation and dissemination of information today. So I would like to address the question of evaluating and disseminating information on problems of these new ideas and technologies, courseware and the promise and application in the schools. I should mention that when we talk of computers—when I talk of computers, I also have in mind other information technologies—for example, broadcast and cable TV, and video recording. The computer is somewhat special in that it can transform information, and be responsive to the user in a way that a prepared television script can not. I want to emphasize that the computer is used, for the most part, in elementary and secondary education not so much for the purpose embodied in its name, that is, to compute, but rather to handle information.

Changes in education come rather slowly. Eric Ashby has told us just how slowly. There was the adoption of the written word some thousands of years ago, the invention of printing some hundreds of years ago, and thereafter the widespread availability of the written word, and more recently, the development of schools. I go through that sequence to emphasize the glacial pace at which the technology of education advances.

You heard yesterday that computers might partially replace schools. Well, they might, but the rate of change in the technology of education has not been very fast in the past. The other side of the coin is that, in fact, in the history of mankind, schools have not been with us for all that long; that is, the school as an instrument for mass education is in the United States only 125 or 150 years old. In a much longer history for mankind, this suggests that possibly schools will not be the ultimate social invention for education for all time, and that computers and other information technologies may therefore have an important role to play in education in the future.

I would like to mention that in a program budget of about $57 million appropriated for NIE in 1977, about $1.5 million was devoted to the concerns of this committee, and our activities were guided by our wish to improve the effective and efficient delivery of educational services on the one hand, and to improve our understanding of human learning on the other.

Our strategy for improving the effective and efficient delivery of educational services is to provide better information and produce to decisionmakers whose choices affect educational services.

In the domain of new information which we are trying to make available to school decisionmakers are two evaluations. One is in the administrative use of computers. I will not dwell on that here. The second, which has been referred to previously in these hearings is a logitudinal study of the impact of computer-assisted instruction on disadvantaged elementary school students in the areas of computational mathematics, reading, and language arts.

The technique used is to provide computerized individual drill and practice, from 5 to 20 minutes per day, to students who are identified as title I students. Longitudinal studeis are difficult to do for a number of reasons: (1) Federal funding patterns are often not stable enough, and (2) particularly with disadvantaged students, there is quite a good deal of family relocation, and there is the problem of maintaining the validity of the sample over 4 years in the case of this study.

There are, therefore, both funding problems and technical problems in doing longitudinal studies. Nonetheless, we do have this one in place. It is intended to test two things. One is the impact of intensity of treatment, or intensity of use, on student achievement.

Dr. Papert mentioned yesterday that we ought to provide refrigerators which only drop the temperature by 1 degree to test the effect of cooling on food storage. In fact, it has been difficult in the past and it has not been done, to test the difference between 5 minutes, 10 minutes, 15 minutes, and 20 minutes of computer usage on student achievement.

Our study is doing that. The study is also longitudinal; that is, it will run over 4 years. We do not have data on the effect of sustained use of computers by students over that period of time.

The study was initiated only last spring, and so we have only the most preliminary sort of data — that is, that it works. But that, of course, we knew in advance, or we wouldn't have undertaken the study. What we need to know is how well it works, and how well it works over how long a period of time, and that data will only be available in the later years of the study.

That information, when we have it, will be diseminated as well and as widely as we know how. We hope it will affect decisions of school superintendents, principals, and so on in their choice of interventions for compensatory education.

In the area of product information to guide local decision makers, we have established at Ohio State University a calculator information center. The functions of the calculator information center are pretty straightforward: To provide relatively expert and otherwise neutral information on calculators, and to guide choices among principals and superintendents for their purchase for school use.

We also have underway some exploratory development of prototype mathematics curriculums for calculators which we will try out with students at some point in the future.

I will mention only one other activity which is an effort less to further the dissemination of what we know or strongly suspect, but which will advance us into the development of new uses of a new technology.

In the area of developing new uses, you have already heard some of the new low-cost technologies. These are the video discs, microcomputers, and so forth. These technologies differ from earlier ones, such as the 35- millimeter film, in two ways: (1) low cost, although perhaps the comparison with film there is not the most appropriate one—the comparison with earlier computers certainly is; (2) a higher reliability. It is our sense that among the factors that prevented the adoptiod of technologies in the schools are cost and reliability.

Of course, there are others, such as availability of courseware and certain institutional and cultural factors. We will be looking at these new technologies from two points of view. One, what are their possible uses? And two, how can we develop these uses in such a way as to facilitate their adoption in the schools?

With that I will close my remarks.

Mr. STICHT. I want to talk about two different themes. Mr. Melmed has talked about the application of current technology. At the NIE, we are also interested in the larger problems that we have heard talked about here, and that is the fact that the computers are getting smarter, and they are proliferating. And not just computers, but all kinds of media are operating on people outside of the school. We suddenly look around and find ourselves immersed in an electronic medium.

Marshall McLuhan discussed these kinds of things. Yet I think one of the most important kind of discoveries that recent fundamental research on learning has made doesn't have to do with those at all but, rather, with the book. We are finally getting around to trying to understand what has happened to us on account of the book. So, as we rush to understand the new technology we run along behind trying to figure out what has happened to us because of the old technology. I think that's very significant because, as John Seely Brown pointed out, until we understand the process of comprehension we're not going to understand how computers may affect our comprehension processes. With such understanding we will be able to do a lot with computers, much as we can do a lot with printed materials.

But as I say, even today we're only beginning to find out just what happens to us and what is happening to us in the area of printed material. So I want to talk a little bit about that. I then want to talk about work on comprehension and, then, our concern with the larger social issues that have to do with the use of media in technology in general and with computers specifically.

First, I want to give a couple of perspectives on how I happen to be interested in this. About a decade ago I went to work for an organization called the Human Resources Research Organization, or Hum RRO. Our work was concerned with developing training programs for low aptitude people who were entering the military under the then newly established Project 100,000.

In the course of that work we discovered that, in addition to having low aptitude test scores, these people also had low scores on reading and arithmetic tests. In general, their basic skills were very low. In designing literacy training programs for these people we conducted further interviews and we found out that their overall processing of information seemed to be lower. We asked them about the kinds of learning projects they had participated in in the course of a year. To qualify as a participant in a learning project, a person had to spend at least 8 hours intentionally trying to learn something; in other words, they had to put in a day's work on a learning project.

We found that people who scored between the 10th and 30th percentile on the Armed Forces qualifying test had engaged in somewhat less than 4 nonschool related learning activities in the course of a year, as contrasted with as many as 10 for elementary school age children, and 7 or so for blue collar workers.

So there was a very low level of participation in learning activities. One person couldn't think of any. In fact, he could only report that he had spent the year watching television. So that struck me as a very significant finding; the person is not processing information, but he is just passively receiving television shows and not learning anything.

So I began to examine the literature on mass communication. That literature revealed that, for the less educated people in the country, an approach had been taken to close the gap between the haves and the have-nots by using the electronic media of radio and television to overcome the literacy barrier that had always separated the haves and the have-nots.

The notion was that through the broadcast media we could close that gap by bombarding the have-nots with information presented electronically. Well, the mass communication research indicated that what had happened when all the electronic information started flowing was that the haves used just as much as the have-nots, plus they used the printed media much more than the have-nots.

Furthermore, it turned out that if you asked people to recall information that they had learned from the mass communication media, those people who had learned from the newspaper and printed sources could recall the knowledge better than those who got the information from electronic media, suggesting that those people who got it from electronic means would not have the information available if they had wanted to use it sometime.

That strikes me as a very significant kind of problem. We have to make certain that in our attempt to use media to overcome problems of inequity that we are in fact successful at that. And it turns out that, apparently, with broadcast media, we don't cause people to process information in the same way that they do when they read about it.

That was one kind of concern I had when we started talking about media and technology at the NIE. Another concern arose from going to shopping centers and noticing that they now have these "time-out" centers, and they're jam packed with electronic games. You can race cars with them, you can fire all kinds of weapons with these things, do word problems, and check your IQ.

I saw all of these kids plunking money into these machines, paying to do the kind of stuff which you probably couldn't get a lot of them to do in school, because these matchines were just so inviting.

As we thought about that a little bit more we decided we should start looking into this whole business of media and technology. We went out to Xerox in Palo Alto, Calif., and visited Allen Kay to see the kinds of systems they are working on out there.

We saw that the system that Allen Kay was putting together involved the development of an entirely new notational system, that is, the way they represent music on a video screen is not the way that music was written when all there was was the printed media.

Apparently, the use of notes and bars and lines is a u eful notational system when you have only the printed medium. ! at in this electronic medium you could represent notes with dot and dashes. You would play an electronic organ into the system and it would record on lines—longer lines, shorter lines, dotted lines—what ou had played. Then you could turn around and take a little "turtle" as they called a control device, and move it around on the table and it would move a pointer on the TV screen. With this pointer you could stretch out a note if you wanted to make a longer note, or you could shorten the note, move it up or down, or push a button and the computer would replay the organ.

Now, this is composition of music in a way nobody ever dreamed of before. In fact, as you see the music represented visually in this way you change your whole concept of what music is. So, in the same that we had seen that the printed word was having major effects s by changing our very ways of thinking about the world, we began to think that these new technologies are going to change the very way in which we think about the world. There can be absolutely no doubt that when you are able to expand time before your eyes on the computer, condense time, when you can manipulate objects, when you can manipulate designs in shorter amounts of time, you begin to form an entirely new notion about what is possible and what is going on in life.

Let me give you a more familiar closer example. One of the technologies we are familiar with now is time lapse photography. Well, with that we now have entirely new conceptions of plant growth. We even think differently about plants in the field of botany.

When you photograph the movement of traffic in and out of the city, you see the city as a living organism, the flow of traffic in and the flow out, the pulsations. And you begin to develop conceptions that are not possible, that would not occur if you hadn't seen such movies.

Well, in the same way the computer, through its capacity for instantly representing ideas in a visual or some other kind of display, particularly a novel notational system, can give you perspectives that you just wouldn't have otherwise.

So we took our impressions from Palo Alto back with us to the Institute and wondered what to do about this new computer technology; as Mr. Melmed mentioned, our budget isn't what you would call grandiose for funding agencies. We looked to see what we were doing of relevance and found that we were fund g research on comprehension of the written word. That's an extremely important line of research, that we have funded as have ONR, NS and ARPA and it testifies to the importance of this work that we have this kind of consolidated effort going on in different agencies.

One of the important findings about the printed language is that it has had a dramatic impac upon our oral language. Perhaps that doesn't sound too impressive except for these kinds o observations. First of all, we've wondered why it is that children from homes where the parents are more highly educated seem to do better in school than children who are from homes of less educated people.

There is now research to suggest that the language of literacy becomes the language of the spoken word in better educated people. The seminal work in this was done by a group of researchers at Rockefeller University. Mike Cole, Sylvia Scribner, and Steven Reder worked in Africa where you can find communities in which illiteracy is perfectly acceptable. In our country it is so stigmatized that to compare illiterates with literates involves many emotional problems. But in Africa among the Vai Tribe, they did find a tribe which some 250 years ago invented its own writing system; bu only some males become literate. But if you study the oral language of the tribe, you find that the women who live around men who are more literate, have oral language more like the language of literacy. It becomes more precise.

Now, transferring back to this country and the problems of the less educated and the more highly educated, a hypothesis emerges that more educated people speak literate language to their kids in their very formative ages. When these children are acquiring the oral language they are acquiring in fact a version of the written language.

When they go to school and encounter the written text, they seem to make the transition to that style of writing, if you will, that style of speech. It is literate speech written down. They seem to make that transition easier than children from homes where that doesn't happen.

So I think that's one significant hypothesis arising from our comparisons of oral and written language and our study of written technology.

A second thing that we have been discovering—we knew it all along but the research has sharpened understanding—that when we became a highly literate society we made a tradeoff. We do not today develop oral language competencies, that is, the competencies that are significant if one lives in an oral society.

Mr. WEISS. Excuse me. If I may leap ahead. Are you suggesting that somehow there is the potential for the computer in providing whatever assistance or complementary function it provides for the teacher to substitute for the absence of being exposed to literate language at an early age?

Mr. STICHT. I wasn't going to do that. On the other hand, certainly if you have computers that can be brought into the house and you can systematically expose kids to that, it would be helpful.

Mr. WEISS. As we talked about yesterday, every barrio in Puerto Rico and in all major cities have television in almost every household. I hope you are not describing a hopeless situation.

Mr. STICHT. I wasn't attempting to. What I was going to say is, I think the situation is now more hopeful. But I did want to carry on with just one more observation about the trade off of skills.

When we become literate, and when kids spend 12 or their formative years learning from books we have purposely not taught memory control. This was always a component of rhetoric in classical times. Classical rhetoric involves how to control your own memory. You know, that when you bring something into your memory to think about now, you have to put what was in your conscious memory. Sometimes you are lucky if you can go back and find what was in your memory before. I presume we have all had these kinds of experiences.

Well, in formal rhetoric one was taught memory control. These things were known technically as mnemonic systems. We don't teach that today in school. We don't teach the rhetorical devices of declamation or emphasis to make a point in another person's head, to make them remember something.

So we have deemphasized memory, and why not? So the book, as an external memory, has led us to ignore, to a large extent, purposeful training of memory. This doesn't mean that kids don't develop such systems. Part of our research is discovering what it is that people who turn out to be smart have been doing, and we have found that they have been discovering on their way, sometimes accidentally, how to control their memory system.

Well, this pervasive influence of the written language affects us, I think, in other ways that we're not too aware of. Today there is a great reluctance to emphasize tradition. You can go to a clerk and be married. Earlier, you would have had a big ceremony. In many native American Indian tribes they began to deemphasize ritual several years ago.

Now, as Alex Haley has pointed out in his talks, when he went back to his native land he encountered a person who had memorized the oral history. But that person could only give the oral history when a drum was beating. He also gave the history according to key events that had happened. So we can make the hypothesis that tradition, rituals, and use of [rhythmic] drumbeats are mnemonic devices that are useful in an oral society for keeping track of history.

It may follow that our reliance upon the written language has lessened our interest in ritual and in tradition. It may. These are hypothetical statements.

My point in the above discussion is this: If we begin to move towards a new technology we have to be aware of its influence on our culture. Just as we've only recently really begun to become aware of what happened to us with the written language, we just must now understand electronic and computer technologies, so that we can determine with some purpose whether we wish to have a skills tradeoff, if that becomes a matter of decision.

Second, if in fact new media technology permit brand new modes of thinking, we need to be able to identify and specify them so that we can train children efficiently. So at the NIE we are funding research on understanding the difference between the written and spoken languages. We have become aware of the emerging revolution in computer technology uses in education. We are trying to get on top of that revolution.

We've decided it might be important to do some solid thinking. So we have planned, for the next year, a couple major conferences, one on the east coast, one on the west coast and perhaps, one other. The idea at these conferences will be to bring together people such as have been here and other groups of media, who would help us plan a coherent program directed toward a better understanding of the nature of comprehension and how to represent it in programing. We could then, in fact, make those smart computers that people want. Second, we could devise a plan of research to help us understand just exactly where the new technologies are taking us and how we can make whatever kinds of adjustments we would need to bring about changes in our schooling and in our education outside the schools.

Dr. SWANSON. Thank you.

This question has been asked of me several times by Congressmen on our subcommittee when I was briefing them and also by some of our early witnesses, especially people connected with the public school systems. Basically the question has two parts. One is a dissemination part and the other is an evaluation part. I know both of you gentlemen have had experience in other Federal agencies around town and so you have a feeling for who has what type of programatic responsibility, either dissemination or evaluation.

The first half of the question, the dissemination question, is a school superintendent comes to us and says I want to use this kind of technology in my school district. My school district is not eligible for title I or ESSA funds or any of those options. It is a middle class school district. But on the other hand, he finds himself like all school districts in a fiscal bind. He cannot splurge on this type of technology. He cannot go to HEW and get categorical grants to fund his CAI or CMI project, even though he is willing to do this.

I assume innovators out in the field like that are necessarily people that we would all like to encourage. Second, he cannot go to NIE because he is not a scholar or researcher and he is unclear about the demonstration options. He cannot go to NSF because he is not in research. What do we do about this kind of person who needs on the order of $750,000 a year which is a large-sized chunk of money especially compared to the average research grant that comes out of any of these agencies? Where does this man get his money? Is this a justifiable expenditure of Federal funds in terms of a dissemination model of this technology?

Do we fund this guy and if so where should he go to get his money?

Mr. MELMED. To the best of my knowledge, in USOE or NIE we do not fund the principal or superintendent that you have described. He must somehow try to find the necessary funds in the local budget. He is inhibited from doing that by the fact that in most jurisdictions schools cannot borrow against the next year's appropriations. So he must be innovative and creative in many ways if in fact he is to succeed in getting equipment into his school.

The cost of equipment is going down and $750,000 is perhaps a fair amount, more than he needs to get started.

In fact, I believe a critical element in the widespread adoption of these technologies in the schools will be the continued reduction in cost which the private sector does, happily, seem to be determined on providing us. As to whether funding for equipment is a Federal responsibility or not, well, I guess that somehow gets resolved in the political process. We are paying a good deal of attention currently to students at the lower end of the distribution, the deprived and disadvantaged student. Occasionally, programs appear that deal with the exceptional child at the upper end of the distribution. There is a program for the handicapped at this time. But my guess is that those programs altogether do leave out the very substantial number of students that fall in the middle of the distribution. Observably, they make progress in any case and that is perhaps why they get less attention.

Mr. WELLS. Is there not a broad analogy, too, in one area; the Federal Government has intervened when it has perceived a rather urgent problem as far as the school lunch programs at a very extensive level financially. Is there not a model here that at least on an interim or experimental basis there would be a role for the Federal Government to intervene to in effect nourish the mind as well as the body in areas where skeptical or unknowledgeable school boards have fears and the impact of technology is a very strongly inhibiting influence on the introduction of some of these ideas and indeed a very inefficient way perhaps for each individual school district to have to work out its own approach to dealing with what is a national set of problems, a national set of purposes and national technology.

Mr. MELMED. We seem not to be struggling too well with the separation of powers that the Constitution provides in the area of education. Certainly, the schools need money and they will seek it from every possible source. Indeed, it appears to me, speaking personally, that in fact the Congress has sought ways to make moneys available, leaning on whatever legal arguments it can find.

As to whether the school lunch is a precedent, again, speaking personally, I would like to see the widespread use of computers in the schools. That is my own judgment, even while it is not absolutely clear and one cannot pinpoint the absolute benefits of availability of computers to students. There have been a fair number of exemplars brought before the committee's attention. I think it would be a useful and desirable investment of funds. But whether school lunch would be a precedent, I am unable to say.

Mr. WELLS. Following this up, if there is one thing that seems to be troubling in terms of children we seem to have beaten nutrition as a major problem. We just finished some weeks of hearings showing that the malnutrition which existed very widely a decade ago has been largely eradicated except for various pockets, not confined to the South but throughout various parts of the country, migrant workers, et cetera, and the major problem now is obesity.

In a decade of intensive work we have in effect solved a major problem of malnutrition by intervening at the school level and the elderly level with Meals on Wheels and these kinds of endeavors.

I guess what we're struggling for is some kind of legislative, programmatic, across-the-board remedy to deal in advance with what I think witnesses have come before us here and given, I think, rather convincing options that we are on the verge of another revolution in the educational system and rather than simply letting it happen to us maybe we can get at least a leg up on it and devote more resources.

I took at your budget of $57 million with $1.5 million devoted to the impact of computers on learning. I almost threw up my hands. We might as well not have any. It is almost wasted. I think we had testimony yesterday from Dr. Brown—it was Dr. Papert's—we have a 1,000-foot canyon and 1,000 people, and each one of them takes 1 foot in order to get across. And that's the way we're doing it. We are so fragmented in our research efforts that we get nowhere.

I look at the NSF budget of $9.7 million for computer-related and science education with roughly 200 grants, so we're speaking on the order of $500,000 per grant.

I am troubled that the severe fragmentation is going to slow us down. If we can't get larger resources, then perhaps we should concentrate on certain priority areas and come up with some sequential way of tackling these problems. We discovered as we contacted people for these hearings that you seem to know each other and there is a certain informal community. But is this community sufficiently, integrated and knowledgeable to act as the agent to select priorities or do we need a more formal agent?

Mr. STICHT. Let me comment on some of this. As I said earlier, we have, at least in my own case, put a lot of thinking together in the last year and have concluded that we had better be doing something in this area. Of course, the first thing that needs to be done is planning, and so we do have some planning activities, as I mentioned, that we hope to get involved in I think that Seymour Papert's paper contains some ideas along this line, too.

It seems to me there has been a reduction in Federal interest in the whole range of media in technology, perhaps most of all, in computers. It would take, I think, a major kind of Federal effort—a commission of some type—to bring a high level of visibility to the problem, and to make some fairly large-scale recommendations.

I, when feeling a little more generous, could almost immediately see what to do with a half billion dollars in the next decade. There would be no doubt in my mind that we could establish responsible centers of excellence that could provide all kinds of technical advice as well as perform very basic kinds of research, to develop smart computers. We could do it.

Mr. SWANSON. Besides that, it seems to me we need some more data base. That is what I wanted to ask Dr. Melmed as to the second half of my earlier question. The first half is about funds, and the second half was asked by several members of the committee, given this disparate source of funding for computers, the categorical grants and CAI's springing up here and there and the drill and practice and some people having demonstration projects. The congressmen asked me who fundamentally was charged with evaluating the impact of that program. I said, well several people are doing systematic evaluations, but it seems to me that the evaluation has been fragmented and scarce as opposed to systematic and comprehensive. I think he felt that there seemed to be a lack of coordination or active description of responsibility among the different agencies over who had the charge to provide evaluation.

I was wondering if you could comment on that?

Mr. MELMED. Those are some pretty large questions.

I could make perhaps three or four points. One is that we turn out to be much smarter after the fact. It is a trite statement. That is, it is easier, I think, for all of us to deal with a clear and pressing problem like nutrition or obesity than it is to deal with a hope for the future. Apparently, it is much easier for us as a Nation to deal with the energy problem after the oil tap has been turned off than to plan for the future.

In terms of funding for this area—computers in education—perhaps you have to divide it into research and development, and evaluation and dissemination. We ought not let those two categories of activity get too far apart; that is, there is no point in having marvelous sorts of technologies at the educational frontier if we leave the schools further and further behind.

I think funding for research and development has traditionally been distributed in the Federal Government, particularly for basic research. For example, the Department of Defense, the AEC, NSF, and NIE have all been sources of research funding. Faculty and the universities prefer that distribution model. They observe that agencies of the Federal Government follow trends, and they are concerned that if they don't work in the area of a current trend they will not get any R. & D. money.

I think it would be unfortunate if that scenario happened. So I think the notion of having multiple sources of R. & D. funding is probably a good thing. It is perhaps seen as slightly inefficient and wasteful, but I think a certain amount of redundancy is a safety valve in terms of advancing research.

On the matter of evaluation and dissemination, I don't know that we have thought our way through that issue. We are now considering how to keep the schools from falling too far behind. One naturally answers money. We have tried that solution but not very successfully.

Another issue is that schools have students and teachers, and even if students are ready to try new things, perhaps teachers are less willing. It is said that teachers teach the way they were taught. They weren't taught with these technologies, and they prefer not to use them. Perhaps as part of a strategy for dissemination, we need to pay some attention to the training of teachers. Given declining enrollments in the schools and the slow rate of entry of teachers into the school system, that training may need to take the form of inservice training as opposed to preservice.

Mr. WELLS. Al, the Summer Institutes which have been recently instituted—or at least—do you have your proposals out now?

Mr. SHIN. We have made the first awards a few months ago.

Mr. WELLS. Are any of these awards going to be in the area related to computer assisted or computer managed education?

Mr. SHIN. We have put a heavy emphasis upon the disciplinary instruction for the sciences, rather than in methods of teaching. There may be some who are bringing in computers in some way, but I doubt it very much.

Mr. WELLS. Would this be completely unfeasible to consider this in terms of guidelines for future institutes?

Mr. SHIN. We have some direction in the legislation that establishes those.

Mr. WELLS. That could be changed.

Mr. SHIN. I think from our standpoint we would want to seek some sort of balance between emphasis on curriculum and methods of teaching and emphasis on disciplinary knowledge. So the answer is, sure.

Mr. RUTHERFORD. I would like to support that. I think teacher training is essential. You have to remember the language labs. There was money available and so the high schools tooled up with a proven device for improving instruction in foreign language. But by and large it didn't work. The labs are not being used any longer and foreign language instruction is still terrible in the United States. So it isn't just putting the money out there. If the teachers do not understand computers and do not have the proper kind of support, computers won't work educationally.

Mr. WELLS. Doesn't this go back to the basic problem that the Armed Forces struggled with over a number of years of trying to determine what are the best ways in which one can teach a foreign language to an adult? And the essence was that we lacked sound theoretical bases on which to construct foreign language instruction programs, so we shifted around different methods in the laboratories and we still don't have a good theoretical conception of how does one learn a foreign language.

Mr. SHIN. Or anything else. Pragmatically, the armed services did discover how to teach foreign languages quite efficiently which was a source of the idea for the labs. They could surely have been used to better purpose than they were, as it turns out.

Mr. GALLAGHER. Carrying a bit further what Mr. Wells mentioned as to your budget of $1.5 million. I note when you opened up your remarks you spoke of the electronic-information-handling explosion. Well, obviously, there won't be much of a bang for $1.5 million. That's almost petty cash. What do you have in mind, if I may ask, at NIE for the next fiscal year?

Mr. MELMED. On the last page of our testimony, I think we state that we don't plan during the next 2 fiscal years to launch either the demonstration and evaluation of new large scale prototypes or broad curriculum development starts. As an agency, we must try to address the entire educational arena. It is very large and there are many problems of different kinds. I remind you of something that you must already know: That as an economic sector education has gotten to be a very large one in the country. Its size is, perhaps, $120 billion. An agency like the U.S. Office of Education, I think, operates with a facilitating budget of perhaps $6 billion or something like that. There is a ratio of about 20 to 1. NIE's budget is about $70 million, and $6 billion to $70 million is about 90 to 1.

In other sectors the amount of money available for R. & D. is substantially greater than what it is in the education sector, where it is less than 1 percent at this time for all areas. IBM spends perhaps 5 percent of its gross on research. Well, education is down at about 0.6 percent, if my memory of the figure is correct. And, obviously, only some fraction of that can be devoted to this area of computers in education.

Mr. WELLS. We will be following up with some written questions. We want to pursue the idea broached yesterday, the idea of a Presidential Commission or some kind of broad conference. We have not settled on this, but we will be following up for suggestions along these lines.

Mr. Scheuer has not yet committed himself to this, but there is a model for us in the legislation of the Commission on Automation Technology and the Economy, which took place in the mid-sixties. And it just may be that the time is right for this sort of thing in the computer learning area.

Thank you very much.

Our next witness is Dr. Harry O'Neil, the program manager for cybernetic technology program of the Advanced Research Project Agency.

[The prepared statement of Dr. O'Neil follows:]

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
1400 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22209

STATEMENT OF
HAROLD F. O'NEIL, JR.
PROGRAM MANAGER, CYBERNETICS OF INSTRUCTIONAL SYSTEMS
CYBERNETICS TECHNOLOGY OFFICE
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

BEFORE THE

SUBCOMMITTEE ON DOMESTIC AND INTERNATIONAL
SCIENTIFIC PLANNING, ANALYSIS AND COOPERATION
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

October 13, 1977

Not for Publication Until
Released by the Committee

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to testify.

My name is Harry O'Neil. I am a program manager at the Defense Advanced Research Projects Agency.

Defense Advanced Research Projects Agency (DARPA)[1]

DARPA is entrusted with the corporate research function of the Department of Defense. The Secretary of Defense, like his corporate counterparts, needs a flexible organization such as ours, reporting at the highest levels, working at the cutting edge of technology, and not encumbered by vested interests or missions dogma. DARPA selects its programs based on the generation or emergence of a new technological approach or idea which, over the long haul, could lead to a major payoff in national security. In addition, DARPA serves as a technical catalyst to take a fresh look at activities in older areas where initiative is needed. DARPA exists to generate, focus, catalyze, organize, execute, evaluate and transition to the Services proven concepts. These can form the basis of development programs that we feel can make a major difference in national security.

Major thrusts of DARPA's program include areas such as space defense, and undersea surveillance. In the past DARPA's efforts have been almost exclusively focused on increasing ... nd performance. In this era of tight budgets, however, DARPA ... the challenge of reducing costs as well as improving performance ... ing the cost of national defense is a major DARPA thrust. My prog... -based training is an element of this thrust.

Why have we chosen to focus on computer-... d training? To answer this question, I will provide some background regarding the Department of Defense training and research environment.

Department of Defense Training Environment

The U.S. armed forces is typified by highly sophisticated weapon systems requiring extremely competent individuals possessing both a sense of mission and dedication to the task. This force requires almost constant updating in narrow fields of advanced technology within the Department of Defense (DoD). Formal training is the major means of updating these personnel. During FY 1978 it is estimated that 248,894 student/trainee personyears or over 1 million officers and enlisted personnel will complete some form of formal training at a cost in excess of $6 billion[3]. Student pay and allowances account for 39% of this figure.

Training in DoD is further characterized by personnel turbulence. For example, in FY 1977, the annual personnel turnover in DoD was predicted to be approximately 20%, or 411,000 individuals. This means that DoD annually recruits and trains a work force of about the same size as the Ford Motor Company (416,120 personnel world-wide).

DoD has been caught in a dilemma similar to that faced by other manpower- and technology-intensive organizations. On the one hand, greater technological complexity induces knowledge obsolesence at an increasing rate. Simultaneously, the competition for decreased resources is exascerbated by increasing manpower costs. For example, in FY 1964, manpower costs represented 47% ($24.0 billion) of the total defense spending. The same personnel costs in FY 1977 we predicted to represent more than 57% ($57.2 billion) of the total budget. Since 1968, the real buying power of the defense budget in terms of constant dollars has decreased by 45%.

To deal with these harsh realities, and to insure no lessening of defense capability, defense planners have tried to hold the line on personnel costs. I view educational technology as a means of reducing such costs and as a method of increasing training effectiveness.

In summary, certain central issues in defense control the development and application of educational technology for the conduct of an efficient training establishment. These are: High personnel costs associated with training as we pay both students and teachers; Increasing sophistication of our weapons systems leading to difficulties in operating and maintaining such systems; The difficulty or impossibility of lateral entry into the Services. For example, we do not recruit Generals from Ford Motor Company executives; and finally, personnel turnover.

In addition, certain broad policies overlay DoD planning and execution of training. In general, the policy is to provide the precise amount of formal individual training necessary to satisfy the requirement. Implicit in this approach are the following constraints: Training courses are designed to impart necessary skills and attitudes with a minimum of instruction; Training which can be accomplished more economically or effectively on the job is used in lieu of formal courses of instruction.

Against this backdrop, military training managers and researchers seek efficiencies. One method is the use of educational technology. Advancement in the state-of-the-art in this area seems to offer the greatest opportunity to meet our training requirements within ever tighter fiscal constraints.

Department of Defense Research Environment[4]

The majority of DoD research and development in educational technology is directed toward development of a technology base for designing alternative, cost/effective instructional delivery systems. Programs are directed toward reducing costs in school settings and improving effectiveness in a small-group, high-technology setting. The undesirable aspects of moving large numbers of individuals to training centers are countered, when possible, by updating and upgrading in small groups in place. A wide variety of R&D programs are currently being pursued or developed toward these ends.

I believe that computers will be the cornerstone of DoD educational technology in the foreseeable future. Any large organization with a significant training budget could not fail to be fascinated by the data suggesting that up to a 40% reduction in training time is possible while realizing equivalent mastery using computer-based instruction as opposed to traditional instruction.

Instruction of uniformly high quality is possible with computers, while realizing a long-term goal of DoD trainers to distribute training to students rather than to distribute students to training. Through centralized updating of curriculum, many logistics problems are avoided. Further, we expect electronic transfer of information to be cheaper in the 1980's than paper transmission of information.

Because of the nature of the military training system, R&D on computers in education and training has focused on three areas: (1) reducing average training time through techniques which permit instruction to be individually tailored to a wide range of student aptitudes; (2) reducing the demand for "people involvement" in the design, development, and operation of military instructional systems through computer support; and (3) providing realistic job-related experience using relatively low-cost computer-based simulations as substitutes for high-cost operational systems. Reaching these objectives requires that data at all levels of prototype and system functioning be obtained and serve as the basis for the design of improved follow-on systems.

The major thrusts in DoD of on-going and planned efforts include both the development of new computer-based systems specifically tailored to meet particular training requirements and the evaluation of existing systems in military training settings.

In view of the substantial cost of most systems, the design and/or selection of a particular system configuration for test and evaluation is usually based on a comprehensive set of trade-off studies and economic analyses. These various systems represent a wide spectrum of hardware/software configurations, functional capabilities, and instructional approaches. Taken as a group, they provide DoD with representative samples of the current state-of-the-art in computer-based educational technology. The major configurations represented include a large-scale CAI system with a central computer and remote terminals (PLATO IV); a dual mini-computer CAI system (TICCIT); a multi-mini-computer CMI/CAI system (Computerized Training System, CTS); and a large-scale multi-media CMI/CAI system with a large central computer (Advanced Instructional System, AIS).

Both CTS and AIS are being developed specifically with DoD funds as functional prototypes for the Army and Air Force respectively to meet, as general instructional delivery systems, particular training requirements. PLATO IV, on the other hand, was also developed with other government support. TICCIT was developed predominately with other government support. These systems are nevertheless being used and evaluated in selected military operational training and R&D contexts. All of the systems are being evaluated against criteria of instructional effectiveness, technical characteristics, and cost. Evaluation results should be available at the end of FY78.

All of the Services are utilizing the data and experience from previous military and civilian R&D efforts in computer-based instructional systems. For example, the design of the Army's Project CTS, which uses a multi-mini-computer concept, is based upon several years of experience using the IBM 1500 system as well as an analysis of the TICCIT system. The AIS, on the other hand, borrowed heavily from the PLATO Project for its hardware infra-structure and from the Navy CMI System for its general approach to instructional management. There are an increasing number of operational systems which may be used to provide R&D information on operating capabilities. The Navy is evaluating information from the TICCIT system in an on-the-job training environment (i.e., crew training for a jet anti-submarine warfare plane). The result of this evaluation will determine future applications.

With this background regarding both DoD training and research environment[5], I will now outline our research program.

Cybernetics of Instructional Systems

The program I direct is called Cybernetics of Instructional Systems and has as its goal to generate an instructional technology base that will lower the cost of training and provide instructional strategies which could lead to superior training without increasing costs. As was outlined earlier DoD training costs are estimated in FY78 at six billion dollars per year. Fifteen to twenty percent of all DoD personnel are in training at any point in time, and most training costs are associated with student and instructor pay and allowances (37%). Thus, if we can reduce training time, we will reduce training costs. A major advantage of computer-based training systems is that they reduce training time while maintaining equivalent levels of performance compared to traditional lecture/discussion type training.

DARPA research efforts in this area complements the activities carried out by the Services in several respects. Where the Services must be concerned with immediate requirements, DARPA focuses on emerging technologies and their potential applicability to the more general problems of DoD training. Second, our main focus is on searching out unique technical ideas which, if successful, would have a high impact on DoD instructional systems, but are too risky for any individual Service to support on its own. Third, DARPA acts in a catalyst and coordination role by encouraging and participating in the solution of tri-Service problems. Computer-based training systems are such a solution to tri-Service problems.

The technical approach followed in my program has been to exploit computer-based training systems in three areas: (1) the development of prototype computer-based instructional delivery systems to reduce costs in the design, management and operation of military instructional systems; (2) authoring research which focuses on reducing the time and cost to produce high quality computer-based instructional materials; and (3) instructional strategies research which focuses both on the reduction of training time and by relating characteristics of individual trainees to instructional content and media.

Our major investment (approximately $4M) in computer-based instructional delivery systems has been in PLATO IV. This system, developed partially under DARPA support, is now commercially marketed and is the most advanced system of its type. PLATO IV evaluation results at Chenute Air Force Base indicated that the system itself is highly reliable (96% uptime): that system response time is well under a second with a peak load of 450 students system-wide; that performance of the PLATO IV group was equal to or superior to a conventionally trained group; that time savings, compared to conventional curricula, is 40%; and that student and instructor attitudes are very positive. These results replicated prior findings at Aberdeen Proving Grounds. Our prior results, in addition, indicated that PLATO IV lessons were more significantly more efficient and effective than either programmed instruction or audio-visual materials.

In FY77 we have completed our demonstration/evaluation of PLATO IV. Our general conclusions are that it met all performance specifications but that the high costs of terminals and telecommunications indicate that the system would not be cost-effective for DoD-wide adoption. The system will, however, remain as a valuable research vehicle in DoD contexts for computer-based education and training.

A major problem was identified in the field test of PLATO IV. This is the observed difficulty in bringing authors who use these systems to the level of competence needed to produce good curriculum materials in a reasonable time at an acceptable cost. This problem is especially acute in DoD because of the high turnover of authoring and instructor personnel. The problem is independent of type of computer-based training systems. Thus, DARPA's major research thrust for FY78 and FY79 is a program called Authoring Aids and is designed to reduce by 40% the time to develop validated curriculum materials. Subject to Congressional approval, we expect to invest approximately $900K in FY78 and $800K in FY79 in this project. We expect to have a validated authoring system for DoD-wide use in FY80.

Promising approaches to authoring aids include job performance aids to guide lesson development, and use of intelligent, computer-assisted instruction techniques. State-of-the-art gaps include lack of a technology base for selection or training of authors, lack of cost data on the instructional system development process, and lack of information on management of the authoring process.

As we are a mission oriented agency I see no need for policy changes to our mission. However, as an individual professional in the field I have several suggestions of potential R&D that would be of great benefit to the civilian sector. I will discuss three ideas: An experimental testbed for computer-based education, a program in learning strategies, and finally, a computer-based educational system in the home. It should be noted that the House Armed Services R&D Subcommittee has given informal indication that they do not feel that DARPA should support work in these areas.

Experimental Testbed for Computer-Based Education

Most of our education decisions are made with insufficient data with respect to effectiveness and costs. What is needed are a series of testbeds on the elementary, secondary and post-secondary levels. The testbeds would have two functions (1) serve as an instrumental facility to test ideas in computer-based education and (2) serve as a center of excellenc. .

Today we have no way to test candidate computer-based education systems in such a manner that reasoned policy can be made. In defense we would not design an airplane without a wind tunnel. Presently educators and trainers are forced to deal with the computer-based training system on the vendor's own terms.

What would this testbed allow us to do? I vision this facility as an instrumented training and educational environment so as to document life cycle costs of alternative innovative educational and training ideas. It will allow us to make side-by-side comparisons of new technology building blocks against an existing capability. Further, it will allow us to evaluate proposed and desired systems capabilities. It should shorten the time from demonstration of feasibility of the concept (proof of concept) to nation-wide implementation.

One intended use is like that of a wind tunnel or flight simulator. It is a tool for development and evaluation of computer-based education issues. It is not a prototype for operational use any more than a wind tunnel is. It would, however, provide data for policy options for tradeoffs between selection/training/educational philosophy/equipment design.

This proposed testbed stands in contrast t how it is being done today. Evaluation of computer-based instructional syst.ms tend to be different technologies in different environments. Further, there is no costing data on the selection/training/educational philosophy/equipment design tradeoffs. There is little institutional memory of lessons learned. From our existing approaches there are few trained implementors of advanced computer-based technology. There is no life cycle costing of alternatives and thus minimal accountability.

Such a setting would allow us to judge alternative technologies in common settings. Entire schools would be instrumented so as to monitor both intended and unintended effects. Policy tradeoffs would be now based on costs and benefits. The testbed would serve also an environment in which to investigate different mechanisms for stimulating innovation such as varying incentives. Finally, we would focus resources on large enough a scale to make a difference. Following such testing, the particular technology could be repackaged, redesigned or disseminated to the educational community at large with realistic cost/effectiveness information. For all of the above activities, ethical concerns regarding privacy, parental and child input, would be an essential component of the design for testbed. Capability for future computer-based education systems that should be evaluated in this context are natural language interfaces and degree of artificial intelligence in such systems.

23-082 O - 78 - 26

What are the technology building blocks that suggest such a testbed?

A major advance in the hardware area is the fact that we are entering into an area of computational plenty fostered by the explosion of silicon integrated circuit technology. The commercial world is already exploiting this revolution (e.g., video games, digital watches, and pocket calculators).

A federal effort would be to "design to cost" a hand held calculator that will perform the functions of drill and practice CAI materials for the elementary and secondary level. It would be done in cooperation with industry and use such technologies as microprocessors, bubble memories and a variation of the strand algorithms. A guess would be such a device would retail at $20-$30. I would suggest that the federal government buy one for every child in the country. Based on the results of Computer Curriculum Corporation (CCC) as well as PLATO IV, I would expect that we could wipe out illiteracy in math, reading and language arts in a generation.

There are many technological innovations that I have left out, laser communications, fiber optics, packet switching, etc. I have left them out because although important, if we had them, we would still have an education and training problem that we would be no closer to solving.

Another set of ideas that should be tested in such a testbed is that of a learning strategies. I will briefly discuss the background and rationale of such a program as well as the expected benefits.

Learning Strategies Program

In the past ten years, both aptitude and achievement scores of college-bound high school students have dropped dramatically.[6] At the same time, the sophistication of our technological society has increased. These factors coupled with decreasing resources indicate that education and training problems will intensify.

I believe one way of improving American education and training as well as reducing costs is to develop and evaluate instructional materials designed to teach basic intellectual and affective skills. I call such skills Learning Strategies. It's based on the philosophical premise that it is better to teach a person to make bread than to feed that person bread continually. In education we teach students content, not process.

Further, although a goal of society, these processes are seldom explicitly evaluated. Students are in many cases viewed as passive recepticles into which teachers deposit knowledge.

One example of learning strategy is the method of loci. Using this strategy, an individual is taught to associate isolated facts with particular locations (i.e., loci). When one wishes to recall the memorized facts, one simply revisualizes the place, bringing to mind the associated facts. Improved recall generally results from use of this strategy. The strategy can be used in other situations to make subsequent learning more efficient and effective.

Learning strategies implies affective and motor as well as cognitive strategies. An example of an affective strategy would be test anxiety reduction whereas an example of a motor strategy would be mental rehearsal of a motor skill. The following learning strategies, I believe, are within the state-of-the-art: elaboration skills; study skills; critical thinking; mental rehearsal; decision making; problem solving; troubleshooting; test anxiety; and self-monitoring skills. Although the list is long, it varies with respect to technical risk, e.g., high risk, self-monitoring skills vs low risk, study skills. Some skills are absent like creativity, as I cannot generate a technical approach to teach it.

The term also suggests the intended outcome of applying these strategies, namely to increase the efficiency of learning. Learning strategies are, I think, potentially useful in a number of learning situations. The potential will be realized when a person acquires facility in their use and familiarity with their application. Learning strategies will not replace specific job skills or knowledge of specific content domains; they are simply a necessary condition for more efficient learning.

I believe that effective education and training occurs when high-quality instruction is presented under conditions conducive to learning to students who possess effective learning strategies.

The potential of success in this particular approach is analogous to improving reading skills as a known method for improving subsequent performance in a myriad of learning situations. In addition, teaching learning strategies directly should reduce the need and thus the cost for extensive instructional support in each and every course. For example, if a student's memory ability was increased then one might expect a decreased requirement for remedial loops and extensive practice in all subsequent courses.

These strategies would be most appropriate for two groups in our society, children and the elderly. For children as the benefits would accrue to the person for his entire life. For the elderly as such strategies could remediate degragation of cognitive and affective functioning.

The final product of the Learning Strategies research program would be an integrated instructional system composed of a series of field-tested self-paced modules. The curriculum would be designed so that extensive resources, instructor personnel, or facilities support will not be required. The modules would be commercially available in the form of audio visual materials, books, and documented computer programs. Such programs could reside on the video-disc on the home computer system which I will discuss next. Finally, evaluation data regarding its cost-effectiveness would be available.

<u>A Computer-based Education System in the Home</u>

I feel one of the major drawbacks in the implementation of computer-based education is that of the fragmented nature of the educational market. Industry has not been able to bring to bear its strengths, i.e., the financial, personnel, marketing and dissemination expertise. However, I see the home entertainment market as providing a base on which computer-based education can ride piggyback. The home entertainment market, e.g., video games with their embedded microprocessors and video discs (e.g., MCA Phillips) will provide this mechanism.

In your living room you have all the makings of a computer-based education system. Your TV set can function as a display, your telephone as a communications link. What is lacking is a method of storing digital information inexpensively in your home as well as an inexpensive computer to facilitate using that information. The advent of cheap microprocessing technology ("the computer on a chip" in your hand calculator) joined with the potential of video discs provide the new technology building blocks to realize this dream. A research program is urgently needed to capitalize on this opportunity. I c.n visualize five years from now that all of the components of a first class computer-based educational system to be commercially available for under $500.

However, this home educational system will require information to the resident on a video disc. What type of information could this be?

I would suggest two alternatives. Number one, the learning strategies curriculum which I have discussed earlier, and second, a course in basic skills (math, English, language arts). This latter course will have been evaluated in the experimental testbed. Distribution could be handled through the Public Broadcasting System to home users who wish to have this as an auxiliary course. Ten years from now one could visualize the same system with an augmented capability for the deaf, i.e., a smart computer program would process continuous speech and display a visual output. This output could be used both as an education device as well as through a picture phone as a communications device.

CONCLUSIONS

The following suggestions for R&D in the civilian sector are recommendations from a personal viewpoint and do not represent DARPA recommendations.

- o Increase level of funding for research and development in computer-based education.
  - Limited risk capital for next generation of systems.
    - -- Basic research base has been extremely lean on funds.
  - Limited resources or mechanisms for pilot projects in school districts and universities.
- o Establish testbeds for computer-based education.
- o Focus a federal program to develop and evaluate a hand held calculator for CAI drill and practice.
- o Focus R&D on future home computer systems.

This ends my prepared statement. I will be glad to answer any questions. Thank you again for giving me this opportunity to testify.

FOOTNOTES

1 Additional information on Defense Advanced Research Projects Agency can be found in: "DARPA: An Investment Strategy for the Late 70's" Commander's Digest, Vol. 19, 1976.

2 Additional information on DoD research in educational technology can be found in: "An Overview of Training and the Use of Educational Technology in the Department of Defense" by Dougherty and O'Neil. Educational Technology, in Press.

3 Additional information on DoD manpower can be found in: Military Manpower Training Report for FY 1978, Department of Defense, March 1977.

4 Same information source as footnote 2.

5 The functions of education were cited from: "Why Education R&D?", American Education, April 1976.

6 Additional information on declining test scores can be found in: Declining Test Scores: A Conference Report, The National Institute of Education, February 1976.

STATEMENT OF DR. HARRY O'NEIL, PROGRAM MANAGER, CYBERNETIC TECHNOLOGY PROGRAM, ADVANCED RESEARCH PROJECT AGENCY, ARLINGTON, VA.

Mr. O'NEIL. I thank you for the invitation to come and testify. I didn't bring a computer with me, but I brought some exhibits to back up some of the earlier speakers' testimony on the privatesec tor producing the necessary technology. These are examples and not meant as advertising for any one company. The Radio Shack Christmas catalog has a $600 computer. Sears Christmas catalog has nine pages of video games, those with microprocessors in them for under $200. And for $15 you can buy the Little Professor. People who are interested in looking at these afterward can come up and thumb through them.

I would like to talk a little bit about why our agency got into computer-based training, the type of research we sponsor, and a few ideas of where I think research and development ought to go.

We have heard a fair amount of evidence that computer-based education works. It works in two ways. One, it is as least as effective as traditional instruction. And usually you can expect a 30-to-40 percent time savings compared to traditional instruction. In our environment we pay our students, so if we can get them out on the job faster, we can essentially have a small instructional force and thus save money for the Nation.

Our major investment in computer-based training has been PLATO IV. Our total investment to date is about $4 million. The National Science Foundation has invested an additional $10 million.

We field-tested PLATO IV at three different military sites, two Air Force bases, and one Army base. The data were very consistent; that is, equal to or better performance and 40-percent time savings with PLATO IV. Student and instructor attitudes were very positive.

We did identify one problem which is the need for some sort of system to efficiently develop instructional materials. We found out that, in some cases, it was taking us a year to train a person. By the time we would have him trained to develop curriculum materials, he or she would be reassigned.

Mr. WELLS. You mean the teacher was reassigned within the school system?

Mr. O'NEIL. Within the military. In some cases the turnover was approaching every 6 weeks. They might be on the same base, but their duties would be reassigned. An officer would be assigned, for example, to a computer-based education project. But if 6 weeks later somebody had to cover the police or fire department, then that person would get reassigned.

Under those circumstances, with the brute force methodology and some selection—that is, finding some bright people and working hard—the demonstration/evaluation of PLATO IV came off. It was clear to us that to disseminate PLATO IV widely throughout Defense one needed a more efficient technology than selecting a few bright people to try to get the job done.

So our program this fiscal year and next, fiscal year 1979, is to focus on this problem and try to create a system to make the development of materials for these computer-based training systems more efficient.

We feel if we had this system, it would be cost effective to go forward with computer-based education, because the hardware costs are coming down.

Plato IV is just one system that Defense invested in. In Defense, we have been looking at three or four different kinds of systems, all with the idea of looking at their plusses and minuses in our environment.

We picked up the TICCIT project from the National Science Foundation. The Navy has also been evaluating it in their environment.

Mr. WELLS. What was your purpose in picking up PLATO IV?

Mr. O'NEIL. Our agency feels that we are, in a sense, one step ahead of everybody else. Thus, we got involved in PLATO IV in the late sixties. It wasn't clear it was going to work, but if it did work, it would have been a real winner. We put a lot of capital into one place, a center of excellence, if you would. It required somebody having the vision that this would be a good thing to do. At the time it was the best system around. Further, it met all performance specifications.

As you can see, PLATO IV can do many things, as Dr. Bitzer pointed out.

Mr. WELLS. But in terms of the ultimate purpose for the use within the military.

Mr. O'NEIL. I think PLATO IV, as a system, will not be the system which we will buy 300 copies to spread around the world. I think that the new technologies that Dr. Brown and others have been talking about will provide a better bridge for the 1980's. This is a personal opinion. We have a lot of field test evaluations going on and I think it is time to look at all of the broad scale systems we have, and then draw conclusions for the mid-1980's and 1990's.

Dr. SWANSON. We brought up this evaluation question with Dr. Melmed. Is it conceivable to do a post hoc evaluation study and what would be the adequacy of post hoc studies? Who should do it?

Mr. O'NEIL. The adequacy of doing an evaluation after the fact is never as good as before the fact. After the project is over, the data is just not there. The forms did not get developed. They did not get passed out. One may not have collected the cost data in the right way.

Most of the individual projects I was talking about within the military have had evaluations on a project level. I think one needs the evaluation one level higher, which is reviewing all the projects and trying to make some sense out of them. No one agency has that function right now, in Defense or in the civilian sector.

Dr. SWANSON. Is that information part of the public record so that NSF could fund a project and have access to that information?

Mr. O'NEIL. Sure. In fact they have been in the evaluation process from the beginning, both formally and informally, because they were funding PLATO IV in the civilian sector.

Mr. WELLS. Dr. O'Neil, since Department of Defense runs an educational system on a very large scale and probably invests—I don't know whether the $120 billion that is assigned to education in this country includes Department of Defense—I guess not. But would it be a fair estimate that there are billions of dollars invested in Defense training systems and training schools and training bases throughout the services?

Mr. O'NEIL. True. If you count the schools, like vocational or technical high schools and colleges, and you count the student pay and allowances—because we pay our students—the figure for this fiscal year is about $6 billion. That excludes all training done on the job. It also excludes all training we buy on contract and all training for new weapons systems.

Mr. WELLS. If you add in that kind of training cost, you are talking of something probably two or three times that again?

Mr. O'NEIL. It is hard to add that in, because from a cost accounting point of view, if they are in the school the costs are attributed to training.

Mr. WELLS. Let me be more direct. There is a lot of money being spent for training and education within the Department of Defense. Does not Defense through your office have a very strong interest in the potential application of either PLATO or the stand'alone type concepts of computers as aids or managers in this education and training process?

Mr. O'NEIL. True, we do.

Mr. WELLS. I did not see a number that represented any total defense effort. We see $1.5 million from NIE and $9.7 million from NSF and is there a comparable number that Defense is allocating?

Mr. O'NEIL. Yes; I could get it for you for the record. Each agency, such as the armed services branches sponsor research in this area, targeted toward their particular problems.

Mr. WELLS. Since ARPA is a very highly coordinated agency, are you familiar and are you working closely with the services in educating or encouraging this kind of activity within the services?

Mr. O'NEIL. Yes. We have a task force that formally meets annually. And, informally, most of us are here in town. As you probably found out by gathering information for the hearings, it is a relatively small community. Within Defense, five or six people fund this kind of activity.

Further as a bureaucrat, you can't come up with an idea or a project and then go through the congressional cycle and find that the Navy is doing the same thing. So just for self-survival, as a bureaucrat, one has to know what's going on. I think in this particular area that we are very well coordinated. Each of us has taken a little different focus in this area.

Mr. WELLS. This is kind of a task understanding rather than any formalized agreement?

Mr. O'NEIL. It's an informal communications channel. It's a formal mechanism in the sense that we have a yearly document that is updated about research and development in computer-based training and education.

Mr. SWANSON. Were you finished with your remarks?

Mr. O'NEIL. I have one or two other things I'd like to talk about. A constant theme that has been mentioned in the hearings is evaluation. I think that it would be useful in evaulation to have what I would call an experimental test bed. The idea is to have an instrumented facility, a school or school system, where we would have ongoing data collection from the start. So, 5 or 10 years from now, we could conduct a longitudinal study. I see a need for the test bed on the elementary and secondary levels. If somebody had a new research idea in this area, we could then plug that into our test bed and evaluate it within that particular context so as to really get some good cost effectiveness data.

I see some Federal agency, probably OE or NIE, who would have the responsibility for managing this. It could also provide the consumer protection aspect, which, I think, is important. It would be very helpful for a school system to have a place where they could get accurate information with respect to cost and effectiveness. It would also give us a way of more rationally allocating our R. & D. resources as a Nation.

Dr. SWANSON. Consumer protection also includes some of the psychological pitfalls that have been brought up?

Mr. O'NEIL. Yes. In instrumentation, I see everything from looking at the cognitive information being developed to the emotional lives of the students. We would also keep track of vandalism. In other words, we could have the whole thing instrumented. If somebody asked if the project was affecting vandalism, we could easily respond.

Obviously, from the beginning, on the planning activity, one would want to get parental and child input.

I speak now as an individual rather than representing ARPA. I think we know that in the mathematics and reading areas—as both the testimony of the PLATO IV folks as well as the testimony of the Computer Curriculum Corp. documents—computer-based drill and practice will improve the mathematics and reading achievement of a broad range of kids. I think it is possible to reprogram the microprocessors which are already existing and which industry is producing, field-test them in our experimental test bed, and then just go out and buy one for every single child in this country. The amount of money we are putting in through titles I through VII, I think, could, in part, be reallocated.

If you had $20 for one child, you would have a one-time cost of $1 billion. I think that over a generation you could wipe out illiteracy.

Mr. GALLAGHER. Is this your personal testimony?

Mr. O'NEIL. Yes.

Mr. WELLS. How do we get to this kind of project that you are suggesting?

Mr. O'NEIL. From a personal viewpoint, I see this Commission, which has been discussed, as being tasked to come up with a broad mechanism. The civilian sector, for example, is worried about certain issues and Defense is worried about other issues. There is a need for a mechanism taking a broad look at the technology and developing a plan as to who should do it and how much it would cost and how to evaluate it. That, having a blue ribbon panel as well as a technical panel would provide input into each other.

Mr. WELLS. What kinds of people do you think would be effective in serving on such a commission?

Mr. O'NEIL. I have never thought that question through. Again—a personal viewpoint—I would try to get the educational establishment involved very early, as well as representatives from the unions and some parent organizations, several technologists to define what will be available, some researchers and a couple of evaluators.

Mr. WELLS. Several other witnesses, Dr. Brown and Dr. Papert, would you mind commenting on this question and your ideas? What types of people, individuals and skills, would you suggest might be on the commission to examine the questions we have been talking about?

Dr. PAPPERT. Let me divide the question into two parts, because I think there are two functions to be served by such a Commission. Maybe we need two different commissions. I'm not an expert on how best to arrange that, but I think functionally one of them is to produce an engagement of minds around the technical problem of what to do, considering various practical suggestions and so on. And the other problem is consciousness raising. It is a necessary function. It is clear from the sum total of the testimony here and what one sees in th e world at large that there is a gap between the state of affairs and the potential it offers on the one hand and on the other hand the awareness in the country as a whole and the educational comr unity, et cetera, about the needs and the possibilities.

So there is the technical aspect and the con iousness raising aspect, and I think you probably need somewhat different people. On the technical aspect, I would like to say a few things about what it should not be. Obviously, they should be technologists and imaginative psychologists. I think they should be not only cognitive psychologists—in education in the past there has been the tendency to think that the experts on reasoning are the people to think of things of this sort.

They ought to be people into sociology and knowledge and relationships into so-called depth psychology. I think it should not be defined as a purely scientific problem. I think they are people whose strength is in appeal to the imagniation.

I would like to find a great film producer or a great poet or a great television man or whatever, it doesn't matter what the particular area is, but somebody whose function in the world has been to think in terms of the appeal to the imagination, such people ought to be there. Of course, the education community needs to be.

Mr. WELLS. I think I would agree that we are certainly talking about a social question rather than a technological issue, but technology drives us to the political and social questions.

Mr. PAPERT. I think one must recognize that the problem is how to bring these two things together. I think there is a big divergence and a tendency for people to think of themselves as humanistic, to not like technology and so to keep away from it, and this tends to create a rift so that the people who would be most valuable in the imaginative and social and affective aspects of all this tend to steer away and that's the problem you've got to face, that's one of the problems.

Mr. WELLS. I guess my last comment would be one which has been reiterated in previous days that this seems to be far too important to let it happen by chance. We at least ought to observe here at the beginning and try to determine what things are possible in contrast to letting it happen to us. I think that is what we are groping for as to what sensible recommendations we can make in terms of legislative remedies or administrative remedies, appeals to the private sector, et cetera. We simply don't know the kinds of things that need to be done.

Thank you.

Mr. GALLAGHER. Mr. O'Neil, on page 19 you mentioned something that another witness touched on as to computer-based education in the home. You say [reading from statement]: "I feel one of the major drawbacks in the implementation of computer-based education is that of the fragmented nature of the educational market. Industry has not been able to bring to bear strength * * *."

Other witnesses have said this, and what is the reason? Is it profit or what? It seems such a natural thing.

Mr. O'NEIL. Again, a personal viewpoint. I think that with some of the 50,000 independent school districts—I would underline "independent"—industry cannot simply sell it, or create the curriculum and distribute it across the entire country. Industry must go and sell each school system. This requires a huge marketing expenditure.

Another reason is that schools only budget for 1 year at a time. They are really strapped for funds. They have something like 80 or 90 percent of their budgets tied up in people. There just isn't a lot of extra money floating around that they can buy things with, after they cover their personnel and utility bills.

Mr. GALLAGHER. Would this apply to the home?

Mr. O'NEIL. The video disks, marketed some time this year by the entertainment industry, will probably just contain movies. It could be like a movie-of-the-month club analogy. For instance, once a month, for $8 or $10, they will send you a video disk and you attach it to you TV set, push a button, and you can see the movie.

The industry will only have to develop this use of the video disk once, and then, it is just a question of mass production and marketing it throughout the country. I think people will buy these video disks. The costs will then go down because lots of people have color sets and they are buying the disks.

The microprocessors will be in the TV set already. Technically, this is possible now. We have the hardware makings, the technology is coming. It is time to start some research. How do you divide education functions between the schools and the homes?

Mr. SCHEUER. I take it you feel that the computer has a great potential for educating kids whom we are now having great difficulty in educating?

Mr. O'NEIL. Yes; in the sense of teaching them mathematics, reading, and the language arts.

Mr. SCHEUER. Writing?

Mr. O'NEIL. No.

Mr. SCHEUER. I don't mean writing with their hands, but composing sentences and paragraphs and pages in cerebral thought, thinking in organized and cerebral ways.

Mr. O'NEIL. I think that's a research question and we can find those answers. I don't consider a research question to be how to improve mathematics and reading achievement at the elementary level; that is, the PLATO IV experience and the CCC experience.

Mr. SCHEUER. Do you think all of the evidence is in?

Mr. O'NEIL. Yes; on that narrow issue of 20 minutes per day in the classroom with the teacher with that type of logic in the computer, yes.

Mr. SCHEUER. For reading, math, and language skills?

Mr. O'NEIL. I feel most comfortable about math, a little less comfortable about reading, and not very comfortable at all about language arts.

Mr. SCHEUER. Wasn't that your phase, language arts?

Mr. O'NEIL. Yes. I feel the data is strong for mathematics and reading and, language arts, we'll know in a year or two.

Mr. SCHEUER. What do you think our government ought to be doing? We are spending billions of dollars in the elementary and secondary education act under title I with no significant success. To your knowledge, have these kinds of research and demonstrations been attempted in Title I or title III of ESSA?

Mr. O'NEIL. Both. Some of the early work in the midsixties was title III funded. Title I now, I think, provides a major source of funding for the Computer Curriculum Corp. That is the mechanism they are using to market their CAI drill and practice equipment.

Mr. SWANSON. I wanted to emphasize that we talked about this with the NIE people that the dilemma here is reaching both ends, the extremely bright with title III and the disadvantaged with title I. And we are missing mainline instruction. I raise the problem Dr. Garner brought up in that he is frustrated in trying to obtain funds for a successful proven technology and there is no outlet for him because he is trying to deal essentially with a middle-class distribution of students both in terms of income and skills.

Mr. O'NEIL. The technology is available. It is expensive right now. It will not be expensive in the future. There is no one place in Washington that you can go to get funding. That is why, I think, the planning commission, or whatever, looking across all agencies is needed. We certainly spend enough money in education. I would see it almost as a contest or a runoff. Everybody could come in and say, "this is our technology and here's our data that says this will improve education," and have funds would be real'ocated on the basis of that kind of evidence.

There is nobody right now worrying about these issues.

Mr. SCHEUER. Where do you think we ought to be building some fires to get the people's attention and more resources put into this for all of the young people who could benefit by it?

Mr. O'NEIL. I think the existence of the hearings has provided some stimulation within agencies for interest in this particular area. This gives us a chance to come here and make a statement about what we are doing. I personally think that the research side of the house is very underfunded. We have heard numbers from NIE of $1.5 million per year. In Defense, this number is a guesstimate. I will get the right number for the record. But the total in Defense, I would be surprised if the total in Defense was $20 million for all three services plus ourselves. In NSF, the figure was $9 million for this year, so that total Federal investment may be $30 million.

Mr. SCHEUER. You will get us the detailed figures?

Mr. O'NEIL. I can get the detailed figures for my agency as well as for Defense.

Mr. SCHEUER. Thank you very much. This has been thought provoking and stimulating and we appreciate it.

Mr. O'NEIL. Thank you for your invitation to testify.

The next witness is Dr. Glenn Bryan, Psychological Services Division, Office of Naval Research, Department of Defense.

[The prepared statement of Dr. Bryan follows:]

"COMPUTERS AND THE LEARNING SOCIETY"

Testimony presented by
Dr. Glenn L. Bryan, Director, Psychological Science Division
Office of Naval Research

To the House Science and Technology Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation.

October 13, 1977

25-082 O - 78 - 27

Dr. Glenn L. Bryan has been the Director of the Psychological Sciences Division of the Office of Naval Research since 1969. For nine years prior to that date he served as Head of the Personnel and Training Research Branch of the same organization. He received his Ph.D. degree in Applied Experimental Psychology (1951) from the University of Southern California where he served on the staff and faculty from 1951 through 1959. He has published extensively in the fields of aviation psychology, electronics troubleshooting, research management and computer-based instruction. He is a member of Phi Beta Kappa, Sigma Xi, the American Psychological Association, the Human Factors Society and a Fellow of the American Association for the Advancement of Science.

"COMPUTERS AND THE LEARNING SOCIETY"

Testimony presented by
Dr. Glenn L. Bryan, Director, Psychological Sciences Division
Office of Naval Research

To the House Science and Technology Subcommittee on Domestic and International Scientific Planning, Analysis, and Co-operation.

October 13, 1977

I am Dr. Glenn Bryan, Director of the Psychological Sciences Division of the Office of Naval Research (ONR). The programs of that Division seek to create basic knowledge and understanding which will lead to new ways and better ways to utilize, equip and manage naval personnel of the future. These programs are carried out, for the most part, under contracts with universities. They are primarily basic in nature, with an appropriate augmentation of applied research and exploratory development efforts. This mix is put together and supervised by the Division staff of nine professionals with the able assistance of ONR scientists from other disciplines and with helpful guidance and advice from representatives of various Navy and Marine Corps offices. The programs seek to involve competent and innovative scientists in areas of research that are relevant to Navy and Marine Corps interests. By so doing, the programs provide new perspectives, new insights and new approaches to naval problems. They also provide channels for scientific information to flow back and forth between the civilian research community and the naval community, thus keeping each abreast of new developments in the other. The emphasis is on the creation and interpretation of a cumulative knowledge base upon which effective new technologies can be built. These give us better ways of dealing with old problems and provide the Navy and Marine Corps with the capability to detect and diagnose emerging problems which may eventually limit the effectiveness of naval personnel. Where possible we assist, within our resource limitations, those in the Navy and Marine Corps who want to implement our research findings. We seek to work closely with the Navy Personnel Research and Development Center, the Naval Medical Research and Development Command and the Naval Systems Commands to promote the diffusion, extension and eventual utilization of the knowledge obtained through the ONR programs. However, my remarks today will be confined to the ONR program alone.

Our research is organized around a dozen programmatic thrusts. These are clusters of related contracts conceived and operated in an integrated manner. The clusters often blend different levels of R&D funding from a variety of sources. Serious efforts are made to coordinate the work of the ONR contractors with each other, with in-house laboratories and with the research sponsored by other services and other agencies. Contracts are generally awarded in response to unsolicited proposals. They are evaluated on their relevance to Navy needs, the competence of the investigator, the scientific merit of the proposed research, and the facilities available for its conduct.

The elements that shape our research programs are twofold: (1) scientific and technical needs to advance the Defense Research Sciences; and (2) operational needs identified in Navy planning documents, in particular the Naval Research Requirements in the Behavioral and Social Sciences established by the Chief of Naval Research and the Science and Technology Objectives on Personnel/Medical Support (STO/PN) promulgated by the Chief of Naval Operations.

Currently, three of our 12 clusters are fundamental to the future development of superior computer-based instructional systems.

I am pleased to have this opportunity to speak on the topic of "Computers and the Learning Society" since it has been a topic that has absorbed much of my personal and professional energy for many years. As a matter of fact, I was recruited to come to work for ONR in the early '60's to formulate a research program that would address the future needs of the Navy and Marine Corps in a world about to be inundated by digital computers. Though the computers at that time were far more cumbersome and more limited than they are now; even then it was obvious that we were on the verge of a computer revolution - a revolution which would have many ramifications for all of mankind and would impact heavily upon the armed forces. The great potential for computers could be seen only dimly. But, many of the problems associated with bringing these new devices on line could be seen all too clearly.

The upshot of this was this was that a group of us began to analyze the naval situation as it existed at that time and as it was likely to exist within the next 25 - 40 years. We also sought to obtain information about prospective developments in the fields of computer science and information processing. Further, we became acquainted with the few (then) on-going research efforts in the field of education to explore the potential use of computers as aids to instruction. These preliminary analyses led us to organize a Conference on the Application of Digital Computers to Automated Instruction, held in Washington, DC, on October 10-12, 1961. This meeting brought together leading scientists and educators interested in exploiting the potentialities of the digital computer for instructional purposes. The proceedings of that conference were published by John Wiley and Sons, Inc. under the title "Programmed Learning and Computer-Based Instruction." To my knowledge this was the first hard-backed, commercial book published on this topic. Many regard it as the beginning of the computer-based instruction age.

Since our ONR research is basic and focusses on fundamental, generalizable issues, it has not really developed any full-blown computer-based instructional system. However, it has consistently supported some of the best research people in the business (including several of those who have appeared before you) who have produced a great deal of the information and understanding which has undergirded and buttressed the many applied efforts subsequently undertaken in the Navy and elsewhere.

Since our work is one stage removed from operational computer-based instructional systems, it is difficult to decide exactly which efforts should be identified with Computer Managed Instruction (CMI), which with Computer-Assisted Instruction (CAI) and which with Computerized Adaptive Testing (CAT). The placement of the boundaries is necessarily arbitrary. However, I estimate that we have spent between 200 and 600 thousand dollars a year on research that has direct relevance to CMI, CAI, and CAT, although I hasten to reiterate, it also applied to other forms of instruction, instructional management, and personnel testing.

It may be appropriate at this point to stop and ask why we decided to make this substantial research investment. Why didn't we sit back and wait for this work to be done on the civilian side? The answer to this question is based on the needs of the Navy and Marine Corps for trained personnel (on the one hand) and the unusual "test bed" kind of situation which exists in all of the military services (on the other).

With respect to the needs of the Navy and Marine Corps; they have the tremendous requirement of taking young people from the farm and from the inner city and converting them in a remarkably short time to fliers, submariners, sonar operators, boiler tenders, and maintainers of the newest and most exotic equipment one might imagine. The success of that training determines the effectiveness of our fighting forces. Indeed, it is at the root of our national security. It must also be pointed out that it is tremendously costly to provide the training necessary. It was recently reported that the Navy alone expends something on the order of $1.5B/yr. on training and involves roughly 20% of the force. Much of the cost is due to the fact that the Navy pays its students while they are in training. Thus, every day in school adds to the already high cost of training. Every reduction in training time not only reduces those costs but puts the trained person to work on the job that much sooner. Also, as has been pointed out, properly constructed computer-based instruction is transportable, easily modified and has a long shelf-life. What better way to provide training to such a highly technical and highly mobile force? What better way to help the reserves maintain old skills and learn new ones? In my mind, the use of computer techniques is absolutely essential to the cost-efficient use of training resources and to the cost-effective utilization of military personnel.

But I have omitted an important point. Military jobs are very specific. People are trained to do specific things, in specific ways, at particular times. When you train a man to fix a radar, you expect him to be doing it on the job in a few short months. It is quite a different situation from trying to teach an elementary school student art appreciation, or civics, or history, or even the harder skills. Because military personnel are assigned to well-analyzed jobs, to perform easily observable duties, the military services provide excellent "test beds" for comparing the effectiveness of various forms of instruction.

But enough of that, now days, most people agree with the necessity of having some basic research carried on by mission oriented agencies. Forgive me for spending so much time on it. But, it is a subject dear to my heart.

Many of the features of modern CAI systems have grown out of research sponsored by ONR. Numerous examples could be cited. The early work on teaching interns the art of medical diagnosis by Feurtzig, the "hands-on" electronic maintenance training system of Rigney, the Russian vocabulary training of Van Campen, and the teaching of computer programming skills by Richard Atkinson are but a few of the successful "spin offs" that have come directly from the basic research program. Perhaps the most significant fundamental development was the work of Carbonnel. He reconceptualized the student-computer interaction and gave clear direction to exciting new opportunities for combining computer science, artificial intelligence and the newly emerging field of cognitive processing, thus pointing the way toward truly generative CAI of the future. (Generative CAI is a highly flexible, on-line, real time instructional scheme where the computer actually alters its own program in the course of its interactions with a student.) The ONR research program is also credited with making substantial contributions to the CMI System which is operated by the Navy Technical Training Command. It is a highly-successful system which is reputed to be the largest CMI system in the world.

Before closing, I would like to call attention to some of the problems that have yet to be solved. Even though the progress of the general field has been remarkable, the toughest problems lie ahead. They involve the ways that we use the marvelous machinery that is available to us. I, like many others, have come to believe that the engineers and technologists can build almost anything that we can adequately describe to them. If this is so, then the only things that stand between us and better instructional machinery in the future are time and money. But, there are problems of a different sort that will require more. They call for real intellectual effort, creative insights and patient scholarly work. These problems are most easily understood if we think of the events that take place within a student's head while he is learning as "processes." From that standpoint, the whole purpose of the instructional system is to cause these processes to occur. Viewed in this light the instructional system is a "process control system." By analogy, the instructional system is something like the pipes and valves of an oil cracking tower and the invisible events that take place within the student's head are like the changes that take place within the pipes as the crude is subjected to the controlled temperatures and pressures of the tower. The point of the analogy (which, like most analogies is not entirely apt) is that the control has to be exercised in terms of the organic chemistry of the crude oil. It would be silly to devote intellectual effort to the design of better refinery towers to the exclusion of efforts to understand the basic chemical processes that the tower is expected to control. In a similar sense, we are now at a point where we have demonstrated sophisticated instructional hardware and software. We are now at a point where the next big gain will be realized by marrying the modelling techniques of artificial intelligence with the empirical rigor of experimental psychology with the help of dedicated instructors and experienced instructional managers. In my judgement, this will provide a basis for determining better ways to use the equipment that is available and eventually lead us to still newer and more effective ways to employ computers in the learning society.

I know of no greater social obligation than the obligation of our ... ety to bring to bear the fruits of modern science and technology ... the pressing problems of those who have not benefited from traditional instruction.

8

STATEMENT OF DR. GLENN BRYAN, PSYCHOLOGICAL SCIENCES DIVISION, OFFICE OF NAVAL RESEARCH, ARLINGTON, VA.

Mr. BRYAN. First of all, let me thank you for this opportunity to appear here.

Mr. SCHEUER. We are happy to have you here.

Mr. BRYAN. Several thoughts come to mind. One of them is the notion, mentioned in the earlier discussion, that an appropriate criterion of effectiveness of using computer-based instruction might be the reduction in vandalism at the school. If one chose to use that as a criterion, it would be necessary to worry about the story that John Kemmeny tells about students who break into the schoolhouse or violate the rules about staying after hours so that they can work with the computers which they find both exciting and helpful. While this isn't vandalism, instances of insubordination or vandalism or something of the sort, it suggests that rulebreaking might actually be stimulated by the student's avid interest in computer-based instruction. Seriously, students are "turned on" to good computer-based instruction.

Under many circumstances, people who have used computers as interactive devices to engage themselves with subject matter and to develop new skills, reveal that this is an intriguing, exciting sort of thing that people like to do. We have an interactive terminal in our office and every once in a while I have to go over and shoo people away. Staff members at all levels are attracted to it. However, it is not universally the case. How and when computer-based learning occurs is not well understood. It would be a bad mistake for this group to assume, despite Dr. Papert's great success in bringing about exciting student-computer interactions, that technology has reached a point where such results will necessarily follow, if every student is given a computer. Sheer availability will not somehow or another cause students to use it and use it effectively. And it does not necessarily follow that if every home has one, you're going to have a hard time getting up a baseball game in the neighborhood because the kids are all inside twiddling with their computers.

Now some learning is fun and sometimes it's fun to use computers to learn. But in my view, learning is a kind of work, a necessary kind of work that people have to buckle down and make themselves do. And since I believe, along with many others, that behavior is really determined by the anticipated consequences of that behavior, it seems to me that what you have to have, and what the computers provide so nicely, is the kind of closely coupled interaction that let's you know how you're coming, to follow what you're doing. Computers have a monitoring capability to supervise the interaction between the program and the student as it occurs and to advise the student, to tell him that he's doing well, if he is, to tell him what he ought to try next if he's stuck, to answer his questions if need be. That kind of closely coupled, directed interaction is the thing that will keep the students working and progressing even after learning ceases to be fun. But even when it quits being fun and becomes work, it can be satisfying, if they're learning something they want to learn and if it is demonstrated that they are making progress—or better yet—when they, themselves, can recognize their own progress. The sense of achievement, the thrill of success can be exhilarating. That experience occurs to some of these young people about which you are concerned far too seldom. Adaptive computer-based instruction offers the promise of gearing instruction to the student so he will experience success in a non-threatening environment. He can be successful, but can also risk being wrong with the knowledge that the system will be "patient," "forgiving," and "helpful."

I guess it's a personal bias but—someone mentioned language labs earlier, and I have a real tin ear with languages. I sign up occasionally for another language course and I do quite well in class. I listen to my tapes regularly. But I don't learn the language. I don't speak the language well when I go abroad. It is very discouraging. When one goes to the work of learning one wants to be able to apply that learning outside of the classroom.

We need training systems that assure the student that he will learn if he sticks with it. Further, we need systems that will be helpful beyond the classroom. In the Navy, what we're interested in is the real world payoff of training. We're interested in the carryover from classroom to shipboard. We have a great diversity of people who come into the service and in a very short time they must perform all sorts of jobs, many of which don't exist anywhere else.

The people come from all parts of the country, from all segments of society. The jobs are everywhere: In the air, on the sea, under the sea. The people are expected to operate and maintain, under very hazardous and very unpleasant conditions, all sorts of exotic equipment that is absolutely essential to our security. Dr. O'Neal mentioned how expensive military training is. We see the computer as playing a significant role in future Navy training, both as a means for reducing the training costs and as a means of providing better training.

We are beginning to see some of these technologies get into the Navy schoolhouse. Progress isn't as rapid as some of us would like. We have some budgetary problems. And it has been suggested from time to time that the uniformed members of the military services are sometimes too conservative in undertaking new sorts of things. So it has to be pretty well demonstrated to them that computer-based systems will work before they will buy into them and put them into the Navy schoolhouse. And we've had some success. In the Navy, the computer managed instruction at Memphis has turned out to be quite successful. The Air Force has a system that operates at Lowry AFB, that is similar in many respects.

We are also beginning to see the impact of computer assisted instruction as it shows up in connection with various Navy training.

In the research area we are clearly aware of what we have to know in order to do this job and do it right. We know that there are great lacks of information, lacks of knowledge and lacks of skill that we are going to have to address through research and development. We are going to have to have computer programs that will be easily modified, that will operate in real time on line, that will have the capability of developing a model of the information that's to be conveyed, a model of the skills to be learned. They will have to have on line capability of keeping track of the progress of the student so that the machinery of the system can provide to the student exactly what he needs at the time he needs it and give the student information that will allow him to know that he is making the progress that is intended.

Mr. WELLS. What types of instruction are being applied in Memphis, at the naval facility in Memphis, and by the Air Force at Lowry?

Mr. BRYAN. I will speak for the Navy because I am more familiar with that. The computer is centralized and the computer management is handled for a variety of Navy technical training courses. Generally, the introductory portion of those courses—and they handle a large number of students on line at the various technical schools of the Navy. Fundamentals of electronics would be typical of the sorts of things they teach, fundamentals of mechanics or fundamentals of aerodynamics.

Mr. WELLS. Did you encompass certain facets of pilot training within this rubric of computer assisted instruction? I recall from another position on the committee that I went to Langley and they have a system in which U.S. pilots and other visitors like myself can fly missions against a Russian plane on a programmed basis. Is that within the framework that you consider to be an appropriate application of this sort?

Mr. BRYAN. Yes; it is, indeed. And the whole possibility of simulation is I think entirely appropriate. It is particularly exciting where the person who is flying the mission can set up the system to try things that he wants to try, so that he can in effect try experimental tactics and things of that sort.

Also in the area of electronic maintenance, for example, the possibility of simulating elaborate electronic equipment which then can be operated or which you can engage in diagnostic troubleshooting efforts is likely to be an area of great payoff. I speak of the simulated equipment which was mentioned in these hearings earlier. We have had extensive work done at the University of Southern California with Dr. Rigney, who has demonstrated within the Navy training context the helpfulness of computer-based training in the electronic maintenance domain.

Also, equipment gets to be more and more complex and as it gets more and more reliable you cannot count on on-the-job experience for practice in dealing with it. Under those circumstances, it is much more effective to depend on supplemental simulation to provide some experience for the person to practice troubleshooting skills, to learn new skills, and evaluate his old ones.

Mr. WELLS. You being from the Psychological Sciences Division I guess would be very concerned with a number of questions which have been raised throughout these hearings and that is the psychological effects, both deleterious and beneficial. Again, we come back to this Langley experience. It was quite interesting to have recounted to us—well, they would bring in Navy pilots and Air Force pilots to train on this instructional facility and one of the very unexpected findings was the degree of emotional involvement which became apparent. Indeed I experienced this myself in that you almost forget that you are not flying a real airplane, that you are really engaged in a one-to-one combat situation. Is that kind of emotional involvement present in other types of computer-assisted instruction? Is it something that should be sought for?

Mr. BRYAN. Yes, indeed. It is also present in other situations. But I don't think it is guaranteed. My introductory remark was intended to emphasize that. The ability of the instructions to adapt is important.

It is present in certain of these one-on-one situations like an instructor pilot and a trainee. It can play an important part about computer-assisted instruction. CAI can be geared to the capability of the particular student at a particular time. In your case if you had lost every battle and if the other guy just flew the socks off of you, it wouldn't be so absorbing. You would soon lose interest. An adaptive system would prevent this from happening.

Mr. WELLS. They did this, by the way. They did rig the computer so that time after time the U.S. pilot would lose against the Foxbat and after this would happen half a dozen times the guy didn't give a damn and didn't try very hard.

Mr. BRYAN. That is right. One of the great advantages of computer-based systems is that they can be adapted on line so that the material you are trying to deal with is appropriate to your level and that keeps you right at the edge where you are capable of learning at an optimum rate and it maintains your motivation. You are not winning them all or losing them all.

I wanted to go back and mention another specific example from the Navy where computer-assisted instruction seems to me to have been used very cleverly and usefully. It is being done out at North Island and it concerns the use of the computer-based instruction to get people ready to go onto a flight simulator.

Now the flight simulator itself is an extremely expensive device and therefore there is only one out there. It is a team affair and you can only accommodate three or four people at a time when they are flying their mission.

When people were put on that simulator, before the introduction of the computer-assisted instruction you had to explain to them what all these knobs and dials were about. And, of course, it is just a horrendous thing as it is typical of a modern aircraft cockpit. Subsequently, they introduced computer-assisted instruction to teach what all of these knobs were for. CAI gave them opportunities to practice, to learn and to clarify misunderstandings.

They discovered that a few hours of that, which could be given to many people at the same time—1,000 if you wanted, I suppose—was worth several hours of simulator familiarization. So, although they did not turn the piloting task over to computer-based instruction, I think they used it in a very ingenious and appropriate way by giving 3 or 4 hours of familiarization. When the students went into the simulator, they knew where things were and what they were supposed to do, so they could begin to practice the team and the dynamic interactive aspects of the task that the simulator was really intended to allow them to do.

I guess that I would go back and say with regard to your question about the psychological effects of computer-based learning, that it can cut both ways. People can feel as if they have been abandoned to an inpersonal, heartless system. I know of an instance, for example, where a computer managed instructional system became depersonalized, and deprived the students of human contact to the point that it affected their morale. That is not necessary. It has to be guarded against.

Basically, I would like to close by underscoring what Dr. Papert says. One of the vital ingredients is to get enthusiastic, capable, imaginative and creative people to join forces in trying to look at this area. It is very complicated. Its roots come from the educational world, from the computer hardware world, from the information science world, and the psychological laboratories. When these first came together it created great problems. Much of our initial effort was to try to get people from such diverse backgrounds in the same room, to try to get them talking to each other in language they could understand.

And even then, once a problem was identified, there was a tendency for each group to want to turn around and deal with it as a problem within its own specific discipline.

The passage of time, and hopefully some of the actions that we took back in the early sixties have led to the development of a community that is much more conversant with each other, much more tolerant of each other's views, much more aware of the potential contributions of the other disciplines. And I think we are in a far better situation now to develop better computer-based instructional systems.

My only plea is in our effort to get on with the exploitation of computer-based systems and that we continue to try to locate ingenious, creative people whose talents can be brought to bear on the problem. I take a great deal of satisfaction from the fact that a large number of the people who have appeared before you have been people who cut their teeth in this business because of support that we have provided. To be successful, we need them—and more like them.

Mr. SWANSON. I would like you to step back for a moment and maybe speak as a personal observer now and one who has been involved in this field for quite a while. A lot of the witnesses have mentioned that they see a revolutionary impact around the corner from the advent of this technology on our society. I was wondering if you could comment on what you thought those claims really implied. Are they in fact true, or is it just another promise such as the new math?

Mr. BRYAN. As a strictly personal thing, I'm not sure I know what a revolution is and, whatever it is, I'm not sure I want to be around when it occurs.

Everybody knows there will be a lot of these devices which will be marketed. They will find their way into the hands of people who have the money in their pockets to buy them. That could be good. I don't think it necessarily will be. A lot of people buy encyclopedias and never open them up.

I am in favor of a more programmatic approach that won't depend upon some explosive "revolutionary" sort of thing. If such a programmatic approach isn't taken, there is a bad revolution with respect to public education that's going to come about. Maybe that revolution is already in progress. It has seemed to me for the last 20 years that there are three groups that can be identified with regard to the public school system. One is made up of the students, one is made up of the faculty and staff, and the other is made up of parents and taxpayers.

It seems to me that each of the groups is dissatisfied with the way things are going. It seems to me that changes are taking place. They are revolutionary in the sense that the character of the schools has changed an awful lot and revolutionary in the sense that it seems to be under no one's control. It is moving the way the contending forces are causing it to move, shifting in undesirable directions in some instances. That kind of revolution may be occurring with regard to the public school system. Certainly we have heard of taxpayer's revolts. I personally feel that computer-based systems have a great deal of potential for dealing with some of these difficult public school problems.

Whether a good "computer revolution" will take place, whether the machines will save us, and whether all of a sudden they will appear over the horizon is hard to say. I think we have to work hard to bring about goals we want to bring about. There is still much work to be done. But real progress has been made. Further progress is possible.

Mr. WELLS. I think the context Dr. Swanson is talking about and which other witnesses had been referring to in the sense of revolution is not an explosion but in the context of what has been happening in human history for the past 10,000 years.

Ten thousand years ago, we developed agricultural science in a rudimentary fashion. Six thousand years ago, roughly, we developed language and mathematical capabilities which began to transform society greatly. Only within the last 300 years have we developed science in a modern sense. The world has changed radically in the last 300 years, and in the past 50 years since then a large-scale intervention by Government in supporting research and development has led to a lot of change in a real revolution sense. So I think that is the context in which we understand the use of the word "revolution" here in that we have been riding the tides of these revolutions by and large rather than understanding what is happening.

What we are groping for is somehow to steer ourselves a little better than simply riding the crest of the revolution as it immerses us from whatever the source may be.

Mr. BRYAN. In that sense, I would agree that we are on the verge of a revolution. It is appropriate to be concerned about trying to steer ourselves a little better.

Mr. SCHEUER. Thank you very much for your testimony. It has been stimulating. We thank all of the witnesses, and we will adjourn until Tuesday, the 18th, at 10 o'clock in the morning in room 2318.

[Whereupon, at 1 p.m., the subcommittee was adjourned.]

COMPUTERS IN THE EDUCATION OF THE HANDICAPPED

TUESDAY, OCTOBER 18, 1977

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON DOMESTIC AND
INTERNATIONAL SCIENTIFIC PLANNING,
ANALYSIS AND COOPERATION, AND
COMMITTEE ON EDUCATION AND LABOR,
SUBCOMMITTEE ON SELECT EDUCATION,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10:15 a.m., in room 2325, Rayburn House Office Building, Hon. James H. Scheuer, chairman of the subcommittee, presiding.

Also present: Mr. Kildee, Mr. Miller, Mr. Jeffords, Mr. Walker, Mr. Glickman; staff: Mr. Wells, Mr. Kramer, Mr. Swanson, Mr. Birch, Mr. Gallagher, Mr. Lavore, Ms. Heron.

Mr. SCHEUER. The meeting of the DISPAC Subcommittee on the role of computers in the education of the handicapped will come to order.

Now, we're going to operate under a tight time frame today because I have a meeting with some White House people down here today at 12:15. So that gives us exactly 2 hours.

I have an opening statement which, in order to save time, I'm to make orally. You are all familiar with the importance of enhancing the effectiveness of the—the cost-effectiveness of our methodologies and our modalities for dealing with kids with special education needs, especially handicapped children. You're working in this field. And so I will spare you my statement in order to save time for the witnesses.

Thank you very much for appearing today.

The first witness is Mr. Robert Herman, Associate Deputy Commissioner, Bureau of Education for the Handicapped.

Proceed.

STATEMENT OF ROBERT B. HERMAN, ASSOCIATE DEPUTY COMMISSIONER, BUREAU OF EDUCATION FOR THE HANDICAPPED, OFFICE OF EDUCATION, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Mr. HERMAN. For the record, I'd like to introduce Dr. Frank Withrow, who is the Special Assistant to the Deputy Commissioner of the Bureau of Education for the Handicapped, and who has been working in the area of computer technology and the education of the handicapped.

Mr. SCHEUER. Now, let me say for all of the witnesses, your statements will all be printed in their entirety in the record. I would urge you not to read your statements. Just talk to us. If all you're going to do is read your statements, just save everybody's time and let the next man move forward, because your statements will be printed.

We've read most of your statements, and those that we haven't read already we will read.

[The prepared statement of Robert B. Herman is as follows:]

STATEMENT OF ROBERT B. HERMAN

Mr. Chairman, I am pleased to be here today to tell you a little bit about how the Bureau of Education for the Handicapped is attempting to bring the benefits of computer technology to improve edutional opportunities for 8 million handicapped children aged 3 to 21. The use of computers will undoubtedly figure heavily in obtaining an equal educational opportunity for all handicapped children. The passage of Public Law 94-142, the Education for All Handicapped Children Act of 1975 with its requirements that a free appropriate public education be provided to every child with a physical or mental impairment, and that each child have an annual individual education program has created a demand for individualized instruction.

In getting ready for universal education for the handicapped child, the Bureau has worked with the private sector to utilize computer technology.

There are two specific uses for computers in the education of the handicapped. One is the use of computers to compensate for the handicapping condition. Computer-generated speech, for example, can be used by persons who have a limited ability to speak. Such systems can be activated by either manual or oral output. The reverse of this example would be the turning of print into speech to enable the blind to have access to the printed page. The technical problems of conversion of print to speech are less difficult than the transformation of speech to print.

Despite these difficulties the Bureau is pursuing some intermediate steps to turn speech into captions for television. A contract with Teledyne Corp. is helping to explore "real time" captioning of live event and program. The system would use a computer-generated print which provides printed English on the screen. In the near future it should be possible to have developed systems which will transform speech into instantaneous print. Such an aid taken to the personal use level would be an invaluable device for deaf individuals.

Other witnesses at this hearing will be describing the effectiveness of Bureau investments in computers and computer technology. Most notable of those are the Kurzweil Reading Machine which converts ordinary printed materials rapidly into spoken English at 150 words per minute. The device could have enormous impact by allowing blind students to read most of the same texts and printed materials as their sighted peers. Other major products of our work is the OPTACON, now a nationally known and tested direct translation reading aid for the blind and Telesensory Systems' very effective "talking calculator." Dr. Kurzweil and Mr. Nelson will go into greater detail I am sure.

At the Clarke School for the Deaf in Massachusetts, experimentation is being carried out to develop a computer controlled speech aid for the deaf. Devices being developed under a contract with the firm of Bolt, Beranek and Newman have the potential of aiding deaf children develop effective speech patterns.

Early experimental development of typewriters for severely handicapped individuals is another example of the personal device which uses computer technology. Cybertype uses a computer in combination with a regular typewriter to allow a variety of severely handicapped individuals to type. Some of these devices enable amputees to type, others allow totally paralyzed individuals to activate the typewriter through a whisper or eyeblink.

The second and most rapidly developing use of computers in the education of handicapped children is computer assisted instruction in regular school programs. The computer can perform two missions. First it can be the patient, non-threatening instructor that can repeat over and over again for a child with a learning problem. It can provide a child who is limited in his expressive abilities new ways to express his ideas and thoughts.

A past experiment with severely handicapped children and telecommunications called Tel-Catch at Amherst, New York has incorporated a computer educational system with television programming to homes where confined handicapped children reside. Tel-Catch, funded under a demonstration grant by the Office of Education, Bureau of Education for the Handicapped, now can bring education to children who are faced with recurring medical problems that force them into chronic absenteeism. Today, this program permits children confined to their home to keep up with classmates simply by dialing their telephone and turning on the family television. A child can choose from a wide range of subjects specifically tailored to his or her needs and at his or her own pace. This interactive system has great potential for traditionally bypassed handicapped children.

Currently the Bureau is funding several computer-assisted instruction projects. One is a project working with severely handicapped children in basic language and math skills. The objective of this project is to work with severely non-verbal children and to provide them with a system for acquiring these skills.

A second contractor, this one in California, is developing materials and experimenting with less severely handicapped children in a regular school setting. Again the subject area is language and math skills. This system is using more traditional programs and is demonstrating the way that computers supplement the regular classroom activities so that moderately handicapped children can keep up within normal classrooms.

The Office of Education has just begun a contract with Gallaudet College and the Computer Graphic Center of Ohio State University to develop materials in three dimensions. Computer graphics do demonstrate some specific language concepts which are difficult to demonstrate in the traditional classroom. Computer graphics can demonstrate difficult concepts to deaf children.

One of the major parts of P.L. 94-142 calls for the handicapped child to be educated wherever possible with his non-handicapped peers. To do this we must be able to train teachers of the handicapped and regular classroom teachers to work with these children in the regular classroom situation. We are in the midst of two computer-assisted teacher training programs. The work is being done at the University of Indiana with the specific purpose of using computer-assisted training techniques to develop and improve the supply of special education teachers.

In summary, computers offer a wide level of potential use for the handicapped. The personal interface which compensates for the person's handicap, the use of computers as a learning aid and the use of computers as information aids all hold promise for education of the handicapped. In some instances with severely handicapped individuals there is the opportunity for the computer technology to open up the world of communications. In some isntances the computer may be able to provide the assistance that the child needs to remain in a regular classroom. In some instances the computer may provide the profession with the information and data required to help plan and deliver the education required by a given child. There are questions facing the special education field as there are in general education concerning the cost effectiveness of the use of computers. We believe that the appropriate use of computers can reduce the need for highly trained specialists and can assist the handicapped child to study along side the regular child. We believe that some of these techniques of individualized programming hold great potential for general education as well as for special education.

We know from past experiments that handicapped children can learn from computer-aided instruction; that there is a greater likelihood of providing a comprehensive curriculum for handicapped children through computer programs; and that personal interfaces with computers are excellent ways for severely handicapped children to have means of expressing their ideas.

Micro computers coupled with new graphic systems such as MCA video disc and telecommunication systems offer a new generation of support for the handicapped. With the support of the Congress, the Office of Education, through the Bureau of Education for the Handicapped will move forward to sponsor demonstration and research activities to develop applications of modern technology to educating handicapped children and to assist states and local agencies in implementing these new techniques where warranted.

Mr. HERMAN. Mr. Chairman, the passage of Public Law 94-142 the Education for All Handicapped Children Act of 1975, which guarantees for all handicapped children a free, appropriate public education, and includes educating the handicapped child in the least restrictive setting makes the need for the use of computers and the application of computer technology and other scientific technology for the handicapped child even more crucial.

While the Congress was working on developing a law that mandated free appropriate public education for all of these children, we have been also pursuing various research and demonstration projects which are designed to enable the handicapped child to pursue his education to an effective completion.

Some of the material you see around you today and that will be demonstrated is the work of dollars appropriated under the Education of the Handicapped Act over the last 8 years, in supporting various research projects and various experiments, and utilizing already-existent computer and other technology.

We have been searching for specific uses over time for computers in aiding to educate handicapped children and for using computers to work with the deaf population especially. Activities like computer-generated speech for people with a limited ability to speak, giving them an opportunity to be able to communicate more effectively, as well as converting computer-generated print into speech for blind people, has been beneficial to the deaf, the blind, and other handicapped individuals.

The Kurzweil Reading Machine—and Ray Kurzweil will be here this morning—has been partially developed in part with the aid of the Bureau of Education for the Handicapped research and development funds.

The Optacon, which is a sensory reading machine for the blind, has also been developed in part by funds from the Bureau of Education for the Handicapped.

So there are a great many activities that are going on. The statement speaks for itself on the kinds of activities that we have been pursuing.

The point of the matter is that as Congress has mandated in legislation the placement of the handicapped child with his normal peers wherever possible, at any opportunity possible, in the so-called least-restrictive environment, it becomes even more important that handicapped children be able to work at their own pace, to have an opportunity to have material presented for them with their own ability to accept it, and to have materials presented to them in a different degree, or in varying degree, of styles and modes.

So we are very much interested in computers and the use of computers in education for the handicapped, especially in the computer-assisted instruction area, where handicapped children, learning disabled children, as well as the broad range of mentally retarded and other kinds of children with difficulty in learning processes have an opportunity for this self-generated, self-paced process.

In addition, we have used the computer to help train regular and special teachers in the in-service and the pre-service training of teachers—teachers who are in schools where they do not normally come into contact with severely-handicapped youngsters, youngsters who are at the low incidence of handicapping conditions.

Also, computer-assisted instruction has been used to train teachers in-service at their home districts, where teachers are not close to a metropolitan area where they can easily come to an in-service training program, or spend a week or 2 weeks or a weekend with experts.

We also designed at Penn State University a process whereby teachers through CAI can learn to deal with the handicapped child.

As more handicapped children move into the regular classroom, as more handicapped choldren move into that kind of a situation where they're with their normal peers, it's important that the teacher in the regular classroom—in fact, it's probably one of the most important things—be immersed in the special education needs of the handicapped child who will be placed under his or her guidance.

Another area of importance is the training of aides. As we deal with the handicapped child more frequently in the public school situation, and handicapped children are returned from residential institutions wherever possible, we are trying to develop aides and paraprofessionals to serve them. That's something you've been interested in, Mr. Chairman, for a long period of time, the development of new careers for the poor, paraprofessionals.

Mr. SCHEUER. You're extremely well informed, and your memory goes back at least a decade. And I appreciate the citation.

Mr. HERMAN. Thank you.

Mr. SCHEUER. Thank you. Serious speaking, I'm very proud of that paraprofessionals program, the new careers program, and if I never accomplish another thing in Congress, as far as I'm concerned my stay here will have been well justified by that.

Mr. HERMAN. Well, I had an opportunity to work with you when you were developing that legislation.

Mr. SCHEUER. Yes. It changed the way we look at the poor, and it changed our perception of what their potentials and their capabilities are.

Mr. HERMAN. Exactly.

Mr SCHEUER. And it's germinated all over the place. In almost all of the media programs we now are involving them in providing services in ways that we never would have thought possible.

Mr. HERMAN. For example, at the Bureau of Education for the Handicapped, we are working with one of the people you've been working with over the years, Frank Riessman and Alan Gardner.

Mr. SCHEUER. Terrific.

Mr. HERMAN. In working with them, they're helping us to guide and shape paraprofessional training programs all across the country at universities and community colleges, to train people to work with the handicapped child. There's such a great need and there's such a great demand. We've also made promises to teachers in the regular classrooms that they would not go without aides and without support services. So we're using——

Mr. SCHEUER. You made promises to whom?

Mr. HERMAN. We made promises to teachers in the regular classroom that there would be aides trained, that there would be a way of training aides for assistance.

Mr. SCHEUER. You know, that's very ironic, because in the early days of the new careers program, as you undoubtedly remember, the teachers were very hostile to the idea——

Mr. HERMAN. That's right.

Mr. SCHEUER [continuing]. Of introducing a second adult in the classroom, who would be looking over her shoulder. There was an enormous amount of hostility and prejudice to overcome.

Mr. HERMAN. That's right.

Mr. SCHEUER. When you tell me today that you've promised the teachers you won't take away their aides, we've come a long distance.

Mr. HERMAN. Mr. Chairman, we're trying to create opportunities for the training of aides. Many universities and colleges, even the 4-year variety, are heavily involved in training paraprofessionals and aides—not just one or two universities around the country, but a great many are into this whole area.

Mr. SCHEUER: Yes.

And, whereas, they first used the aides mostly for taking off galoshes, and serving lunch, and keeping attendance charts, and issuing bus passes, we've found now that the computer can issue bus passes——

Mr. HERMAN. Yes, sir.

Mr. SCHEUER. Now the aides are an integral part of the learning process, particularly where the child—and this is particularly true of handicapped children—has need of a one-to-one relationship with a concerned, caring adult. There the aide plays an indispensable role in helping the teacher handle the large class, because there comes a time when that kid needs a 1-to-1 situation for 15 minutes, or an hour, or 2 hours. Without it, they've come to a dead end. With it, they can still be part of a classroom group.

Mr. HERMAN. Exactly.

Mr. SCHEUER. The teachers have moved in a full circle. They have come to believe that the presence of one or two aides is indispensable for them to play their role.

Mr. HERMAN. That's exactly right. In fact, in their concerns about Public Law 94–142, the teachers in New York State——

Mr. SCHEUER. Would you translate that into the English language?

Mr. HERMAN. I'm sorry. Public Law 94–142 is the act which you helped to pass up here, the Education for All Handicapped Children Act of 1975, which is the free appropriate public education guarantee to all handicapped children.

In their concerns and their raising of issues around the country many teachers, including New York State Teachers Union, have raised the concern that the aides and paraprofessionals that they have within the classroom will go on, will stay there; and also they will get additional help and support in bringing help and support and services to these children.

Mr. SCHEUER. I can tell you that that was not the point of Al Shanker and the Teachers Union 10 or 11 years ago.

Mr. HERMAN. Of course, now they're in there.

Mr. SCHEUER. So we've come full circle.

Mr. HERMAN. Yes.

Mr. SCHEUER. Well, I congratulate you on—completely apart from this testimony—on the work that you've done over the years with the aides and whole paraprofessional program. I think we've done a wonderful thing. We've given people honorable and meaningful careers who never would have expected to have achieved such status by and large, and we've also enriched the education system and made it more relevant and more sensitive to people.

I think that this has turned out better than any of us ever dreamed, even those of us who supported the program, like Frank Riessman, Tom Gardner, Pearl, and Russell Nixon.

Mr. HERMAN. I think you and your staff were exactly correct some 10 years ago.

Mr. SCHEUER. So, in terms of the computer, do you find that the aides are able to use the computer with the child?

Mr. HERMAN. What we're finding is that we can train aides and teachers through the use of computers, through the use of computer-assisted instruction, to work with the handicapped child in the regular classroom.

Mr. SCHEUER. I guess on a more sophisticated level than that aide could have functioned at without the aid of the computer.

Mr. HERMAN. Yes. And also independent learning.

Mr. SCHEUER. Yes.

Mr. HERMAN. They can learn at their own pace, they can learn on weekends, they can deal with instruction where they are not necessarily near a major university or college, where there are opportunities for inservice training. And that's very important.

The cost of inservice training is enormously high. Also, when you bring teachers to the big city, they don't want to return to the smaller rural areas, and we often lose them from the very important job they're doing with the handicapped child at the local level.

So, we're trying to keep the teachers at the local level, keep them at their home bases, and use computers and other kinds of resources in order to get aid to them to improve their ability to work with the handicapped child.

In summary then, we think the computers and computer-assisted instruction and computer technology in all forms of science have an enormous effect on handicapped children—not only handicapped children, but all exceptional children such as gifted and talented children, who also need to learn at their own pace, and also need to move in a direction which might not be usual to the so-called normal range of children.

Mr. SCHEUER. Yes; I was talking to Prof. Abe Tannenbaum, of Columbia University, and he thinks the potential of applying the computer to teaching the specially gifted children is enormous and totally untapped. He thinks there's tremendous potential there.

I suspect that we'll have another day of hearings on the use of the computer for teaching gifted children.

Mr. HERMAN. Well, there are unique projects, like Tel-Catch, in Amherst, N.Y., which is experimenting with that. They've shown it works very, very well with children who are chronically ill and who need to be at home for long periods of time, children who can't get out ordinarily during severe weather. By simply turning on their television sets, by having cassettes with them, and other kinds of instrumentalities, they can keep up with the kids in the classroom. They can keep up, and when they're able to return to the classroom situation they can be current. And this is very important where children with cerebral palsy, or who are chronically ill in other areas, or who are crippled, children who can't get out for one reason or another for prolonged periods of time, have the opportunity to keep up with the regular classroom schedule

So we see those areas as extremely important.

Mr. SCHEUER. Yes.

Mr. HERMAN. But I think you'll see this morning the fruits of a lot of the labors of Congress in appropriating funds which helped to develop many of these activities.

But I think the next important thing is the validation, the engineering validation as well as the educational validation, of some of these great activities that have been carried on. And then, of course, the implementation phase, convincing local school boards and universities and colleges around the country that they are not only educationally beneficial, but that they're cost effective for children, as well, and that it will lower the very heavy cost, very heavy burden, of providing education to the handicapped child.

One of the things that is keeping us back in this area, of course, is the high investment at the beginning, investment in the hardware, and investment in other kinds of materials that go along with advanced technology.

Mr. SCHEUER. One of the things that I guess has discouraged the Congress was in the operation of the title I program of the ESEA act, the Elementary and Secondary Education Act. Two months before the end of the funding year, the money's just been appropriated, and in a frantic effort to spend the money, the schools buy a lot of hardware.

Mr. HERMAN. Yes.

Mr. SCHEUER. And the hardware ended up in a storage room. If it ever did get out of storage nobody knew how to use it. And it was a great, big, fat mess. I think the Congress was a little bit turned off by that.

It's unfortunate that it turned out the way it did, because with a little thought and a little effort the hardware can be made enormously effective. I hope that in time, by intelligent administration of this program involving hardware, it can sort of overcome that stigma brought on by the operations of title I of ESEA.

Mr. HERMAN. I think you need people with training in the use and maintenance of this hardware and other materials.

Mr. SCHEUER. I think that's right.

Mr. HERMAN. This is needed within the school district so they don't have to call or get into heavy contracts with private operations.

Mr. SCHEUER. Congressman Brademas unfortunately had a leadership meeting this morning, so he wasn't able to come. But he has at least two very able representatives who will ask questions.

Mr. WELLS. One very brief question, Mr. Chairman.

Mr. Herman, we had testimony last week to the effect that the computer early on simply replaced, analogously with the aide situation, took on payrolls and inventories, very trivial kinds of clerical operations. And this is typically what we do with a new technology. And I believe Dr. Papert used the analogy that the automobile was the horseless carriage, and the terminology was very apt, that that's the way we thought of the automobiles simply as replacing the horse. And in the computer area we started out with very comparable types of things. Now we're moving to new levels of understanding, new levels of appreciating the full potential of the computer.

For example, in diagnosing learning difficulties of children in the classroom.

Are there some special applications of diagnostic—that is, using the computer as a diagnostic tool in looking at the special problems of the handicapped?

Mr. HERMAN. I'd like to ask Dr. Withrow to help on this.

Dr. WITHROW. There's been a great deal of discussion of this, and there has been some beginning experience along these lines. One experiment that we funded, with Bolt, Beranek & Newman in Massachusetts, with the deaf, was involved in the diagnosis and remediation of speech. As the child speaks, certain kinds of games actually take place on the television screen. For example, the pitch has to do with how high the basketball net or the circle is; the duration is whether the ball goes through the net.

That's a great simplification of many different techniques. It made young children, in effect, work with the materials. Then, one could develop and define the particular problems that were within their speech, and not only diagnose, but actually use the technology for remediation.

There are a number of other examples in which severely handicapped children which had no other means of expression, could express themselves through some kind of interface with the computer. And in those instances—and we're still in a case study basis—we have found that some children—severely handicapped, unable, to speak, with maybe just an ability to move a hand or an eyelid—have a great deal of intelligence. They've learned to program computers. They've learned to talk and work with computers.

Mr. WELLS. What struck me was an example of Dr. Papert's, in Dr. Papert's testimony last week, in which a child, a teenager, was considered retarded until one of his experiments in working with this child, by enabling this preson to work with the computer, suddenly opened up entire new— this child was not retarded at all—and opened up complete intellectual horizons, and it was his estimate in a few years this person would be able to do ——

Mr. HERMAN. Autistic children and children who are severely deaf also have had the computer open up the world to them. Children who had not reacted previously to people, through the computer, have often had the world simply opened up to them, and a whole learning process begins.

There's also been some very exciting things done in diagnosis of medical conditions and they may have some application in diagnosing educational needs.

Mr. WELLS. Are we doing enough research—it's an overall question, obviously, that we ask— do you have enough money? Are you—is this an area in which resources should be allocated? What areas would you suggest would need more resources, more work in this area?

Mr. HERMAN. Well, it's always tempting to say that, we don't have enough resources or could use more resources—we always could, because the dollar is scarce, and the demand great. It's always easy to say that we could use more resources in this area.

What I think we really need, though, is more cooperative ventures, more understanding from the service deliverers—more opportunities to experiment with various kinds of materials and techniques, more opportunities to experiment in local school districts to see what really works and what doesn't work.

We've had a great number of successful efforts in using some kind of computer-assisted instruction, between the title I program, between Education of the Handicapped Act program, and many other areas—Public Law 89-313—Institutionalized Children program—which we've seen many opportunities to use diagnostic as well as teaching materials.

Mr. WELLS. Well, I won't belabor the point, but it just seems such an important subject, as far as the concept of pilot programs and product research projects.

Thank you very much, Mr. Chairman.

Mr. SCHEUER. Jim?

Mr. GALLAGHER. One question, Mr. Chairman.

Mr. Herman, another witness today will state that there's a very severe problem downtown in the area of jurisdiction. I understand from his testimony that you sponsored a meeting and invited the Veterans' Administration and NSF and a number of other groups to attend this meeting. And this witness stated that there's a question of jurisdiction in this field, and who's funding what, and so forth.

I was just wondering if the proceedings from this meeting could be provided, with the chairman's permission, to this committee.

Mr. HERMAN. Certainly. But I know of no such problem.

Mr. GALLAGHER. He stated there's a very severe problem in this whole area, downtown agencies—in other words, who's more equal, who's really responsible, who does the funding.

Mr. HERMAN. Well, we—yes, certainly. The answer is yes, of course.

Mr. GALLAGHER. Fine.

Mr. HERMAN. We've certainly been very sensitive to the issue of jurisdiction in the area of education for the handicapped children, and have tried to bring together groups of people who have been able to improve services and programs.

We just completed an agreement with the Rehabilitation Services Administration, an agreement signed by Commissioner Boyer and Commissioner Humphrey, concerning improved services for the handicapped.

We have been working very closely in other areas. I don't see--I didn't see any jurisdictional problem up until this point, but since you call attention to it we might be able to focus on it.

We have had meetings. We are bringing together, under Allen Dittman, one of our senior research people assigned to this area, people to consider problems, and try to coordinate Federal funding, and to target on particular areas in which there is a need for further work.

The answer is yes, clearly.

Mr. GALLAGHER. And you're the leading coordinator, Government-wide, across the board?

Mr. HERMAN. So far as educating handicapped children we're trying to play that role, yes, sir.

Mr. GALLAGHER. Thank you, Mr. Chairman.

Mr. SCHEUER. Questions?

Mr. BIRCH. Thank you, Mr. Chairman.

Mr. SCHEUER. Would you identify yourself?

Mr. BIRCH. I'm Tom Birch with the Committee on Select Education.

Mr. SCHEUER. Would you introduce your colleagues?

Mr. BIRCH. Yes. I have with me Belita Heron, who is also on our subcommittee staff; and Marty Lavore, who is a staff member on the full Committee on Education.

Mr. Herman, very often we have seen the development and research going into these technological devices that are used in the classroom. However, the dissemination of these innovations has been limited.

I wonder if you could tell us what sort of assistance or guidance the Federal Government is able to provide to make these devices more widely applicable in classrooms?

Mr. HERMAN. We recognize this problem. We've done a lot of research in the Bureau of Education for the Handicapped in the last 10 years or so.

One of the things we're very much concerned about is the market, the professional marketing, of materials and techniques. And we've established a special unit in the Bureau to handle all marketing of successful technological products stemming from Bureau-sponsored research. We've established a unit with a number of outside advisers from the private industry, various different consumer organizations, and people who have been working with the handicapped across the country, as well as producers of the materials.

Two areas that we've selected for heavy work and heavy testing is the Optacon, which you'll be hearing about later today; and the Kurzweil reading machine. We've gone to a very complex review process to make a determination of where the Federal money could be best utilized in disseminating the effective outcomes.

Now, a lot more could be done. We are trying to do a lot more with limited resources in this area.

But we believe that a lot of the good technological devices that have been developed must be gotten off the shelf, whether or not they are for low incidence populations, and they're not really profitably attractive to private producers; or if there are simply opportunities for mass marketing. So we believe that we should be getting a lot of these things off the shelf, and we have taken steps to do so.

Mr. SCHEUER. Your testimony was marvelous, but we have time restraints and we've been going almost a half hour. We've enjoyed every minute of it. It's been very productive.

Mr. HERMAN. Thank you.

Mr. SCHEUER. Thank you very, very much for your testimony. We've enjoyed it, and we've profited by it. Thank you.

Mr. HERMAN. Thank you.

Mr. SCHEUER. The next witness is Ray Kurzweil and Barry Unger of Kurzweil Computer Products, Inc.

Now, we are in a terrific time bind here, gentlemen, so why don't you talk for 5 or 6 minutes, and then leave another 5 minutes for us to ask questions. We're going to have to stick to a pretty rigid 10-minute limitation from here on in.

[The prepared testimony of Raymond Kurzweil is as follows:

THE KURZWEIL READING MACHINE FOR THE BLIND,

DEVELOPMENT AND DISSEMINATION

Raymond C. Kurzweil, President
Barry Unger, Executive Vice President
Kurzweil Computer Products, Inc.

Hearings on the Role of Computers in Educating the Handicapped

Subcommittee on Domestic and International
Scientific Planning, Analysis and Cooperation
of the
Committee on Science and Technology

and

Subcommittee on Select Education
of the
Committee on Education and Labor

United States House of Representatives

October 18, 1977

Mr. Chairman, we very much appreciate this opportunity to discuss before this committee the reading machine for the blind that we have developed. My name is Raymond Kurzweil, President of Kurzweil Computer Products, Inc. and co-testifying with me is Barry Unger, Executive Vice President. The interest in our project over the last several years by the Committee on Science and Technology, and the Subcommittee on Select Education, and that of Sherman Roodzant, Science and Technology Staff Member, with whom we have worked closely, has meant much to us.

I would like to start out by demonstrating the machine for you, after which I will describe briefly how it works, and some issues of relevance to these hearings. Barry Unger will then describe some of the programs, including those sponsored by the federal government, to distribute the machine in the field, and to maximize its usefulness based on blind people's experience with it.

The Kurzweil Reading Machine converts ordinary printed materials, such as books, magazines, letters and reports into spoken English at approximately 150 words per minute. The system reads most common styles and sizes of type, handles many forms of print degradation, and thus allows blind and visually handicapped persons to read ordinary printed material rapidly, with minimal training required, and without fatigue.

The user operates the device by placing printed material face down on the glass plate which forms the top surface of the scanning unit. He then presses the 'Page' button on the control panel to activate the reading process. A specially designed scanning system we developed scans the page and transmits the image in electronic form to an image enhancement system. This system, which we designed and implemented in hardware, increases the contrast found on the page and brings out particular features that improve the recognition process. The enhanced image, now in digital form, is transmitted to a small computer contained within the reading machine which contains unique programs we developed to separate the image into discrete character forms, recognize the letters on the page, group the letters into words, and compute the pronunciation of each word. Pronunciation is accomplished through the use of over a thousand linguistic rules plus two thousand exceptions to the rules stored in the computer's memory. Additionally, a stress contour over each sentence is computed by a set of syntactical rules.

Before I press the page button on the control panel and direct the machine to read the page I have just placed on the scanning unit, I would like to point out that the synthetic speech output requires a small amount of familiarization. Persons who have never heard it before vary in their ability to comprehend it. All of our experience to date, including the results of several independent studies, has indicated that after several hours of exposure, users are able to understand the synthetic speech as well as human speech.

(Demonstration of the Kurzweil Reading Machine)

An important feature of the reading machine is its user controls. For everyone, sighted or blind, reading is properly an active rather than a passive process; one re-reads interesting or difficult passages, pauses at unfamiliar words, skims the page to find material of particular interest, and so on. The Kurzweil Reading Machine is operated by the user with a set of 33 keyboard-mounted buttons to allow the user to effortlessly make these choices. For example, the machine stores in its memory the last 300 characters that it has scanned, allowing the user to back up and hear words over again, have particular words spelled out, and other functions.

(Demonstration of User Controls)

The most difficult part of the research and development that we have conducted over the past ten years has been in the area of the recognition of printed characters. Printed material differs tremendously in a wide range of specifications, including well over 150 type fonts, different types of printing processes, different paper, ink and print qualities and a wide range of types of printing errors. Dealing with these vagaries of print was the biggest challenge in the technical development of the machine.

A key design feature of the reading machine is programmability. Most of the intelligence in the system, and by intelligence I mean any information handling process likely to require change in the future, is implemented in software, which is loaded into the reading machine's memory using a standard 3 inch digital cassette tape. This enables us to improve the reading machine's performance without modifying physical components. For example, the reading machine did not read italics when the first field model was installed at the Perkins School for the Blind in November, 1976. In January 1977 our italic recognition project was completed, and this capability was implemented at the Perkins site simply by providing them with a new cassette tape containing the computer program to recognize italics. The Perkins staff inserted the tape, loaded the new code into the reading machine, and the machine was then able to read italics. Similarly, other improvements have been and will continue to be provided to field sites without changing hardware.

Another advantage of the programmable feature of the machine is that we can take advantage of each new generation of digital computer components - new memory devices for example - in each new model of the reading machine, without having to redesign the heart of the technology, which is implemented in software.

We have a major development effort under way aimed at reducing the size and cost, and improving the performance of the reading machine by using advanced large scale integrated circuit technology. For example, we are designing a special computer optimized for the reading machine application. We are also working on a new speech synthesizer which will provide a more natural speech quality. We have nearly completed the design of a third model, which will be relatively portable, will provide speeds faster than human speech, and will be significantly less expensive to produce. The goal of the project is to provide a portable high performance reading machine that individual blind persons can afford within the next two to four years.

I would like to say a few words concerning the nature of the project, and of our company. We see our company as an organization devoted to developing technology in the area of computer science known as Artificial Intelligence, and applying these developments to human needs with a focus on the disabled. We believe that significant potential exists to develop computer based technology that can eliminate or significantly reduce the handicaps associated with physical and sensory disabilities. Perhaps the principle barrier to blind persons in taking full advantage of educational and vocational opportunities, has been the difficulty in accessing ordinary print. We hope the reading machine, can provide a major contribution to eliminating this barrier. We intend to develop other products which we hope will contribute to expanding opportunities for other handicapped populations.

Barry Unger will now describe our programs to disseminate the reading machine and to refine it based on this field experience.

Our first machine, which as Ray noted was installed at the Perkins School last November, received much public notice. Since then eleven other machines have been placed at field sites in seven U.S. cities. An additional thirty-five machines are being constructed for placement over the next ten months. In line with the capability for continuing on-line technical refinement that we have discussed -- the "programmability feature" -- our principle objective has been and continues to be to place reading machines in a wide variety of user settings so that the machine can be refined based on the experience of blind users. Reading is a complex activity. Print specifications differ significantly among printed documents as we have noted. The purpose of reading may also vary, ranging from skimming to intensive study. Data from a broad selection of users is helping us to optimize the machine's capability to handle the largest possible diversity of reading situations. Such information is currently being collected under programs funded by:

1. The Bureau of Education for the Handicapped, U.S. Office of Education, H.E.W.
2. The National Federation of the Blind
3. The Rehabilitation Services Administration, H.E.W.
4. The Veterans Administration
5. The Library of Congress
6. The Social and Rehabilitation Service

7. The Massachusetts Commission for the Blind
8. The Sloan Foundation
9. The Hearst Foundation
10. The Amoco Foundation
11. The Fleischmann Foundation
12. The Pew Memorial Trust
13. The Perkins School for the Blind

Mr. Chairman, we are aware of the interests of the two subcommittees represented here today in the education of the handicapped and in scientific planning, analysis and cooperation. We also know of Congress' continuing interest in and oversight responsibilities for the programs of the Executive Branch. We would like, therefore, to discuss our testing program in two areas as they relate to the concerns of these two subcommittees.

First there are our programs with the United States Government. In our opinion the most appropriate role for the federal government is to help with the transition between initial development and the final on-going and self-supporting system that will make the reading machine with related support services available to individual blind users.

Our evaluation and demonstration programs with the Bureau of Education for the Handicapped within the Office of Education, which began in July, 1975, have truly played this decisive role. The BEH program has been testing the reading machine with both elementary and secondary school blind children, including children with secondary disabilities, with some very encouraging results. After an average of 10 to 15 hours of instruction, students have become independent readers, comprehend the speech output as well as human speech, and are using the reading machine on their own to read school texts and homework assignments, to check their own typing, to read instruction manuals on the construction of such things as portable radios and musical instruments, for personal reading and many other uses.

Under this program, data is being collected at sites regarding the machine's performance on different text specifications such as type style, print, format, paper and binding; and regarding factors facilitating ease of operation such as user controls, physical configuration of the machine, and efficient maintenance. During this coming year, an attempt will also be made to measure educational impact of the machine - specifically on students, teachers, sites, curriculum, and opportunities for "mainstreaming" - or education in the least restrictive environment - and individualization of education.

We want to learn how the machine fits into existing educational programs. We also want to find out what additional new skills have to be taught as a result of the opportunities the machine opens up. For example, now that blind children can rapidly read ordinary printed materials, new skills in using regular inkprint libraries and book stores may need to be taught to accomodate their expanding reading interests.

The Bureau, and its director Dr. Edwin Martin, have been very supportive of our work, and have taken a leadership role in the prosthetics field by recognizing with our project and with others the critical need to move devices, which have demonstrated their value in the education or rehabilitation of the handicapped, out of the laboratory, and into the field.

In this regard, I am pleased to announce that a new program recently funded by the Bureau of Education for the Handicapped will place 30 reading machine in a variety of educational settings over the next year in both residential state schools for the blind and in mainstreamed public school settings. This major program will enable significant improvements in the machine to be implemented, and will develop a full educational and support system for the optimal use of the machine with blind children.

Two important programs are being funded by the Rehabilitation Services Administration (RSA) and the Veterans Administration (VA). The RSA program is focusing on improving the reading machine specifically for the vocational needs of working age blind adults. Under this program, machines are being placed in a variety of rehabilitation settings, with a focus on examining and improving the machine's use in work related applications. The VA program is focusing on the reading needs of blinded veterans. Knowing of Congress' special concern for handicapped veterans, I have brought with me to be submitted for the record an article that recently appeared in the Blinded Veterans Association Bulletin describing the installation of a Kurzweil Reading Machine at the Hines V.A. Hospital in Chicago, for use in their Blind Center.

In terms of your interest in scientific cooperation, I am pleased to be able to tell you that there has been a high degree of cooperation between BEH, RSA and the VA on the Kurzweil Reading Machine projects, both in terms of transfer funding and in sharing of evaluation protocols among the agencies and with evaluators from the National Federation of the Blind.

An important program that we would like to mention is the consumer-based formative evaluation of the reading machine that we and the National Federation of the Blind have organized in collaboration.

Social scientists emphasize that lack of understanding of the perspectives of others can inhibit our efforts to solve problems. It is essential, therefore, in our opinion that potential consumers of new products be involved in the development of these products. We have presented our ideas on cooperation between consumer and scientist in specific detail in a paper published by the American Association for the Advancement of Science in a book titled Science, Technology and the Handicapped; in light of the subcommittee's interest in science policy we are submitting a copy for the record.

The National Federation of the Blind has for the last three years advised the Company on the development of the machine. As part of the current study, the Federation is placing six reading machines in a variety of user situations - for example in the office of a blind executive, a lawyer, an engineer or scientist, or in a library for college students. On the basis of the suggestions that result, the Federation is providing guidance on ways in which the machine can be made more responsive to the needs of blind readers, through such things as additional user controls and improved physical configuration. Testing under this program began one year ago, and consumer feedback has led to many valuable improvements to the machine., For example, the Federation stressed the importance of reading xerox copies in a work situation. As a result of this suggestion, a contrast enhancement feature was implemented to handle photocopies. Other examples include the new italic capability and the improved handling of columnated page formats such as is found in magazines.

The Federation's testing program incidentally has been designed and implemented by its own blind scientists, engineers and teachers.

We are submitting for the record a short article from the Federation's monthly magazine The Braille Monitor describing the progress of their testing program. As the article points out, use of the Kurzweil Reading Machine is on an 18 hour per day basis. I am pleased to say that all of the field sites are making very extensive use of each reading machine and that over 100 users have been trained and are using the machine on a regular basis.

STATEMENT OF RAYMOND KURZWEIL, PRESIDENT, KURZWEIL COMPUTER PRODUCTS, INC.

Mr. KURZWEIL. OK. I'd like to use the brief time we have to just describe very briefly the machine that we've developed. I'll give you a demonstration of it, and Barry Unger will mention some of the programs we have to disseminate the machine in the field.

We have 12 machines in the field right now in very active use. There are two machines here.

The Kurzweil reading machine for the blind is a device designed to——

Mr. SCHEUER. Is that where you watch this thing, from the other side?

Mr. KURZWEIL. Either side is fine.

Mr. SCHEUER. All right.

Mr. KURZWEIL. It's a device designed to convert printed material to spoken word speech to enable blind students and adults to read ordinary printed material. This has been a major problem, and particularly in mainstreaming visually handicapped children, because they can't read the same textbooks or printed materials as the sighted hearers.

The device——

Mr. SCHEUER. How fast does it reproduce the spoken word?

Mr. KURZWEIL. I'll demonstrate it for you right now.

The student places the printed material face down on this glass plate [demonstrating]. A book could also be used, and is held in place by this book holder. It's operated with a control panel. If I press the page key a small camera begins searching for the first line of text. You can see that going back and forth. Once it finds it, it begins reading it out.

Now, it takes a little time to get used to the speech.

[Demonstration.]

Mr. KURZWEIL. Let me slow down the speech rate. You might understand it a little bit easier.

The machine said it can see no next line.

As you can see, there are many user controls that enable——

Mr. SCHEUER. We've had a quantum jump forward in congressional hearings when the computer testifies. [Laughter.]

Mr. KURZWEIL. You said I couldn't read my testimony.

Mr. SCHEUER. We may have a harder time stopping the computer. You have to pull the plug.

Mr. KURZWEIL. It's not very good at answering questions, though. It is able to back up——

Mr. SCHEUER. Well, I suppose in the future the computer will be programed to answer questions. As a matter of fact, it is now. I've seen computers that answer questions.

Mr. KURZWEIL. Some questions.

The machine is able to go back and repeat words or spell words out. If you don't understand a particular word, you can go back and go letter by letter and have it spelled out.

Mr. WELLS. Mr. Kurzweil, the demonstrations last week and the other similar equipment I've seen of this sort always use a male voice, whereas the——

Mr. SCHEUER. Is the computer a male chauvinist pig? [Laughter.]

Mr. KURZWEIL. We're working on a female model.

Mr. WELLS. What I'm getting at is most reporting services, telephone inquiry services, have gone to the use of the female voices because they're more understandable to the vast majority of the population.

Mr. KURZWEIL. It turns out, if you look at the format structure of male and female voices that the male voice is simpler and easier to reproduce. We are working on a new synthesis system that will have a more complex voice and the high pitch might sound more natural.

Mr. WELLS. And more understandable.

Mr. KURZWEIL. Right.

After a few hours of use, the reading machine voice is as easy to understand as human speech.

Over a hundred people have been trained to use the machine and are able to comprehend it with no problem at all.

Mr. SCHEUER. How fast could you speed that up to? The normal human voice is what, 125 words a minute?

Mr. KURZWEIL. I ran it at slow speed, since you haven't heard it before.

Mr. SCHEUER. But for a trained person——

Mr. KURZWEIL. You can go on this model to 150 words a minute.

Mr. SCHEUER. Normal human speech would be about 125-to-150 words a minute.

Mr. KURZWEIL. Right now it goes up to normal speed. We have a new model which will be available this summer which will be significantly smaller, relatively portable, and will go up to about 250 words a minute. It's variable. A person would start off with a slow speed, but could work up to compressed speech speed——

Mr. SCHEUER. Could you do the kind of thing with this speech that they teach you to do with speedreading so you could hear speech that was at the rate let's say of 1,000 words a minute?

Mr. KURZWEIL. Well, this new model will go up to 250. Experiments with compressed speech show that people can understand it up to 250, 300 words a minute. After that it becomes a little bit difficult to understand.

Mr. SCHEUER. Well, of course, 300 words a minute is more than twice the rate of normal human speech.

Mr. KURZWEIL. That's a good reading speed.

Mr. SCHEUER. Yes. It's not a bad reading speed.

Mr. KURZWEIL. As I mentioned, we have a new model which will be finished in about nine months that'll be quite compact and portable; it'll be much faster; it'll have a more natural speech quality, and it'll have a number of other improvements.

Mr. SCHEUER. And you could put any newspaper, magazine, technical journal——

Mr. KURZWEIL. Any reasonably well-printed material.

Mr. SCHEUER. Does it turn the pages, or do you have to do that?

Mr. KURZWEIL. You have to turn the pages yourself. Of course, we're conducting quite active research to make the machine easier to use and expand its capabilities, and so on, and also to place machines—Barry might want to mention a few words about the programs we have to disseminate it. Barry?

Mr. UNGER. I'll try to be brief.

Basically, we placed our first machine in the field with the Perkins School for the Blind last November. Since then, 11 other machines have been placed in the field in 7 U.S. cities. An additional 35 machines are now being constructed for placement over the next 10 months

The purpose with these machines, as with the past machines, has been to sort of focus on continuing technical refinements on the machine by gaining information on the needs of people in different situations. We have settings—public school settings, working blind adults in offices, professional situations.

We've received funding from many different Government and private agencies.

Mr. SCHEUER. Would this be adaptable to kids who are not blind, but who have some sort of reading disability like dyslexia?

Mr. KURZWEIL. There's some experimentation going on now in public schools with the Bureau of Education for the Handicapped, placing the machine and testing it out with other exceptionalities besides blind.

Mr. SCHEUER. Which?

Mr. KURZWEIL. Learning disabilities, dyslexia, and so forth. It is another potential application, particularly as a remediation device, rather than a substitution for reading. For the visually handicapped, the device would be actually used as a primary source of access to ordinary printed material.

Mr. KILDEE. Mr. Chairman, on this—it's taken awhile to develop this to this point, but would you still consider this a first generation in the development?

Mr. KURZWEIL. Well, this—the project's been going on for 10 years. This is a finished production unit, and we've got machines in the field which are being used, many of them on an around-the-clock basis.

Mr. KILDEE. It's finished production, but——

Mr. KURZWEIL. There will be other improvements. We've been working about a year on a new model which will be—the main advantage will be that it's quite portable and inexpensive. We expect the machine will be available for well under $10,000 within a few years. And we hope to make a portable model within the economic reach of individual bind persons available very quickly.

So that improvement, getting smaller and getting it less expensive, is the major goal of our research right now.

Mr. KILDEE. That's all I have.

Mr. UNGER. I just want to say that in light of the comments made earlier by Mr. Birch and also by Mr. Herman, right now we're starting a new program which was just funded by the Bureau of Education for the Handicapped, which will place 30 machines in a variety of educational settings over the next year, and this will be in both residential State schools, and also in mainstream public schools.

I think this really addresses the issue of the Government's role in going from the research stage to the widespread dissemination stage. As a result of this kind of program, not only will there be significant improvements in the machine, but there will also be—will develop a full educational and support system, including the curriculum material. the learning material. As we introduce the machine to the students, this is the sort of thing that will bridge the gap between—that Mr. Birch referred to—between the development of the machine and the widespread dissemination.

Mr. SCHEUER. OK. Again, I'm going to have to use the hook here.

Mr. KURZWEIL. We will be demonstrating the machine after the hearing, if anybody wants to get a more detailed——

Mr. SCHEUER. Very good.

Dr. SWANSON. We sent out a "Dear Colleague" letter to people in the House, and they'll be by.

Mr. KURZWEIL. Thank you.

Mr. UNGER. Thank you, Mr. Scheuer.

The third witness is Dr. Jeffrey Nelson, vice president of Telesensory Systems, Inc., of Palo Alto, Calif.; and Mr. Vito Proscia, also vice president.

Dr. SWANSON. If I might add something, Mr. Chairman——

Mr. SCHEUER. Can you step forward?

Dr. SWANSON. All the devices will be on display this afternoon after the close of the hearing until approximately 4 p.m., so——

Mr. SCHEUER. And will there be people here to explain them?

Dr. SWANSON. Right. The people who brought them will explain them.

Mr. SCHEUER. Very good.

We sent out a "Dear Colleague" letter to all Members of Congress, and we hope that some of them will be stopping by.

[The prepared testimony of Mr. Nelson is as follows:]

Chairman Scheuer, Members of the Sub-Committee on Domestic and International Scientific Planning, Analysis, and Cooperation, and Members of the Sub-Committee on Select Education:

My name is Geoffrey Nelson. With me today is Mr. Vito Proscia; both of us are Vice-Presidents of Telesensory Systems, Incorporated, of Palo Alto, California. Before describing Telesensory System's work in the field of the handicapped, let me first give you a brief background on the history and areas of interest of TSI.

TSI was incorporated in 1970 in Palo Alto to manufacture and distribute the Optacon, a print reading aid for the blind. The Optacon, which is an acronym for OPtical to TActile CONverter, was developed in eight years of research in the integrated circuit laboratory of Stanford University, and at Stanford Research Institute. Using the latest developments in integrated circuit technology, the Optacon was made small enough to be completely portable and inexpensive enough to be individually owned. Word of TSI's Optacon spread quickly, and as a result there are now almost four thousand Optacons being used by blind people in over forty countries world-wide. TSI is now recognized not only for its technological expertise, but also for its ability to identify, educate, and support a very specific handicapped end user with a complex high-technology product, in a climate of limited funding. Since TSI's modest beginning, the company has grown to a current level of employment of nearly 150 people with several product lines. Our present principal devices are sensory aids for the blind, but our general area of interest is high-technology aids for the handicapped.

I should point out at the outset that, while important, high-technology devices such as the Optacon and other new developments do not alleviate one of the most serious consequences of blindness: social attitudes of the public about the blind. The educational process, we feel, should not be limited to helping the handicapped, but also should include education of the public about the considerable abilities of the handicapped.

It is also important to recognize that manufacturers and other professionals should not be the only inputs to the design of programs and devices to assist the handicapped. TSI strongly supports the concept of consumer involvement in these programs, particularly at the very initial stages. In this way, with a cooperative effort between consumers, government, and manufacturers, cost effective, meaningful devices and programs will result. TSI welcomes, even solicits, the involvement of the organized blind in our early design stages and favors legislation which would institutionalize such consumer involvement.

A recent development which we feel will have great impact on the education of the handicapped, is the "microprocessor", which is a low-cost form of mini-computer. A microprocessor is essentially the entire central processing unit of a computer on a single integrated circuit, or chip. It is a member of the family of large-scale integrated circuits that reflect the present state of evolution of a miniaturization process that began with the development of the transistor nearly three decades ago. In conjunction with other electronic components, microprocessors are currently revolutionizing such diverse areas as manufacturing process automation, jet aircraft, automobiles, machine tool control, video games, microwave ovens, refrigerators, telephones, burglar alarms, and high fidelity sound systems. These devices make possible far more sophisticated processes and controls than have ever been economically feasible before.

Microprocessors are playing a similar important role in Telesensory Systems research and development processes in new product areas for the handicapped. TSI is perhaps the only company in this field with the necessary technical skills in both hardware and software to take advantage of the advent of microprocessors. Telesensory Systems already has one product on the market that is built around a microprocessor. This device is our Speech Plus, a talking calculator for the blind. In a few moments, my colleague, Mr. Proscia, will describe how this microprocessor-based product has already had a substantial impact on the education of the blind. In addition, in the near future, we expect these miniature computers to revolutionize braille, and to greatly enhance the reading capabilities of the blind. Telesensory Systems is conducting active research projects in all of these areas. Let me now permit Mr. Proscia to describe two of these: the Speech Plus calculator that I mentioned earlier, and our work in the computerization of braille.

****

Chairman Scheuer, Members of the Sub-Committee on Domestic and International Scientific Planning, Analysis and Cooperation, and Members of the Sub-Committee on Select Education:

My name is Vito Proscia and I am a Vice President of Telesensory Systems, Incorporated (TSI) of Palo Alto, California. For approximately a decade, I have been involved in sensory aids technology for the blind--the first four years of which I spent as the Director of the Sensory Aids Evaluation and Development Center at Massachusetts Institute of Technology and succeeding years as Vice President of Sensory Aids Programs at TSI. In addition, I am a member of the Board of Trustees of National Braille Press of Boston and Sensory Aids Foundation of Santa Clara County, California. My primary responsibilities at TSI have been to establish dissemination programs for its products and to help identify and coordinate new product concepts relating to the unmet needs of the blind.

An example of a microcomputer-based product which will soon fulfill a very important role in the educational process of blind children is the TSI Speech Plus Talking Calculator. In the past, blind children have found it difficult coping with, handling, or exercising numerical functions or numbers because of the limited methods and apparatus used in dealing with mathematical problems. Working with decimals and nonlinear functions is particularly difficult for the blind, and is now more manageable because of the introduction of the Speech Plus Calculator. The American Printing House, a federally aided corporation which is the largest distributor of educational aids for the blind, is presently distributing a modified Speech Plus calculator which has been designed especially for the needs of blind children. The American Printing House is finding a great demand for this calculator, and it is expected that the calculator will hold great promise in classroom use.

(Demonstration of Speech Plus).

Even though Braille is very important to blind people in that it is the major writing method and an important reading method, Braille has not benefited sufficiently from our space-age technology. Recently, TSI has initiated a new project which has the objective of extending the usefulness of Braille utilizing modern technological advances. Research and development are underway on efficient, silent, electronic Braille displays which can be integrated into various systems involving keyboards, tape cassettes, solid state memories and microcomputers. These "Paperless" Braille systems will reduce the bulk required by paper Braille, make publication, storage and retrieval less expensive, and simplify and increase the convenience of writing, editing, and indexing without reducing reading speed.

The product of particular interest to the education of blind children is the Paperless Braille Read/Write device. Braille can be produced by storing it on a cassette tape either by direct keyboard action or through the use of a computer. Approximately one cubic foot of Braille paper reading material can be stored on a single cassette. The Read/Write system presently under development will be approximately the size of a Library of Congress Talking Book cassette machine. (Illustration of Read/Write system).

The Read/Write device will be portable, battery operated and will include some of the following applications:

1. Terminal for computer aided instruction for blind children
2. Braille teaching machine
3. Braille writer, note taker
4. Literary Braille reading machine
5. Audio playback and record
6. Communicator for the deaf-blind including telephone communicator
7. Dictionary look-up in Braille and voice
8. A filing or record-keeping system
9. Attachment for a selectric style typewriter, calculator or computer

The most important feature of Braille to a blind person is the ability to read and write. Presently, no device exists which allows a blind person to read and write silently and efficiently in the classroom. The addition of a microcomputer to this device expands its capability with respect to searching, filing, indexing and retrieving information. The compactness and portability of the Read/Write device will provide the user with convenience and expanded utility with respect to educational advantages and vocational opportunities.

****

Vito has just described two microcomputer-based projects at TSI, both of which will soon have considerable impact on the education of the blind. Next, I'd like to describe what is our most intensive engineering effort at Telesensory Systems, namely, a spoken word output reading system for the blind. The objective of this research is to extend the usefulness of the Optacon by allowing more rapid reading rates and reduced training requirements. As early as 1968, even before the formation of TSI, work performed by members of current research staff demonstrated the usefulness of speech reading systems. We are now developing a system which can be used in either of two ways: first, as an accessory to the present Optacon building upon the print scanning capabilities of thousands of present-day Optacon users, and secondly as a completely independent automatic reading system. Under partial funding from the National Science Foundation, we have performed fundamental research which shows promise towards what will ultimately be a portable and personally affordable production unit. I would like to play a taped sample of the speech technology that will be incorporated into the production unit.

(Playing of tape).

As the computer explained, this sample speech is what a blind user will hear from TSI's reading system. The Text-to-Speech System which the computer used to synthesize this particular speech is based upon years of research at the Massachusetts Institute of Technology. The electronic system which produced the speech was larger than would be practicable in a portable reading system. Moreover, this system does not currently operate in what is called real time which will be essential in a practical reading machine. However, under partial funding from the Seeing Eye Incorporation, we are hard at work on transforming this laboratory system into special purpose, state of the art, electronic hardware, incorporating extensive use of microprocessors. We expect the final system to be both small enough and fast enough for a practical reading system.

The implications of such a system on the educational process of the blind are enormous. Such a system will not only enhance the availability of ordinary classroom materials for blind students but also reduce the need for sighted reader support, facilitating the mainstreaming of blind children into the educational system. TSI's Optacon, in its present form, has already made significant contributions to this mainstreaming process through a program funded by the Bureau of Education of the Handicapped, in the Office of Education. This three-year program, which involves the establishment of graduate teacher preparation programs at 22 universities and the dissemination of the Optacon to several hundred school children throughout the country, is currently about half complete and has been very well received. We expect the spoken output reading system to extend the reading abilities of blind children even further.

Two questions we are frequently asked are: how much this machine will cost, and when it will be available. Both of these are difficult questions for us to answer at this time. However, we are fully committed to a design goal of a price that will permit personal ownership of this machine. To TSI, this means that the price must be under, and probably well under $10,000. While this price is still very high to most of us, it is important to realize that this machine will allow a blind person to be more nearly competitive with his sighted peers in terms of reading, and this in turn implies that the educational and vocational applications of such a reading device are enormous. If you consider that such a system will mean a great improvement in a blind person's lifetime earning power, the original cost of the machine becomes less of an obstacle.

As to the question of when the machine will be available, we expect that we will have a production version approximately 24 months from today. We now have operational laboratory versions for testing and developmental processes in our research facility in Palo Alto.

Mr. Proscia and I have discussed TSI's use of computers to aid the handicapped in three areas: the Speech Plus talking calculator already on the market, an extensive development project in the area of electronic braille production and reproduction, and our research on a spoken word output reading system. But, what role, if any, should the Federal Government play in these devices? Telesensory Systems has several specific recommendations in this area.

First, the Rehabilitation Services Administration is currently precluded by law from funding any activities, including development of devices of these types, to private industry. There is no such limitation in the educational legislation sector. Yet the Office of Management and Budget[1] has recently expressed the Government's general policy of reliance on the private sector for needed goods and services. Telesensory Systems actively supports House Bills HR 7735 and 7736 and Senate Bill 1905, all of which remove this funding restriction from RSA legislation.

Secondly, it is essential, particularly in the educational and vocational aspects of such devices, that the Federal Government play a principal role in the dissemination process. Because of the limited market for such high-technology products, the prices to the handicapped consumer are unfortunately higher than any of us would like, and thus federal funding is important if such technology is to become effectively used on a wide basis. Existing federal legislation is in the right direction but a more aggressive approach by both the legislative and executive branches would greatly improve the process.

Our third recommendation is to suggest that the Federal Government should play an active role in the development process. Historically, most devices of this sort have failed to reach the marketplace because the market size for devices for the handicapped does not in general support the extensive development monies required to bring such products to fruition. All private industry must of necessity view each project from the point of view of its financial merit, and most products for the handicapped fail that test. However, with federal support for the development process, the manufacturing and dissemination of such devices at a reasonable price becomes much more realistic. We have developed a financial analysis which I would like to include in the record, which shows that the Federal Government receives more in tax dollar revenue from the employment of people using these devices, than it pays to private industry to support the development process.[2] In other words, it's an "everybody wins" situation: private industry has a financially viable product, the government succeeds in educating and rehabilitating handicapped people with a positive cash return, and most important, the handicapped individual lives a more productive and satisfying life.

Thank you very much. Mr. Proscia and I would be happy to entertain any questions at this time.

---

[1] OMB Circular No. A-76

[2] Attached letter of September 20, 1977, to IEEE Spectrum

TELESENSORY SYSTEMS, INC.

3408 Hillview Avenue
Palo Alto / California 94304
Telephone 415/493-2626
Telex 348352

September 20, 1977

Ronald K. Jurgen, Editorial Director
IEEE Spectrum
445 Hoes Lane
Piscataway, NJ 08854

Dear Ronald:

Two recent Spectrum articles (September 1976, pp 45-49, and November 1976, pp 37-40) have discussed the great need for application of science and technology in the service of the physically handicapped. This need is being recognized as a Government concern, especially in carrying out Governmental roles in education, rehabilitation, and welfare. Indeed, in many cases, the application of science and technology in this area will be cost-effective both in reducing costs to the Government and in doing a better job. However, except in a few cases in which Government has participated in research and development, very little science and technology has been utilized in the handicapped field. There is a growing awareness that more needs to be done.

These points are clearly illustrated in a recent report from the National Research Council entitled, "Science and Technology in the Service of the Physically Handicapped". The following quotations are relevant:

Pages 3 - 4: Findings and Recommendations

"The introduction of technological advances to aid the handicapped usually requires a continuing effort that initially may be close to basic research and that progressively (in a gradual or stepwise fashion) moves to the stage of practical utilization. For products to aid the handicapped, industrial participation is often not available in the middle stages of product development because of limited size and high risk of market failure.

4. Therefore, it is essential to support research and development efforts at all stages of this process, not only at the two end points. Mechanisms should be investigated which would allow Government to participate in the support of middle stages of product development to establish clinical and economic feasibility up to the point where industrial participation can be enticed".

Of necessity, a company must view its involvements in new product research and development in financial terms. Because of the small market size, it is very difficult to find investments in the handicapped field which offer attractive return. Nevertheless, new products for handicapped, especially those providing job opportunities, can repay society in terms of dollars and cents.

A simple hypothetical example may illustrate the above points. When considering a new product, a company will estimate the R & D costs and project expected sales and revenue. Expected rate of return on investment will then be determined and compared to company standards. Figure 1a illustrates such an analysis for a low volume product requiring $200,000 R & D investment and having expected sales of $2 million over a four-year period. When taxes are accounted for, a net cash outlay of $100,000 results in an equal total return. This is clearly an unattractive investment for the company (better to put the money in the bank!) and will not be undertaken.

If one does a similar cash flow analysis from the Government's point of view, the situation is quite different. The Government's investment, as shown in Figure 1b, is $100,000 tax revenue loss. Besides receiving corporation income tax in return (estimated at 50% of profit), the Government receives individual income tax income. This income comes from payroll tax on the incremental labor to produce the product and payroll tax on the income from jobs opened up to the handicapped. In the example, only 10 new jobs per year are assumed to be created by the 500 units sold. As a result, the Government receives an attractive $310,000 in return for its $100,000 investment. Moreover, if the equipment removes people from public assistance, the net return will be even larger. Unfortunately, these benefits will not be realized, since the company will not invest in the product because of a meager return.

Figure 2a and 2b illustrate how the analysis changes if the Government elects to invest $100,000 in the research phase of the product. The Government's return is reduced, but the company's is correspondingly increased. Both parties receive a doubling of their investment, and a rate of return greater than 25%. Everybody wins, most importantly the handicapped consumer who benefits from the product.

Unfortunately, Title II of the Rehabilitation Act of 1973 does not permit Federal assistance to private, profit making agencies and organizations. This fact essentially prevents the Government/industry cooperation described above and locks private industry out of participation in much of the research and development on devices to aid the handicapped in this country. Yet private industry must become involved before these devices can be made available to handicapped individuals. This situation also explains why many developments never get out of the universities and non-profit institutions.

Rep. Olin E. Teague, Chairman of the Committee on Science and Technology in the U.S. House of Representatives, has introduced a bill (HR 7735 and HR 7736) in the House which would correct this situation. This bill simply authorizes Federal assistance to private, profit making agencies and organizations under Title II of the Rehabilitation Act of 1973. Support of this bill is needed. Can IEEE help?

Sincerely,

James C. Bliss

JCB/jms

James C. Bliss, Ph.D.
President

Figure 1 HYPOTHETICAL CASH FLOWS FOR AN INVESTMENT IN THE HANDICAPPED FIELD - NO GOVERNMENT SUPPORT

ASSUMPTION: $200,000 R & D Initial Investment
2000 units sold for $1,000 each over 4 years
500 per year at 10% pre-tax profit

a) Cash Flow for Company

Year	Expense	Tax Saving	Net Cash Out	Profit	Tax	Net Cash In
0	($100K)	$ 50K	($ 50K)			
1	($100K)	$ 50K	($ 50K)			
2				$50K	($25K)	$ 25K
3				$50K	($25K)	$ 25K
4				$50K	($25K)	$ 25K
5				$50K	($25K)	$ 25K
	Total		($100K)			$100K

b) Cash Flow for Government

Year	Tax Revenue Loss	Corporation Tax Income	Company Payroll Tax Income[1]	Payroll Tax Income from Jobs Created[2]	Net Cash to Government
0	($50K)				
1	($50K)				
2		$25K	$15K	$15K	$ 55K
3		$25K	$15K	$30K	$ 70K
4		$25K	$15K	$45K	$ 85K
5		$25K	$15K	$60K	$100K
Total	($100K)				$310K

[1]Assumes labor cost per unit = $200 and Payroll Tax @ 15% (including FICA)
[2]Assumes 10 jobs created per year at $10K and 15% Payroll Tax

Figure 2 HYPOTHETICAL CASH FLOWS FOR AN INVESTMENT IN THE HANDICAPPED FIELD WITH GOVERNMENT SUPPORT OF R&D

a) Cash Flow for Company

Year	Expense	Tax Saving	Net Cash Out	Profit	Tax	Net Cash In
0	- 0 -	- 0 -	- 0 -			
1	($100K)	$50K	($50K)			
2				$50K	($25K)	$ 25K
3				$50K	($25K)	$ 25K
4				$50K	($25K)	$ 25K
5				$50K	($25K)	$ 25K
	Total		($50K)			$100K

b) Cash Flow for Government

Year	R & D Support	Tax Revenue Loss	Net Cash Out	Corp. Tax Income	Co. Payroll Tax Income	Payroll Tax Inc. from Jobs Created	Net Cash to Government
0	($100K)		($100K)				
1		($50K)	($ 50K)				
2				$25K	$15K	$15K	$ 55K
3				$25K	$15K	$30K	$ 70K
4				$25K	$15K	$45K	$ 85K
5				$25K	$15K	$60K	$100K
	Total		($150K)				$310K

STATEMENT OF GEOFFREY NELSON AND VITO PROSCIA, VICE PRESIDENTS, TELESENSORY SYSTEMS, INC.

Mr. NELSON. Fine. Thank you very much.

Let me just briefly acquaint you with Telesensory Systems, (TSI) because it is a unique company, and I think it will serve as good background material. Telesensory Systems was founded in the early 1970's by a group of researchers at Stanford University and SRI, who were involved in the development of the Optacon, which is a device for tactilely reading printed material. In other words, it's a sensory aid for blind people.

The device has been developed and has continued to be developed, over the last several years and has now been disseminated partially with Federal assistance to nearly 4,000 people all over the world.

TSI has grown to about 150 people, and several products, all of which are devoted to the handicapped field. And so far, all of our product lines are in the area of blind people.

When the Optacon, which is the reading machine, was in development, computer technology was not sufficiently advanced to permit any kind of personal ownership. That picture has changed very much in the last few years.

Now there are microprocessors, which are basically minicomputers, available at very inexpensive prices. These devices we are now incorporating into a number of products, all of which are aimed at the handicapped field.

The first of these is the Speech-Plus Calculator, which is currently on the market. I'd like to ask Mr. Proscia say a few words about Speech-Plus. Vito?

Mr. PROSCIA. Chairman Scheuer, I am a blind person who's attempted to make a professional career. It's very difficult in 5 or 6 minutes to explain to the committee the problems that blind people are facing. Particularly in the educational environment things are improving, but we have a long way to go before we're able really to solve many of the problems.

I am trained as an engineer. I graduated from CCNY and Columbia University and Brooklyn Poly in the early 1950's. Early in my professional career I applied my talents to the defense of our country in the aerospace industry.

But about 10 years ago I decided that perhaps I could use these talents to look into devices for the blind, in particular. After being at MIT for a number of years on the faculty and in the laboratory at the Sensory Aids Evaluation and Development Center, I felt that it was very appropriate that the commercial world should be involved in, not only the development, but dissemination of, devices for the handicapped.

I think the best way to illustrate this is to show you what we have. One of the problems seriously facing blind people is the use of arithmetic.

What Telesensory Systems has done is to develop a calculator that talks; we call it a Speech-Plus Calculator. This calculator here has a special interest because it's been modified from our standard calculator to be used in the classroom by blind children.

And, just to illustrate this, when I pull the switch the calculator clears itself. [Demonstration.]

Every time I press a key on this calculator an announcement [illegible] be made as to exactly what I've depressed. This calculator [illegible] been made possible because of the state of the art of microcomputer [illegible].

To give you an example of how a person would use a device [illegible] sort, and particularly in the classroom [illegible] illustration. As a mathematics [illegible] rate down. As the child is listening to the answer, he could [illegible] it in the braille [illegible].

So that is a typical example of how a microcomputer technology could be applied to the needs of a very highly specialized [illegible]. It does fulfill an unmet need in the classroom.

Dissemination is a serious problem in the devices [illegible] we have been able to cooperate with a federally aided corporation, the American Printing House for the Blind, to disseminate and distribute the Speech-Plus calculator.

In fact, the demand for the calculator [illegible] very interesting [illegible] business meeting recently and a statement by the executive director of the American Printing House [illegible] knowing that the availability of the device [illegible] about a hundred calculators [illegible].

This [illegible] a very interesting example of how a device developed by industry [illegible] applicable to the needs of handicapped people. [illegible] have an [illegible] eventually will have [illegible] vocational [illegible].

DR. SWA[illegible] [illegible]

MR. [illegible]

DR. SWA[illegible] [illegible] the [illegible]

MR. [illegible]

DR. [illegible]

MR. [illegible]

DR. SWA[illegible] [illegible] that to [illegible].

MR. [illegible] the nature of [illegible] handicapped [illegible] the market [illegible]

MR. [illegible] there in the room [illegible]

[illegible] people who [illegible] people who [illegible] far greater than available [illegible]

[illegible]

[illegible] postdoctoral [illegible]

[illegible]

[illegible]

[illegible] reading [illegible]

MR. [illegible] arithmetic [illegible]

[illegible]

MR. [illegible]

[illegible] problem [illegible] funding [illegible] the market [illegible] one of the recommendations [illegible] that TSI would strongly make, by the way, is that the Federal Government adopt a more aggressive role, not only in the dissemination process, but also in the development process.

As you can appreciate, any business enterprise has to view proposed new products in financial terms, as well as in humanitarian terms. And the difficulty with that is that most products for the handicapped fail that test.

We've developed an analysis which is included as part of our testimony for the record, which shows that if the Federal Government sponsors the development, even with private industry sharing the other half, the Federal Government receives more back in tax revenues, both from corporate income tax on profits for the product, as well as income taxes on the people who are employed as a result. The Government receives more back in tax revenue than it spends in development.

If the Federal Government offers funding for development, that makes it much more possible for private industry to view things more favorably in a financial sense.

Mr. SCHEUER. It seems to me that you could make an awfully good case that something like this could radically improve a blind person's capacity to earn and function as an independent person

Mr. NELSON. Well, that case we do try to make.

Mr. SCHEUER. Or loan it to the blind person for $1 a year, something of that kind.

Mr. NELSON. There is already legislation within vocational rehabilitation which does facilitate this.

The difficulty is that the legislation is interpreted by the State departments of educational rehabilitation throughout the country, and in greatly varying degrees. Some States are very progressive in this area, and other States are very restrictive. So it comes down largely to a question of the State policy.

Mr. SCHEUER. Let me announce that we've been joined by two of my colleagues, Jim Jeffords of Vermont and George Miller of California; and Dale Kildee, of course, who is going to take over the chair in about an hour. So we have four very much interested and involved Congressmen.

Why don't you let us start asking you questions now? May we?

Mr. NELSON. Sure. We have another device we'd like to show you, as well.

We have with us today Mrs. Carol Gillespie, who is a local resident, and who is an Optacon user. We will ask her to demonstrate the Optacon.

This is the Optacon here [demonstrating]. As you see, it's small and compact, portable. And, after she's demonstrated it, I'd like to tell you just quickly what our plans for the future are with regards to the Optacon.

Mr. SCHEUER. Is this young lady blind?

Mr. NELSON. Yes, she is. She's reading some material which she brought with her.

Ms. GILLESPIE. Usually I would be reading, putting the material on the table.

[Demonstration.]

Ms. GILLESPIE. The Optacon is taking a picture. This is the camera part of the Optacon, and when I turn it on it takes a picture. It takes a picture of the printed letter. And, through the converter, which is this wire, it converts the picture into tactile material--it's not braille, but a raised printed letter so I'm getting the shape of it.

Mr. SCHEUER. The regular printed letter?

Ms. GILLESPIE. Right. A circle would be "O."

Mr. NELSON. We do have a visual display by which we could show you what she's feeling.

Mr. SCHEUER. How many words a minute can you read?

Ms. GILLESPIE. I think probably 50 or 60.

Mr. NELSON. I have here a visual display, which is simply a device which displays what she is feeling under her finger.

Ms. GILLESPIE. Now normally, when I use the Optacon I don't use the visual display.

Mr. NELSON. I'll hold this up here so you can see it. The display is simply a device for demonstration.

What you see is what she is feeling under her index finger.

Mr. GILLESPIE. I'll display the capital letters so I can demonstrate that if these letters were very large, it is very difficult to read for a blind person, because my fingers cannot feel the entire letter. On the camera is a zoom lens with which you can either make the letters larger or smaller.

Now, if I were to go to the small letters—there's a capital "I" and the small "i".

Mr. SCHEUER. Can you read at that pace?

Mr. NELSON. She's reading it now.

Mr. SCHEUER. I can't begin to read it that fast. I guess you practice.

Ms. GILLESPIE. There's the "if." There's the "y," the "o," and the "u"; "v-i-s-i-t," and capital "A"-"m"—"American cities."

One of the reasons why I like this machine is that braille is very difficult to use. The Optacon adjusts so that you can adjust the intensity of the rods and the vibrations of the rods in the pins and so read more efficiently. The Opticon has opened many doors to me, because I never read print. I've been blind since birth.

I went to college using just braille, and cassettes. The Optacon has given me not only independence but a sense of privacy. I no longer have to have someone reading my phone bills and saying, "Gee, you made two calls to California, and you made—who do you know in Houston, Tex?"

I work with students, and I think the Optacon will increase the spelling ability of students.

Mr. SCHEUER. Were you here when there was a demonstration of the Kurzweil reader, and the computer spoke the printed word?

Ms. GILLESPIE. Yes.

Mr. SCHEUER. Now, there, apparently the speech rate got up to 250 words a minute, as compared to your 60. How would you compare the attractiveness of those two modalities to you?

Ms. GILLESPIE. I've never actually seen the Kurzweil reading machine, but I would probably like to use a combination.

Mr. SCHEUER. Now elaborate on that.

Ms. GILLESPIE. I wnet to a school for the blind, and then went to public school, and then went to college in New Haven, Conn. If one were to go through the English literature—and we were assigned

18 books a semester then I would want something that would be able to read quickly.

However, there are times when things come to my desk and I just can't lug a heavy machine around with me. So I just take the Optacon. It doesn't necessarily have to run on electricity; it also runs by battery. I don't have to call on someone to check out if the page is upside down or not, because I can tell quite easily.

Mr. NELSON. Mr. Chairman, may I interject here? We do recognize the value of speech output and, in fact, we have an extensive development project underway at TSI in our laboratory in California, the purpose of which is twofold: to develop an accessory which will speak when plugged into the back of the machine, just as this visual display is, and to develop a completely scan-along system.

Mr. SCHEUER. What?

Mr. NELSON. In other words, the accessory version will use hand tracking, as the young ladys just demonstrated. The automatic version will be a completely hands-off system.

I have a very brief recording of the speech which has been developed for that, which I will play for you. I might add that this is artificially generated speech, so you may find it a little difficult to understand:

DEMONSTRATION

Chairman Scheuer and members of the Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation, and members of the Subcommittee on Select Education, this recording represents an example of electronically synthesized speech from the computer laboratory at Telesensory Systems, Inc. The scientists at TSI expect talking computers to be an important and educational tool in the education of handicapped children in the near future. It is essential that the Congress recognize the key role that Government must play in making such technology available to those handicapped individuals who can profit from it. Thank you for your kind attention.

Mr. SCHEUER. Now, is that converted from the printed page into speech?

Mr. NELSON. This is conve[illegible]ed from text into speech. It's done completely with synthesizers, completely electronically.

Our project objectives are a machine which will [illegible] available in about 24 months, which will be portable, and which [illegible]ll cost under $10,000. This is a very intensive research effort current[illegible] going on.

We don't see this as replacing th[illegible] curre[illegible] Optacon, as Ms. Gillespie has indicated. There are applica[illegible]s for both. And so it's a device w[illegible]h enhance[illegible] this type [illegible] machine, [illegible] places it.

M[illegible] [illegible]HEUER. Remarkable.

Jim.

Mr. JEFFORDS. I'm sorry. Did you give the price of the Optacon?

Mr. NELSON. With training, it's about $3,000. There's a substantial training requirement. Ms. Gillespie reads at 50 or 60 words a minute. That's above average. And, furthermore, it takes a considerable period of time, probably on the order of a year, to reach that speed.

Mr. SCHEUER. That would be an advantage of the speech approach.

Mr. NELSON. It reduces the training, and it's faster, that's right.

Ms. GILLESPIE. Training does require about approximately 50 hours.

Mr. SCHEUER. Is it difficult to keep that camera on an exact straight line as you go across the page? To me that would be very difficult.

Mr. NELSON. It is.

Ms. GILLESPIE. We start with a tracking aid. After a person learns what it is like to track using the aid then he takes it off, then he practices without it. It does take some time. It can be learned in 50 hours.

Mr. JEFFORDS. How does that break down that cost of $3,000 with part of the equipment cost with training cost?

Mr. NELSON. Well, list price for the Optacon is $2,895, and the training depends on the source. But it's usually around a few hundred dollars.

Mr. JEFFORDS. The machine cost is by far the larger part then.

Mr. NELSON. That's correct.

Mr. JEFFORDS. Now if there were a larger demand for the Optacon, would that significantly cut down the cost or not?

Mr. NELSON. Well, the problem is, again, the one I alluded to earlier, the number of people who have skills to take advantage of technology of this sort are very limited, even though there may be a legally blind figure of over 1 million people in this country. The number of people who can actually take advantage of the Optacon are on the order of tens of thousands.

The point I'm making is that there is not an enormous vast market. And so I think, as a result, we never get to the kind of volume production that the electronics industry has. We build things by the hundreds, whereas they are building by the tens of thousands. And as a result, we never get the economies of scale that are possible in the field. And as a result of that, the costs tend not to come down.

The Optacon has come down in cost. The very first Optacons were built under a contract with the Office of Education, and they ran I think about $15,000 apiece. When it was introduced on the general market, it was about $5,000. It now is down to approximately $3,000. We don't think that we're going to decrease the cost any more. This is about as far down as we can go.

Mr. SCHEUER. We've been told in earlier sessions of these hearings that the cost of computers is going to zoom down on a tremendous order of magnitude. Professor Papert, didn't you tell us last week that the computer that cost $1 million 10 years ago or $35,000 5 years ago is $500 now and will cost $75 5 years from now, something of that order?

Dr. PAPERT. That's about correct, in spirit.

Mr. SCHEUER. In spirit.

Mr. JEFFORDS. That's what I was wondering, whether there were parts of this, or something that would come down, or whether there aren't such items that will come down.

Mr. NELSON. Well, to some extent that's true. There are some general-purpose component parts. And in those cases we participate in the cost reduction that's made available to everyone.

Mr. SCHEUER. Dr. Papert, were the cost reductions that you spoke about a factor purely of technology in computer wiring and new technology, shooting amount of rays, and what-not, or was it a factor of mass production? Here there are limitations on mass production, I understand, because of the intrinsically limited market. But would they enjoy the potential of the same reduction in cost of new technology?

Dr. PAPERT. I believe they will. But you will see that, if you lift the problem of making devices for the blind out of the specific context of the blind, and see it as a systems problem in a wider context—I believe that in 5 years, in some small number of years of time, everybody will want to have talking machines. So that the cost of making that type of device which produces speech will benefit probably the mass demand of the talking machine by people who aren't blind, for other purposes.

And so I do think that in that perspective it's very difficult to see that.

Mr. PROSCIA. Mr. Chairman, I would like to point out 5 years ago I started the marketing organization of Telesensory Systems and set up a system by which we were able to expose the availability of the Optacon and our other products. The major cost the company is facing is not the manufacturing cost, but it is the cost required to disseminate and to expose the equipment to the population in which we're interested. That's a very large cost for any private organization.

It's because it's difficult to locate the marketplace with respect to the actual user. They're so widespread and few that the costs incurred in the marketing activities are really quite high. And this is, I think, one of the ways the Government, in terms of support of the dissemination, can be helpful in decreasing these costs.

Mr. SCHEUER. It would seem that blind people constitute such a small, discrete group with such a clear commonality of needs that it should be very easy to reach them by phone and by mail.

Mr. NELSON. Government records of blind persons are not available to private enterprise. Rehabilitation Services Administration is precluded from supplying any names, if I'm not mistaken.

Ms. GILLESPIE. They have the confidentiality.

Mr. SCHEUER. Well now, how many blind people would be on those lists, 1 million, 500,000, 100,000?

Mr. NELSON. 500,000 probably, or less.

Mr. SCHEUER. Wouldn't it be possible for HEW to circularize that list once to ask those people individually if they would like to waive their privilege to bona fide organizations that are producing usable technology for blind people? It seems to me if I were a blind person I would want that in order to hear from the people who have technology to help me.

Mr. NELSON. That's a good point. But you have to bear in mind that there's the additional limitation, even beyond the identification function, of the funding problem. And currently, as I alluded to earlier, at least within Rehabilitation Services Administration, there is a definite vocational need that has to be demonstrated. And that vocational need is basically one that is determined to be valid or not valid by the States, because they are the ones who administer the Federal moneys involved. The States take greatly differing views as to the appropriateness of technology. As I mentioned, some States are very progressive—the chairman's own State is extremely restrictive in this way. There are very few, if any, devices funded by some States. So it's not only a question of identifying the blind, but it's also a question of working within the governmental bureaucracy to facilitate the dissemination process.

Mr. SCHEUER. Let me say, incidentally, that Congressman Teague of Texas, the chairman of this full committee, including Congressman Brademas and I and a number of other Congressmen, have sponsored an amendment that would lift that prohibition of Government assistance——

Mr. NELSON. 77–35?

Mr. SCHEUER. 77–35, exactly. And we hope that becomes law before very long, under Congressman Teague's leadership and under Congressman Brademas' leadership.

Is there anybody from HEW here? Yes? Oh, of course. What would be the problem in canvassing the 500,000 people or so who would be on HEW's computer tapes and ask them if they would like to waive their confidentiality and have their names and addresses and phone numbers made available to private sector firms that are producing this kind of technology?

Mr. HERMAN. I don't know, but we certainly can check into that.

Mr. SCHEUER. Incidentally, we've been joined by Congressman Bob Walker of Pennsylvania, one of the very hard working and diligent members of our subcommittee.

Do any of you have any further questions?

Mr. MILLER. I have just one question.

Mr. WALKER. No questions, Mr. Chairman.

Mr. MILLER. You mentioned the potential market runs into the tens of thousands. Obviously people who are aware of it and can afford to purchase the mechanism are fewer.

What's the potential within educational institutions, university libraries or public libraries?

Mr. NELSON. We don't feel an appropriate way to provide technology of any sort is to have it centrally located. You can appreciate this if you considered being in a position of having to go to some place to be able to read. That would be a very awkward situation. So we very much support the concept of portability and personal ownership. In general, our experience with public institutions, such as libraries or central locations on universities, and so on, has been very poor.

Mr. MILLER. In other words, it would seem to me that—I mean I think that clearly, if you create portability, and the convenience of that it's very, very attractive. But it would seem to me that there's some obligation, just as they provide me a reading table in the university library or a quiet room, or whatever, when I want to use those facilities, there's some obligation to also make that library accessible to sightless individuals onsite.

Now, I appreciate the convenience aspect of it. Everybody can have their own machine, and that would be very well for your market. But I'm asking would you view—or do you talk to people about what is their obligation, in fact, in the case of the university or school library to make that facility readily available onsite for people.

Mr. PROSER. I think there's an overall important concept that we have to be aware of, and which is a goal of the Telesensory System, I think what's important is that what we would like to do is not introduce a piece of equipment which would obsolete some other form of communication for the handicapped. What we would like to do is develop a family of products that would allow the individual an alternative, a selection, something that would meet an immediate utility of some sort. For example, I'd like to have available to me as a blind person, not only an Optacon, but the spoken word output with regard to the Optacon, because there are instances that I am required to read long passages.

Mr. MILLER. Nobody's arguing with that. But if you're also riding public transit or you're going great distances, you may not want to have the obligation to take the mechanisms back and forth with you. You may want them in your home, but if you also decide that you're going to spend Saturday in the library, why should the library be closed to you because you're sight-impaired?

Mr. PROSCIA. I agree. And that's an alternative that I would like to personally see happen. In other words, there should be centralized systems, and there should be personalized systems.

Mr. SCHEUER. Is most of the blind population in this country located in metropolitan areas?

Mr. NELSON. Yes.

Mr. SCHEUER. So they would have convenient access to a public library?

Mr. PROSCIA. Yes.

Transportation always is a problem. In other words, independent travel is another problem that technology is trying to address itself to.

Mr. MILLER. What I'm saying is in the district I represent we have a very large project known as the Center for Independent Living in Berkeley, to have for blind students to have their own apartments, to become independent, to be able to go to part-time jobs, and be able to go to the junior college which is 15 or 20 blocks away.

It seems to me that they ought to have the opportunity to also leave their apartment, not have to lug this equipment at night—and I don't know. This one's very convenient, obviously, in terms of size and so forth—but to go over to the junior college and to study at night, and have a facility on a publicly funded campus for their convenience and their use.

Mr. PROSCIA. I agree with you, but you don't limit it to that.

Mr. MILLER. No, no. I'm not suggesting you limit it to that at all. I think that the idea of a personal system is fantastic, and the interchange of systems is fantastic.

But I'm saying some people won't ever be able to go for that, and just to give them the same sort of accessibility that sighted individuals have.

Mr. NELSON. Well, we do pursue all of those things that you've mentioned.

Mr. MILLER. My point is do they pursue you? Do the public libraries come to you or the university libraries make that part of their budget?

Mr. NELSON. No.

Mr. PROSCIA. No.

Mr. MILLER. That's my concern.

Mr. NELSON. That's part of the difficulty I alluded to earlier. The marketing costs are very high, because it becomes a question of convincing individuals, a large number of individual institutions, and a large number of rehabilitation counselors. There are literally thousands of people in the system throughout the country, all of which have to be approached on a one-on-one basis because there are no top-down kinds of programs. It has to be a matter of convincing individuals to spend money for which they always have alternative uses on devices of this sort. And it becomes a very time-consuming, expensive process to do that.

Mr. JEFFORDS. With respect to the 504 regulation, discrimination against the handicapped, has there been any incentive there for libraries, et cetera, to be required to purchase this equipment?

Mr. NELSON. I think that will come. It hasn't really happened as yet. It hasn't had that impact at this early time. But I think that is certainly likely to occur.

Mr. JEFFORDS. The gentleman from HEW, you were nodding your head there. Do you know what the intentions are with respect to that aspect?

Mr. HERMAN. No; I don't. I don't. But I would assume that every library would not have to purchase one.

Mr. JEFFORDS. I don't know why they wouldn't. That's what I'm curious about.

Mr. HERMAN. Well, Mr. Jeffords, not every school has to make every part of that school accessible under 504 regulations. The program has to be accessible. I would expect that a community library would have to be accessible to the blind as well, and if the Optacon was—but, if this was thought to be a legitimate device to make that library accessible for the blind over any other kind of device, then the community library, where a handicapped person can easily get to might have one of these devices available—but not every library in the city might need to have to have available an Optacon.

Mr. JEFFORDS. Well, if you require them to put a ramp in, for someone who can't get there because of a mobility problem, what's the difference between that and the fact they don't have something which is available to allow them to read? I don't see as far as discriminating against the handicapped, it can be distinguished between the two.

Mr. HERMAN. There's a reasonability thing. I believe the 504 regulations don't prescribe that every place must be made accessible. But the community service must be made accessible.

Mr. MILLER. No. But if the city of New York has no library with these kinds of facilities in it, I suggest they're in violation, just as if the city of New York had no library without ramps.

Mr. HERMAN. Well, I would suggest even further that in the city of New York, say in the borough of the Bronx, if there was no library or if there weren't several places, reading stations, for opportunities for the blind to participate, they would be in violation because—but, of course, I'm not privileged to make that kind of statement. I'm biased on behalf of expanding and improving services to all these children.

But I would assume that would be the thing, accessibility within reason.

Mr. SCHEUER. Any further comments or questions from my colleagues? Dan?

Mr. GLICKMAN. No.

Mr. SCHEUER. Bob?

Mr. WALKER. No.

Mr. SCHEUER. OK. Your testimony has been absolutely inspirational. The three of you have wonderful and stimulating and provocative ideas, and I can't thank you enough for coming.

Mr. NELSON. Thank you.

Mr. PROSCIA. Thank you, Mr. Chairman.

Mr. SCHEUER. Next is Mr. Gregg Vanderheiden, director of Trace R. & D. Center for the Severely Communicatively Handicapped.

Mr. VANDERHEIDEN. We're presently in the process of trying to correct several errors with regard to that title, including the fact that the title refers to "handicapped" as though it were a population or a nationality that exists as such. Actually, it should be something on the order of "individuals with a handicap," or something similar.

Mr. SCHEUER. Yes. OK.

Do you have some technology to show us?

Mr. VANDERHEIDEN. Yes; we do.

Mr. SCHEUER. Why don't you get right into it?

[The prepared statement of Gregg Vanderheiden is as follows:]

COMPUTERS AND THE EDUCATION OF SEVERELY HANDICAPPED INDIVIDUALS

Remarks Prepared for

The House Science and Technology Sub-Committee
on Domestic and International Scientific Planning
Analysis and Cooperative (DISPAC)

October 18, 1977

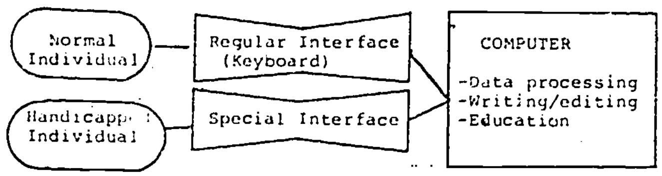
Gregg C. Vanderheiden
Director

Trace Research and Development Center
University of Wisconsin- Madison

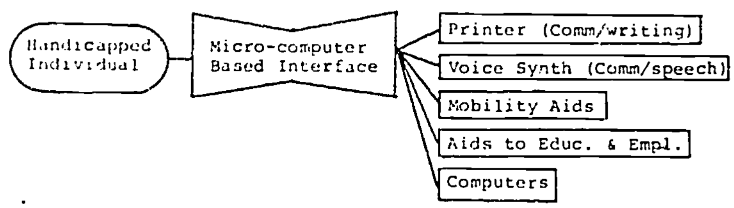
When considering the use of computers with or by handicapped individuals it is helpful to note that there are several different ways that computers may be used. Some computer uses applicable to handicapped individuals parallel those available to non-handicapped individuals. In other instances the computer may be used to accomodate or partially compensate for a handicapping condition which an individual may experience. Each of these uses are quite different and place different constraints on the development of computer systems. Use of computers with handicapped individuals could be broken down into three basic types of use. (Fig. 1). The first involves use of the computer with the individual experiencing a handicap in the same way and for the same purposes as it would be used by a non-handicapped individual. For example, the computer may be used for accounting, inventory control, computer aided instruction etc. If the person has a physical handicap which prevents him from using the standard computer interfaces (keyboard, light pen, visual display) then a special interface may be needed to allow him /her to interact with or control the computer. With this type of computer use (hereafter referred to as Type 1), the computer is used to accomplish the same type of things for a handicapped individual as for a non-handicapped user (although there may be some modification of specific programs as in CAI.) Type I computer use involves opening up to handicapped persons the same potential benefits of the computer for education, recreation, and employment as are open to non-handicapped persons. Thus Type I use may be characterized as "Use of Computers in Traditional Manners by Individuals Experiencing a Handicap".

The second type of use of the computer would be to help accomodate an individuals specific handicap and remaining abilities. In order for an individual to receive an education s/he must be able to interact in the classroom, do independent work, do homework, take tests, move about etc. If s/he can not perform the above, then s/he will experience a handicap in receiving an appropriate education, securing a job or conducting activities of daily living. If s/he were totally unable to perform any of the above then "handicap" would be an insufficent descriptor as the individual would be unable to derive an appropriate and meaningful education. Type II use of the computer then involves use of computers as interfaces between severely physically handicapped individuals and the people and objects (typewriters, paper, books, wheel-chairs,etc.) in their environment which are necessary in the educational process. It is important to bear in mind though, that computers are not needed as part of an interface for all physically handicapped individuals. Simple mechanical or electronic adaptations may also suffice in some cases. But for severely physically handicapped individuals computers, usually in the form of microprocessors, are often needed in order to accomodate the limited physical control of these individuals and to do so in an efficent and cost-effective manner. Since the use of computers in this manner is essentially to accomodate the disabilities and enhance the usefulness and effectiveness of the handicapped individual, Type II use of the computer may be characterized as "Use of Computers to Interface and Enhance the Use/Control of Other Devices".

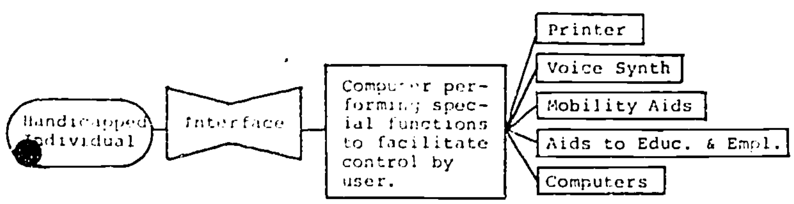
THREE TYPES OF COMPUTER USE BY
INDIVIDUALS EXPERIENCING HANDICAPS



TYPE I: REGULAR USES OF COMPUTER: Enabling individuals with a handicap to use/access computers for the same purposes as everyone else.



TYPE II: USE TO INTERFACE/ENABLE: Using computer to enable individual with severe physical handicaps to access and use/control other devices and materials. (incl. other computers)



TYPE III: USE TO FACILITATE/ACCELERATE/OFFSET: Using computer to help reduce handicap experienced by the individual by providing special functions to minimize the number of signals needed from user or to otherwise speed up his control or use of other devices and materials

The third way computers can be used with handicapped individuals is by allowing the individual to increase the effectiveness of his/her skills by providing intermediate processing between their control commands and the output to the object being controlled. For example, a child unable to control a wheelchair sufficently to drive it, making corrections for deviations in direction due to floor slant etc, might be made self mobile if he could simply tell the chair to move forward and have a small inexpensive processor make corrections for changes in direction. Or, a child trying to do four level addition step by step on a TV screen (he cannot write) could have a 46 step process (which provides the child with more physical exercise than math skill excercise) changed to a 9 step process which approximates the procedures that non-handicapped children use when learning to add. The microprocessor would not add the numbers for him but merely facilitate his moving about on the writing area (TV screen) to facilitate and accelerate his ability to do math, written work, tests and to use standard or pre-printed test sheets etc. This third type of computer use then deals with the facilitation or speeding up of an individuals ability to do things or control other devices. Since this acceleration can be as much as 5-6 times it would be possible to allow an individual to do his homework in two hours instead of ten, or of doing all of his homework instead of one fifth of it. In class it may mean the difference between participating in class activities. This third type may be charaterized as "Facilitation/Acceleration of Control or Productive Ability".

With these last examples it is apparent that with the advent of miniature, inexpensive computers (you can now purchase entire micro-computers the size of your fingernail for approximately $26.00) the impact of computers and computer technologies on handicapped persons and their education is no longer limited to the use of large systems or computer assisted instruction. While these uses still have special capabilities to offer handicapped persons (particularly the physically handicapped person whose input/output is speed limited) the use of small or microcomputers in special aids adds the potential of providing the teacher with tools s/he can use to allow use of more conventional educational techniques and materials as well. By providing the individual who has a severe or multiple handicap with the ability to use standard materials and procedures the teachers task in preparing materials is much reduced, the possibility of proper placement or mainstreaming is greatly increased and the probability that the individual will be able to use the skills acquired when s/he leaves the educational system is also greatly increased. The ability of the individual to do his/her work in a reasonable amount of time is equally important and has equal effects on reduction of needed teacher or aide time and increase in effectiveness of the child in his educational environment.

Aids to Education vs. Educational Aids

At this point it is helpful to distinguish between Educational Aids (systems etc.) and Aids to Education. "Educational Aids" here refers to materials, devices, teaching machines, etc. which are designed for the purpose of facilitating the teaching/learning process. "Aids to Education" refers to devices which were not designed for educational purposes but which are necessary in order to receive an appropriate of effective education. Eyeglasses would be one common example of an aid which is not an educational device but which is often necessary for education. A wheelchair is a second example. If these devices already exist then the educational community need not concern itself directly with them except to see to it that the children get the aids they need in order to function in the classroom. If these aids did not exist then it becomes necessary for the educational community to consider these as "aids to education" and to assist in their development. This is necessary if the educators are to have any chance of providing these individuals with an appropriate or meaningful education.

Cost Effectiveness of Personal Aids to Education

It is a happy coincidence that in addition to the "equal education" motivation for providing these individuals with necessary techniques or aids, it also turns out to be economically expedient to provide them with the ability to function and interact with regular materials, procedures etc. An individual who can manipulate and use standard educational procedures, materials and facilities needs much less individual one to one teacher instruction times, less or no assistance from special teacher aides, less program preparation time, less or no special materials development time, can participate effectively in larger classes, may be able to attend regular classes in regular schools, can do more independent learning, can progress further in the educational system (including full earned college degrees) and has a better chance of being productive after his education. This adds up to lower costs while in the educational systems, more advancement, and better economic outlook afterward. It is an unusual instance that you can gain in all three ways. But if we've decided to provide meaningful education and employment for these individuals that's the way it works out. The cost to provide even a poor to mediocre education is so high ($2500 - $29,000/year or $40,000 - $464,000 for their 16 year educational span) that any significant fractional decrease in educational costs can be economically very significant. Appropriate aids can be cost effective simply because proper and appropriate aids are much less expensive than the human services which they reduce.

Discussions of economics should really be secondary however. Since the individuals we're referring to cannot receive and appropriate or meaningful education without the ability to read, write, move, or even talk, the economic aspects should be secondary if we are really serious about providing a useful and appropriate education for these individuals. To paraphrase a colleague, Dr. John Eulenberg, on the topic of communication aids, " The cost is simply too great not to provide them with effective means to communicate and participate. The cost is too great both for the individual and for society ....to be excluded... and to not be able to communicate is to be excluded."

Examples of Current and Future Efforts in These Areas

It can be seen that there is a potential for the use of computers in education not only for system use such as computer aided instruction or teaching machines but also (in their mini or micro form) as part of personal aids which can help an individual with a handicap to adapt himself fo standard educational programs. In the latter application the computer looses its computational character and becomes a doer. and aide, an assistant or a controlled extension of the individual.

The government, the Bureau for Education of the Handicapped and researchers in the field have recognized this need, and several examples of development efforts in this area can be found in the research supported by BEH and other government groups. Some examples of existing work mixed in with potential future developments are as follows.

For the visually impaired we see a good example of a Type II (Interfacing/Accelerating) application of the computer in the work of Kurzweil and the work at Telesensory Systems Incorporated. Here computers are being utilized to translate printed English into spoken English for the blind who would not normally be able to use atandard printed materials. A similar application for the deaf might provide just the opposite- a speech to text translation, although this is beyond present capabilities. An aid for the deaf which is currently possible is a shorthand transcription system currently being developed by Newel et al. in England. Based on a device similar to the stenotype, a deaf member of parliament is able to follow the conversation on the floor of Parliament by reading a phonetic like trasncription appearing on a personal display. With refinement and a microcomputer base, easily readable direct text translation may soon be possible.

For individuals who are non-vocal and severely physically handicapped (NVSPH), computers are currently making in-roads both in the area of interfacing (TypeII) and facilitating (Type III). Facilitating applications are much more prevalent here due to the speed limitations of the individual who is NVSPH, limitations which are not as prevalent or severe for individuals with vision or hearing impairments.

One of the major problems in aids for individuals with severe physical handicaps is the tremendous variability of handicaps and abilities. In the past this has resulted in a need for a great many different (and therefore more expensive) aids to meet their needs. By using microprocessor technology. communication aids are being developed which can be adapted to meet the needs and capabilities of widely varying users. The aids can adapt to the user rather than requiring the user to adapt as best he can to the operation of the aid. (see AutoCom and VersiCom) Because the microcomputer allows both the physical interface and the operational mode of the aid to be easily and inexpensively tailored to the limitations and capabilities of the user, a much faster and more effective communication channel can be provided. This is important when one considers that the last paragraph can take as long as 1-2 hours for an individual who is only able to use a scanning technique.

Use of the microcomputer also allows the aid to be easily modified to work with a range of output modes including page turners, typewriters, correctable TV displays, or voice synthesizers as they are needed for interaction of proof of activity in the educational process. Because the speed of communication and control can be very slow due to the physical impairment, several researchers are working on computer based procedures for accelerating communication and helping to offset the slowness caused by the physical handicap. (Type III applications). Examples of such would be the work at Tufts New England Medical Center (Richard Foulds et al) and the Rehabilitation Institute of Chicago (Dudley Childress et al) where anticipatory scanning techniques have been used to help increase the speed of scanning techniques: the text/speech and auto-intonation work being conducted with NVSPH children at Michigan State University (John Eulenberg, Mort Rahimi et al) and the word/phrase and math/writing facilitation and syllable base research being conducted at Tufts and at the Trace Center, University of Wisconsin (Gregg Vanderheiden, Deberah Harris et al).

Summary

With advancing technology and dropping costs, the application of computers is moving beyond just large system applications, bringing its potential benefits to bear on the adaptation problems of individuals with handicaps. In these applications the computer looses its computer programming character and takes on a facilitating/assisting role or a role of an extension of the individual- a prosthetic of a sort.

Personal aids are now becoming possible which can not only greatly increase the functioning of severely and multiply handicapped individuals, but reduce the costs to provide appropriate and effective education . Especially in the area of the severely physically handicapped, microcomputer based aids are needed and are already becoming available commercially.

Progress has been made but progress has been slow. Those not familiar with computers find it hard to relate to the use of microcomputers as small assistive devices and consider the use of "computers" for such basic purposes overkill (when in fact they cost less than non-processor implementations of the same functions). Those familiar with computers are usually oriented toward the large systems and applications appropriate to them. As a result millions of dollars have been spent around these areas while little has been done to exploit the potential of microcomputers toward facilitating the function and education of individuals with severe handicaps.

Another very severe problem has been one of jurisdiction. In the area of communication aids for the NVSPH individual there has been mush discussion and even a government planning session sponsored by BEH and attended by NIH, NSF, RSA, and the VA to determine who should be funding the development of such aids. The area seems to fall between the areas of focus in the various groups and researchers have had much difficulty in securing funds to work on developments in this area. More awareness and better coordination is therefore seen as necessary in the area of facilitative devices. This is especially true as they relate to young individuals and to education where technical aids have only had a very limited application until just recently.

Overall the field is an open and promising one. It is one which is characterized however by 10% technical advancement and 90% advancement in our understanding of the proper and effective use of technology. The two greatest problems of the field at this time seem to be: 1.) the hesitancy to believe that technology can be helpful and 2.) once technology or technical aids are seen as helpful- they are often assumed to be solutions in and of themselves. This latter problem has led to instances of disillusionment. Perhaps the best way to view technical aids for severely handicapped individuals is to compare them to a tool box. It would be impossible to build a house without them, but giving a man a tool box will not make him a carpenter. Technical aids are essential parts of the solution (for some individuals) but are only the start. How they should be designed or what exactly their function should be to facilitate the development of the rest of the solution for an individual is what we are just now beginning to find out. Much work needs to be done but the potential for these individuals is great.

STATEMENT OF GREGG VANDERHEIDEN, DIRECTOR, TRACE R. & D. CENTER FOR ... ERELY COMMUNICATIVELY HANDICAPPED

Mr. VAND... First, I'd like to show you 60-second film clips as an i... to one of the individuals we're working with so you hav... what population the technology to be demonstrated wa...

[Film.]

Mr. VANDERHEI... is is Craig. As you can see he's a young man severely invol... th cerebral palsy. Craig in this picture is 14 years old. Due to ...vere physical involvement he used to spend large portions of his day ...itting on both of his hands to help stabilize himself. You'll notice he has side braces on his chair and he also uses a lap belt at times to hold him into his chair.

Mr. SCHEUER. We... these infirmities with which Craig was born?

Mr. VANDERHEIDE... Yes.

Mr. SCHEUER. The... were birth defects?

Mr. VANDERHEIDE... Right. Cerebral palsy is a congenital motor problem.

Here you see Craig trying to operate other types of things that he might use in a classroom situation. From the film you can see he obviously is unable to use a typewriter. You can also see the problem we have now in trying to educate somebody like Craig who is unable to manipulate or handle conventional educational materials.

Mr. SCHEUER. Is Craig of normal intelligence?

Mr. VANDERHEIDEN. Craig has had his IQ estimated over 130.

Mr. SCHEUER. Does he have speech?

Mr. VANDERHEIDEN. He has absolutely no speech, no control of his oral vocal mechanisms.

Mr. SCHEUER. How can you measure his intelligence?

Mr. VANDERHEIDEN. "That's why I said estimated." As a matter of fact, a better word might be "guesstimated" because there are no real means for measuring numerically the capabilities of someone as physically involved as Craig is. In addition, Craig's functional ability at this point would probably be very, very much diminished because he has had no real means of expression for the first 14 years of his life. To exemplify the problem, imagine yourself with your month taped shut and your arms and legs bound, and then placed into a first grade situation and told to get an education. This is the kind of problem we have with these intelligent but physically involved children.

Technology now can allow us to interface this kind of an individual, and allow him to control materials and devices for education and daily living. From the film, we can see here that with proper interfacing techniques even somebody who's as severely involved as Craig is can be provided with a functional means of communication.

Now, the piece of film you are now seeing was shot 5 minutes after the film you just saw. You can see the tremendous increase in control that he seems to have as a result of having an interface like this, which was developed to take advantage of the individual's abilities instead of amplifying his disabilities.

This is also the first time that Craig has seen this interface. He operated it for only about 30 seconds before we turned the camera on for this picture. You'll notice his movements are still erratic, but he is successfully printing his name out.

I have an example of the board here for you to see.

Now, this morning we've been talking about personal aids and the ability to produce aids which can be with the individual, which can move around with him. Some of the aids we've seen this morning are already portable. Others are heading in that direction due to microprocessor technology.

Here is an example of an aid which is on the "portable personal aid" level. The entire system fits right within the lap tray. It mounts to the wheelchair arms and the individual then can communicate on it.

Let me see if I can't demonstrate that a bit here [demonstration]. It has a couple of displays. One of them is an LED display, similar to a calculator.

Now, as you can see, the aid is able to interpret even very erratic pointing motions. Actually, Craig was in very good form in that film. Often he is much more involved and would be pointing something on the order of this [demonstrating].

Now, in that flailing I have printed out an entire message. The board can print out the message on a strip tape.

Here you see the message that those flailing motions produced.

Mr. SCHEUER [reading]. "Would you like to go for a drink?" [Laughter].

Mr. VANDERHEIDEN. These are the kind of aids which are now being developed for severely involved persons. This aid would be for someone with Craig's disability. There are other aids for individuals who can't point at all.

Now many of the newer aids are being make possible through the introduction of microprocessors. As a matter of fact, the microprocessors being used are very small. You see an example here [indicating]. The microprocessor, actually microcomputer, is on the silver chip in the middle which is smaller than a dime. You can get them down to about $10 or $12 in quantity.

Now, more power—more memory—increases the cost but this is not the major cost.

The cost of developing the aids is only partially in the technology. And in developing aids of this kind the problem turns out to be something like 10 percent technological developments, and about 90 percent advances in our understanding of how to apply them and how to correctly bring the technology to bear on the problems of the individual with a handicap.

For instance, one of the things we found when developing the aid was that it had to be able to fit the individual. As a result you'll see that the input grid here is not printed on. The individuals actually make up their own input grids and vocabularies. So you could start out with a child who is just starting to learn and can't spell, by working with symbols and pictures to help a very young child begin to communicate. Then, the aid can grow with the child, adding things to it to meet the needs of the individual as he gets older.

A voice synthesizer, for instance, can be placed directly inside of this aid to allow the individual to interact in the classroom.

When we look at these aids, we see that they're not really educational aids, but rather aids to education. We are seeing that technology can not only serve to give us educational aids such as teaching machines, computer-aided instruction, and so forth; but, can also use computers and computer technology to facilitate the actual development of personal aids which are aids to the education process as well as aids to the person's whole life.

For example, if a person cannot speak and has no way of communicating or interacting, we're essentially excluding him from the world. By providing him with effective personal communicative aids, he can communicate, interact and participate in the world around him. If nothing else, a person should be able to interact with people around him if he's going to be considered a person.

Mr. SCHEUER. Any questions? Jim?

Mr. JEFFORDS. Is this available, or just in an experimental stage?

Mr. VANDERHEIDEN. About 40 of the aids were constructed on a trial basis and put for sale, if you will, on a cost basis by the University of Wisconsin. They were gone within 2 months.

The Bureau of Education for the Handicapped, which funded the latter developments of the aid is currently releasing this aid for production via the marketing mechanism that was mentioned earlier. There are several companies who have, for some time, been very, very interested and have already offered to take it. It's being processed through the BEH mechanism, in order to select the best one, and to make sure that equal opportunity is given to everybody who would like to manufacture the aid.

Mr. JEFFORDS. Do you have any idea what the anticipated cost for an individual to purchase it?

Mr. VANDERHEIDEN. Yes. The cost is an interesting thing. The anticipated cost when it comes out probably will be in the area of $4,000 to $5,000; and that over its lifetime, which is probably at least 10 years or more, to about $400 or $500 per year. Now, the cost to educate these individuals ranges from $2,500 to $27,000 per child per year, which ranges from about $40,000, some to $454,000. So the cost is very small to allow them to participate instead of just observing the educational process.

Mr. JEFFORDS. Do you have any idea of the number of individuals that might utilize such equipment?

Mr. VANDERHEIDEN. Yes. The marketing study tried to determine that number. Largely these individuals are so severely multiply handicapped that they show up in multiple categories, and there aren't any good clear statistics. The best estimate, however, would be that there are somewhere near 80,000 that need communication aids of this type. But not all of them could use this one. There are other techniques. That's one of the powers of the microprocessor, and that is that this basic aid can be adapted to all of those, because it has the microcomputer in it.

It might also be interesting to note that the aid existed in a non-microcomputer form prior; it was much less flexible and cost a lot more. So that the introduction of the computer rather than raising the cost, cut the cost by several thousand dollars.

Mr. JEFFORDS. Could this be used by paraplegics?

Mr. VANDERHEIDEN. Yes. It could be used by anyone who is severely motor or speech impaired and who could not use typewriters, or pen and paper, or other devices. This is only one device.

We're involved on researching and disseminating information on aids developed all over the world, and there are many devices available in this area. This would just be an example of one of the more advanced ones.

Mr. JEFFORDS. After a stroke, elderly people would be able to use this also?

Mr. VANDERHEIDEN. Yes. It also has been used by stroke victims and the elderly. A man in California, for instance, purchased one of the aids that we had available for his wife, who had a stroke.

Mr. JEFFORDS. Thank you.

Mr. GALLAGHER. That boy Craig looked totally almost hopeless when you put him by a typewriter. With this machine in front of him—you say he'd only seen it 30 seconds?

Mr. VANDERHEIDEN. Yes. He had it about 30 seconds, which is about as much time as it took for me to get set up with my camera.

Mr. GALLAGHER. He actually did better than you did at trying to imitate him. I mean he——

Mr. VANDERHEIDEN. Craig is better than I am.

Mr. GALLAGHER. I don't know what his IQ is. You say it could be high. But his motor operation compared to the old typewriter improved. He seemed——

Mr. VANDERHEIDEN. He is quite good, as I said. He does very well on it now. He does better than I do on it. That's not uncommon for our kids, to be able to surpass us when they use the aids.

The thing that we have to remember is that when we're working with those individuals very often we see the motor handicap, and we don't see beyond it. When I first saw Craig, and I'm sure when you first saw Craig on the film, your estimate of his capabilities was far different than after you saw him using the aid.

Mr. SCHEUER. That's why I asked the question.

Mr. VANDERHEIDEN. That's right. Only now are they beginning to really be able to do a good assessment on him. And I don't know exactly where his intelligence will fall. But it is clear that it is really quite good, because he's making incredible gains in language development, from having nothing after 14 years, to what he has been able to achieve since then.

These individuals also have good potential beyond this. We now have an individual who is like Craig, who is securing a job as a computer data entry. We have another one who's a computer programer.

Our whole conception of the severely handicapped is changing. I like the terminology that John Eulenberg at Michigan State uses:

> These aren't severely handicapped individuals, they're individuals who are experiencing a handicap, and in this case a severe handicap.

And although Craig would be listed among "the severely handicapped," there's no reason that, with proper interface, that he has to retain that title. He might just be somebody who has severe celebral palsy but is only moderately handicapped.

Mr. SCHEUER. I like the phrase "people with special education needs, or special work needs, for some kind of help or support to enable them to function up to their maximum capacity."

Mr. VANDERHEIDEN. Right.

Mr. SCHEUER. Who is to say who is handicapped?

Bob?

Mr. WALKER. No questions.

Mr. SCHEUER. Dan?

Mr. GLICKMAN. I'd just ask—you know, public school districts all over the country are being required under both State and Federal mandate to educate all children, and these would seem to be valuable tools, and particularly in the concept of mainstreaming, when you're putting children with various special education problems into the classroom. I see you're with the University of Wisconsin. I don't know what relationship you have in terms of getting public school districts all over the country interested in this.

Have you had any contact with them? What problems do you see in getting school districts, the ones that are responsible for educating 90 percent of our children, into this thing?

Mr. VANDERHEIDEN. Yes. We are in contact with them. We do have to be careful, though, how we look at these aids and the school's role in their purchase. I'd like to reiterate a comment that was made earlier regarding whether or not the schools should be involved in buying them. It is important that these aids be thought of as personal aids to communication. The children need them, not just for education, but throughout their lives. Via the school, however, awareness can be generated. The danger is that the school system might be tempted to buy one for a classroom full of handicapped kids. This would be akin to buying a wheelchair for a roomfull of cerebral palsy children and letting each use it for a while during the day. How does a person talk the whole rest of the day? How do they participate, do homework, and classroom activities?

Mr. SCHEUER. Bob?

Mr. WALKER. No questions.

Mr. SCHEUER. Thank you very, very much. This has been a remarkably interesting presentation that you have given us, Mr. Vanderheiden. We appreciate it very much.

Mr. VANDERHEIDEN. Thank you.

Mr. SCHEUER. The next witness will be Dr. Sam Ashcroft, director of the National Center on Educational Media and Materials for the Handicapped of Ohio State University.

Dr. Ashcroft, we look forward to your testimony.

Do you have technology to show us, or are you simply going to testify?

Dr. ASHCROFT. I have no technololgy hardware to show you——

Mr. SCHEUER. OK. Why don't you——

Dr. ASHCROFT [continuing]. In that sense.

Mr. SCHEUER. Since we have six really very interested Congressmen, both on the committee and off of the committee, why don't you make your testimony really not more than 4 or 5 minutes, so that they have a chance to go at you?

Dr. ASHCROFT. I'll be glad to do that.

[The prepared statement of Dr. Ashcroft is as follows:]

12 October 1977
Final Draft

Computers and the Learning Society: The Role of Computers in Aiding the Education of the Handicapped

Testimony for the House Committee on Science and Technology, Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation (DISPAC)

by
S. C. Ashcroft, Professor
Faculty for Exceptional Children
The Ohio State University
Columbus, Ohio 43210

October, 1977

INTRODUCTION

Computer technology is making highly significant contributions to improving the lives and education of persons with handicaps. These highly significant contributions are illustrated by a tiny computer connected to implanted electrodes in the visual cortex of a blind person so that a subminature TV camera in a glass eye can provide a visual prothesis. From this complex experimentation at one extreme the applications range to the relatively simple problem of facilitating the enumeration of the approximately eight million handicapped chiluren who need special education. Between these two extremes lie a whole range of applications of technology facilitated by microelectronics which have brought new hope and new problems to handicapped persons and their education.

In our technologically oriented society we must learn not only how to gain access to information but also how to make effective use of it in making major decisions about education, work, and style of life. Technology has had both beneficial and detrimental aspects for disabled, impaired, and handicapped individuals. Although it enables the person with a handicap to minimize some of the effects of their handicaps and thus inspires new hope and aspirations, a related inability to cope with technology or failure to understand and use it effectively may complicate the handicap, foster despair, and separate disabled individuals even more from the mainstream of society than they have been in the past. What is needed is to encourage, rather than to restrain technology, but to invest proportionate effort in the social, cultural, and psychological aspects of advancing technology and what it can mean for the individual with a handicap.

Following are brief descriptions of current developments that illustrate the role that computers can have in aiding the education of the handicapped and also indicate some of the problems yet to be solved in this exciting area.

THE NATIONAL INSTRUCTIONAL MATERIALS INFORMATION SYSTEM (NIMIS)

For the past three years we at Ohio State University have been engaged in the development of the National Instructional Materials Information System. NIMIS, as we know it, provides information on a wide variety of instructional materials which can be used in classrooms and other settings to educate handicapped children. NIMIS is a computer-based, on-line interactive retrieval system specifically developed for the purpose of assisting teachers, parents, and other educators in locating information about instructional materials. Such an on-line computer-based system enables individuals to "converse" with the computer. The individual asks questions by typing them on a computer keyboard and the answers immediately appear on a television screen.

NIMIS provides descriptive information concerning more than 35,000 selected instructional media and materials. The materials are the of four kinds: child-use instructional materials - materials used by the child or by the teacher and child interacting in the process of education, instruction, and evaluation. Secondly, teacher education materials - instructional materials used to prepare teachers to select, use, evaluate, design, and adapt media, materials, and educational technology for the special education of children with handicaps. Third, materials for measurement and evaluation - materials designed to provide for evaluation, assessment, measurement, and diagnosis of the current skills and abilities of the child with a handicap. And fourth, prototype materials - materials of an experimental or one of the kind nature that have been developed as models for possible future development.

Most of the instructional media, materials, and educational technology in the NIMIS are non-print materials such as instructional kits, films video cassettes, audio cassettes, filmstrips, games, toys, and other materials exploiting audiovisual technology for the special education of persons with impairments, disabilities, and handicaps.

NIMIS, with its 35,000 materials for special education, is only a small part of what is generally available. It is estimated that there are more than 300,000 instructional materials available commercially in

1974. In the previous twenty years this figure reflected an increase of 200% in textbooks, 500% in 16mm motion picture films, 700% increase in records, and 800% increase in filmstrips as well as innumerable audio tapes and cassettes, video tapes and video cassettes, overhead projection transparencies, multimedia kits, 8mm filmstrips, games and simulations. Unfortunately, all too few of these materials have been developed and tested with instructional effectiveness as a primary consideration. Even fewer have been specifically designed for use with persons who are handicapped. The descriptive information on instructional media, materials and technology included in NIMIS is expected to be accompanied by evaluative information. Currently, hard evidence and data are lacking on most materials. However, all materials in the present system have been selected by specialists in the education of the handicapped and most of them are accompanied by a statement such as, "...evidence shows that this material is currently being used by teachers and educational programs (for the various disability groups)...." It is to be hoped that evidence of the effectiveness of instructional materials to achieve learners' objectives and teacher goals will be improved as the system develops.

THE NIMIS THESAURUS

Access to information stored in NIMIS is gained through special indexing terms called descriptors. These precisely defined terms are very important in retrieving information about instructional materials. There are more than 800 such descriptors included in the Ins· .ctional Materials Thesaurus for Special Education, 3rd Edition. The Thesaurus may be one of the most significant contributions of the NIMIS. The use of computer technology to aid teachers, parents, and students in the selection of appropriate instructional materials for handicapping conditions that have significance for education requires careful definition of terms, precision in language, and detailed specification of instructional objectives. Thus, the use of computers motivates a more objective and scientific approach to the special education of the handicapped than has heretofore been commonly practiced.

INSTRUCTIONAL MANAGEMENT SYSTEMS

Among recent innovations in special education, making use of computer technology is the development of instructional management systems, instructional objectives banks or collections, and computer-based instructional support systems. These systems are designed to enable teachers to individualize instruction and to identify the instructional objectives, teaching techniques and related instructional materials needed to attain highly specific instructional goals. We recently queried more than 20 such systems to explore the possibilities for providing an interface between such systems and the NIMIS. Incomplete analysis indicates a wide range of sophistication in such systems, apparent duplication of effort, and the need for standards, criteria and guidelines for system development. Such guidelines should not be intended to reduce diversity nor to dampen creativity in innovation, but to maximize the possibilities for complementary and compatible systems and to facilitate their use of a national system like NIMIS.

THE EDUCATION OF ALL HANDICAPPED CHILDREN ACT OF 1975 (P.L. 94-142)

The widely heralded Education of All Handicapped Children Act of 1975, Public Law 94-142, requires the free and appropriate public education of all handicapped children in the least restrictive environment through an individualized educational program. Section 504 of the Rehabilitation Act of 1973 provides that schools may not exclude the handicapped. Providing an individualized educational program for eight million handicapped children including accessibility to schools, unbiased individual appraisal and an individualized educational prescription is a difficult task. Accessibility to the required instrumentation for unbiased diagnostic and appraisal through the National Instructional Materials Information System and the availability of information about instructional materials specifically related to diagnosed instructional objectives is unlikely to be accomplished without the aid of computers.

Public Law 94-142 requires the identification of all handicapped children. This demographic task can be facilitated by computers but is complicated by the problems of labeling, categorizing, and codifying individuals and information about them. Thus, the computer provides assistance but not without accompanying complication in the effective and humane management of information about individuals.

COMPUTER APPLICATIONS TO THE HANDICAP OF BLINDNESS

Perhaps the impairment of blindness and the potential for associated disabilities and handicap illustrate the potential for ameliorating the effects of handicaps through computers more dramatically than in any other case. Current developments for the habilitation, rehabilitation, and

and education of persons who are blind are in tune with the current interest in such motion pictures as Star Wars and such television programs as Logan's Run. Whereas the computer assisted visual prothesis using electrodes implanted in the brain is still in embryonic experimental stages, the Kurzweil Reading Machine for the Blind produces synthesized speech from the optical scanning of the printed page replicating graphic symbols as speech sounds. The Kurzweil Machine with a moderate computer capacity contains a reasonably large vocabulary but when this vocabulary is not adequate to the printed message the machine spells the word out letter-by-letter. Without highly sophisticated computer technology and micro-miniature electronics such access to aural translation of print would continue to be unrealized independently by persons who are blind. Currently being field tested, the Kurzweil Reading Machine at about $15,000 per prototype device, is expected to be improved rapidly and to be demonstrated effective as a reading machine for blind persons.

For some years now the American Printing House for the Blind, the largest publishing house for braille and large type and audio materials for the blind in the world, has been using computer applications to facilitate the transcription of print to braille. Through a computer interface, a typist working at an ordinary typewriter, connected on-line to a computer can prepare braille materials in accordance with the complex orthography of the braille system. Thus, an ordinary typist with computer assistance can replace a braillist whose training typically required more than a year.

A recent French development called the Digi-Cassette or Portable Braille Recorder can provide in one small four pound package a computer terminal for a blind person. The digi-cassette encodes braille and auditory material on an audio tape cassette and provides a braille readout in a twelve-cell recurring display at speeds under the control of the reader. The machine, in addition to its audio output from the same tape cassette can also be interfaced with an inexpensive calculator. Computations on the digi-cassette can be displayed visually on the inexpensive calculator and calculations made on the calculator can be displayed in braille on the digi-cassette. This unique substitute for a braille writer which also includes a braille reading machine can open new employment and occupational opportunities for blind persons by providing a computer terminal in a small and relatively reasonably priced package.

A PROPOSAL FOR INTERNATIONAL COOPERATION

The availability of this promising technological development from France - the birthplace of Louis Braille - has significance for international cooperation. Many contributions to special education have come to us from abroad and more recently, we have contributed to the special education and general welfare of persons with handicaps through technical assistance and exporting ideas, equipment and materials. During the Summer of 1978, the CouncilforExceptional Children will sponsor the first World Congress on Special Education in Scotland. At that time we expect to propose the development of an International Instructional Materials and Professional Information System to foster the exchange of materials and information among all the countries of the world. We believe we will be the beneficiaries of such an exchange and can make a contribution to the education and welfare of persons with handicaps everywhere.

The illustrative applications of computers to aiding the education of persons with handicaps both nationally and internationally is only symbolic of the vast array of possibilities that can be opened by the effective use of computers. The Education of All Handicapped Children Act of 1975 ushered in a new era for the education of the handicapped and the Section 504 of the Rehabilitation Services Act opens new occupational vistas for the handicapped. While these legislative enactments provide for the civil rights of the handicapped and open doors to persons with handicaps that have heretofore been closed or inaccessible, technology must now facilitate the full realization of the potential of the handicapped individuals. Computer technology can make a significant contribution to this direction.

STATEMENT OF DR. SAM C. ASHCROFT, DIRECTOR, NATIONAL CENTER ON EDUCATIONAL MEDIA AND MATERIALS FOR THE HANDICAPPED (NCEMMH)

Dr. ASHCROFT. It's a very hard act to follow without hardware, after these fascinating demonstrations.

Mr. SCHEUER. Well, all of these demonstrations have been hard acts to follow. It's been a marvelously interesting morning for us all.

Dr. ASHCROFT. I know that you were interested, from your questions, in marketing and dissemination, and that has been one of our tasks at the national center.

One of the means for distributing information about these kinds of devices is the national instructional materials information system, or if you'll excuse me for using an acronym, NIMIS.

We, for the past 3 years at Ohio State, have been developing this system, which is an online computer-based retrieval system for information about instructional equipment and materials for use by teachers, parents, and others who work with children who are handicapped. It's an interactive system, so that the individual can query it, get responses and have identified instructional media, materials, and educational technology that are responsive to specific needs of handicapped children.

During these past 3 years, more than 35,000 such instructional materials have been indexed into the system. They are materials of four kinds: child use instructional materials, materials for use by the child himself; materials for teacher education, materials for instruction of teachers in the use of such equipment and materials; and materials for diagnosis and appraisal of problems of children with handicaps—particularly their education problems, assessment and measurement of learning handicaps. The fourth category of materials has been prototype materials, materials and equipment in early stages of development of the kind that you have seen here.

There is a correlated clearinghouse for information on professional special education at the Council for Exceptional Children.

I might point out that the national instructional materials information system has recently been recompeted by the Bureau of Education for the Handicapped. Ohio State no longer has that contract, and it is now with the University of Southern California. And we presume that NIMUS project II will be an extension, in general, of the current system.

Among the many benefits of this system is the NIMIS Thesaurus, a dictionary of descriptors—more than 800 terms—relating to such instructional media and materials, which help in introducing precision in language and for detailed specification of instructional materials to meet specific instructional objectives.

Another recent development in special education, particularly relevant to diagnosing the learning problems of children with handicaps is instructional management systems. These are systems that use instructional objectives and instructional technology, to relate to specific problems of handicapped individuals.

NIMIS can be a very useful device in providing instructional materials responsive to unique learning problems of handicapped individuals.

Dr. ASHCROFT. I'd like to call your attention to a new device for the blind, a portable braille recorder, being introduced in this country from France. The portable braille recorder is a 4-pound device that records on audio tape, along with audio material, braille information which can be read out in a 12-cell display from the same reading and writing device. This device can serve as a computer terminal for blind persons and opens new employment and educational opportunities for the blind.

I'd like also to call your attention, finally, to the World Congress on Special Education, to be held in Scotland next summer. I know your committee is interested in the international sharing of information. And we expect to propose there an international instructional materials and professional information system, to share information from this country and also to obtain information from abroad for use in this country.

Mr. SCHEUER. Will there be exhibits there of the kind of breakthroughs that we've seen and heard this morning?

Dr. ASHCROFT. I'm sure there will; yes.

Mr. SCHEUER. Are there any of the people who talked to us this morning who would find any difficulty or problems in exhibiting their technology in Scotland next summer? Is any kind of U.S. assistance needed or appropriate here?

Mr. VANDERHEIDEN. I think that travel outside of the country, in general, is very difficult for any research group. Federal funds, of course, are not available. Grant funds, except with a lot of strings cannot be used for out-of-country travel. So in general, all exhibition of the work that I'm familiar with in this field has been constrained to this country.

Mr. SCHEUER. Well, I think there ought to be a way for the kind of technology we've seen here to be exhibited to countries abroad. I think it would be well for our image as the compassionate, humane, and decent people that we are for breakthroughs of this kind to be exhibited abroad in addition to the neutron bomb.

The gentleman from the Office of HEW, Mr. Herman, would you also give us some kind of memo as to what the current status of the art is so far as the capability of these private sector firms to exhibit abroad, and where the funding would come from, in cases where they would need a little assistance for travel and so forth—can that be done under existing legislation? Or would new legislation be required?

I feel very strongly that we should share with the world the fact that we are concerned, that we are involved, and that we are sensitive to the needs of those—and I won't even say handicapped—of those with special needs, both educational needs and vocational needs. And I think our country has to make it possible for these exhibits to be shown in Scotland next year.

Yes, sir?

Mr. MILLER. The NIMIS program is for dissemination of information about programs that are available for teaching, for management, for student aids?

Dr. ASHCROFT. Not about programs, but information about instructional materials and technology.

Mr. MILLER. Instructional materials.

But on the receiving end, the local education agency, what have you, must have the ability to purchase the programs. You are not suppliers? What I'm saying——

Dr. ASHCROFT. Yes. The National Center has been a supplier of information through a program of the Bureau of Education for the Handicapped, a learning resources program, a regional program which has made it possible for local education agencies to get this information.

Mr. MILLER. What has happened? I mean——

Dr. ASHCROFT. That is being redesigned now, and we don't know what it will be——

Mr. MILLER. In light of 142——

Dr. ASHCROFT [continuing]. In the future.

Mr. MILLER. What's the change been?

Dr. ASHCROFT. We anticipate that there will be a substantially increased local demand for the service. But there still needs to be preparation on the part of teachers and the local education personnel to utilize the information.

Mr. MILLER. Now, when you say NIMIS II, at USC, what are you saying? What are they doing that is different from what you have done at Ohio State?

Dr. ASHCROFT. The request for proposals issued by the Bureau of Education for the Handicapped called for a redesign of this system, and it's to be called NIMIS Project II, and they'll be undertaking that redesign in the immediate future.

Mr. MILLER. For what purpose? Redesign as to what purpose? Yes?

Mr. HERMAN. Mr. Miller, if I may, we are obligated to recompete these activities every couple of years.

Second, the new competition was based to bring into focus new technology, and to deal with No. 94–142 in the States' increased responsibilities under No. 94–142.

Basically, the Bureau feels that it's necessary to deal more directly with the States at this time. That's the advice of outside people and State people helping us also. We also feel it's necessary to use our technology and whatever financial assistance we have to help the States to, then in turn, deal with their local education agencies instead of the Federal Government to go so far with the States as to take away any State initiative, and supply information to those people.

And we also, of course, want to take, while we had this opportunity to redesign the project, advantage of the new technology, such as minicomputers and microcomputers.

Mr. MILLER. But it's not a break in the flow of information?

Mr. HERMAN. No, sir.

Mr. MILLER. OK. Thank you.

Mr. SCHEUER. Any other questions from the members?

[No response.]

Mr. SCHEUER. OK. Thank you very much. It's been very interesting. We very much appreciate your time and effort in coming.

Next is Dr. Seymour Papert. the director of the artificial intelligence laboratory at Massachusetts Institute of Technology.

[The prepared statement of Dr. Seymour Papert is as follows:]

INFORMATIONAL PROSTHESIS

Statement of Seymour Papert

Cecil and Ida Green
Professor of Education

Massachusetts Institute of Technology

To the House Science and Technology Subcommittee (Chairman, James Scheuer) on Domestic and International Planning, Analysis and Cooperation.

October 18, 1977

(1) Many tens of thousands, perhaps hundreds of thousands, of Americans now condemned by such diseases as cerebral palsy to lives characterised by isolation, cultural deprivation and dependency could be liberated through proper use of computer technology. In the extreme case people who neither speak nor write and whose formal education scarcely reaches the level of the first grades could have access to culture, to communication, to social lives, and to careers.

(2) The reason why this has not yet happened is not technical but institutional. It is the direct consequence of policies and traditions in the funding agencies. These policies were appropriate in the pre-computer epoch but are fundamentally out of tune with what it takes to engage a sophisticated high technology. The key issue is illustrated by a current call for proposals by the Bureau for the Education of the Handicapped. This document indicates that the available funds will most likely be distributed in sums in the vicinity of $100,000 to each of twenty or thirty research projects. This is like trying to cross a thousand foot wide canyon by lining up a thousand people each capable of jumping one foot and ordering them to jump! If instead, the B.E.H. distributed a million a year to two or three serious, integrated projects, real results could be obtained. Of course, more money is really needed. But even larger sums would do no good without changing the policy of fragmentation into projects of sub-critical size. The deployment of the new technology needs to be considered in terms of total, integrated systems.

(3) The need for a holistic, global systems approach to the problem of liberation of victims of severe cerebral palsy

is not an isolated case. In my testimony on October 12th I showed how the same issues plague the whole field of applications of personal computer power to problems of enhancement of education, and of the quality of life in general. In that testimony I recommended the formation of a small number of centers of academic excellence in the new discipline of studying and developing this neglected aspect of the potential use of the computer. I believe that this same suggestion also provides the most effective approach to the use of computers to liberate the severely handicapped. Such centers could have a sufficiently wide span of expertise and of technical resources to provide the infrastructure for particular projects.

An example which refers back to the suggestion of an "informational prosthetic" for the severely cerebral palsied will give some insight into the need for a system. A person who is quite unable to manipulate physical objects or to speak, almost always has some control, even if slight, over some muscle. Once this residual control has been identified, and given that sophisticated expertise in artificial intelligence and pattern recognition is available, a computer can be programmed to recognize patterns of movement of that muscle and thus a channel of communication can be established from the person to the computer. Once established this channel gives the handicapped person the power to learn (provided that expertise in computer based education is at hand) to control that computer and so to carry out whatever acts a computer can be programmed to perform. In brief, these acts involve the manipulation of information. Thus, highly sophisticated manipulations of words, pictures, and sounds will come within the power of someone who previously could not perform more than the most rudimentary actions.

The gateway to culture is opened. So is the possibility of numerous careers, some of a routine nature, some highly creative. For example the person could now become a computer programmer or a technical writer or a novelist.

It should be evident that achieving this requires building a rather large system requiring in addition to computer hardware and software a social component and the organization of information. Clearly, building such systems will not come about through a larger number of projects each of which tries to provide a small improvement in the lives of the handicapped. Nor should this problem be confused with the more straightforward one of helping people with lesser degrees of impairment. For example, people who become paralyzed as a result of an accident have been linked to computers and have become very successful programmers. But these are people who already had an education, so the educational component of the system was much smaller than it would be in the case I am considering. The same remark applies to the development of social skills, to rebuilding a damaged self-image and so on. In short, our problem has many components only some of which are present in the simpler case. But none of these components pose insuperable difficulties. Our failure to build the system is due entirely to the difficulty in mobilizing resources of expertise, technical facilities and funding. This situation is quite inexcusable.

STATEMENT OF DR. SEYMOUR PAPERT, CECIL AND IDA GREEN, PROFESSOR OF EDUCATION, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. PAPERT. I'd just like to put two things before you.

First of all, I'd like to show you a tiny little piece of technology, and then I'd like to raise what I think is a critical issue about the whole perspective of this sort of thing. I'll try to spend just 2 minutes on each.

Mr. SCHEUER. Fine.

Dr. PAPERT. Now, the piece of technology—I think you can see it—as you can see on that screen, maybe you can see a little crude picture of a stick figure.

[Demonstration.]

Dr. PAPERT. I'm not going to be able to show you very much, and if you all come this afternoon we'll take you through the detailed steps. I want to use that as an example, which I'll illustrate in the context of prototype pilot experiments which we did at MIT, which I mentioned last week, and which Paul Goldenberg [phonetic] participated.

A child very much like Craig—you saw how by hitting at the right place on a board he could make a ticker tape come out with writing on it. Now, in these experiments I'm going to tell you about, by hitting on a similar board, which is connected to the computer, he can do anything that a computer can do.

One of the things that—this wasn't Craig; it was somebody else exactly in the same condition—he can instruct the computer to draw lines, and he can make pictures. Having made the picture, he can instruct the computer to print it, and get not only the ticker tape but a drawing.

Similarly, he can instruct the computer to make music. Similarly, if he does instruct the computer to make words, this can be not only on a piece of ticker tape, but it can be kept in the computer memory and be corrected later, and a part of his personal filing system forever. So 10 years later he can go back and look at his notes and his archives. He can cause it to be mailed as a letter.

All right. That's a little sample of the technology.

You'll notice that the picture drawn there of a stick figure—see, it's just the simplest picture you can imagine. Next to it is the star.

Part of what we're trying to do is create a way in which somebody with almost no previous knowledge of any form or thing, who has never drawn anything, who knows little geometry, who can't talk to a computer in terms of X's and Y's, can nevertheless begin to draw something which he has never done before.

The way he begins to draw is by using this computer system, in which there's—within the computer there's a little animal, with which he can identify. You call a turtle, and he instructs the turtle to walk on the screen by saying "Walk forward", and the turtle moves in the direction it's facing; or he can tell it to turn left or right. And this way he can draw on what he's already observed other people doing, walking around. And vicariously he can do it. And so this knowledge that he's been building up by observing the world gets channeled into a form where it's useful, where it is instructional—of course, he's learning geometry. But he is opening up the possibilities of being able to cause action in the world, and eventually have many sorts of careers.

Well, that's the glimpse of technology I wanted to give you.

I want now to raise a problem. Raising the problem puts me in a—I find it's an invidious, difficult situation, because when you ask us—by us I mean anyone in this sort of community, trying to make innovations—to come to you and tell you what we have done, we tell you what we have done and show you our wonderful pieces of machines and what great things they do.

There's a sort of built-in resistance in the whole procedure to tell you what we haven't done, because it's by telling you what we have done that we establish our credentials, that we get more money, that we justify the money we've got, and so on.

I think what we have done is so far short of what could have been done that—I think people mention who's in violation of the law for providing opportunities for the handicapped—I think we as a nation are in permanent violation of that law.

I'd like only to give an example to illustrate what I mean by this, by again referring to somebody in the position of the adolescent with cerebral palsy—that isn't Craig, who we saw. You can see how Craig is able to act on this board in order to produce writing. Now, I think that's a typical example of the kind of the phenoma of the situation that we're all forced into all the time in this sort of education, because the limitations of the funding and the resources available—I say it's a typical example of the concept of the automobile as the horseless carriage; if you take the new thing, the engine, and you put it in the carriage that you already have.

Now, in this case we have an education system that works mainly through interchange of words between teachers and students, and we make a machine where we automate that particular function. We make a new device which sits inside an otherwise unchanged—which expects to function inside an otherwise unchanged education system.

Whereas, in fact, a reconceptualization, a rethinking in systems terms, of the whole process of education, of what people should learn and how they can learn it, leads to a whole different picture of what can be done. But it's something which no individual group is very easily able to do in principle, and also because—this is my main recommendation, the main recommendation point I want to make—because of the kind of scale of funding which has become established in this business.

It becomes much easier for people to make other devices which fit into the otherwise unchanged system than for anybody to be concerned with the change of the whole system. As a result, we see more spectacular developments in areas like these machines for the blind, where the particular special need is such that making a particular device does in fact so transform the opportunities for the individual that you don't have to think in terms of changing the whole system.

I think for Craig it might be that if he is going to learn, not only how to put out a written message, if he's going to learn geometry, drawing, music, literature, we need to think in much, much broader terms. And this can't all be mediated simply by conceptualizing it as the problem of communication—conceptualization which I don't think anybody does willingly, but is forced to do by the way in which the conditions of work are set up.

And so I want to make this recommendation, that we as a community, that Congress treat it as a matter of extreme national urgency, to consider the systems aspect, the holistic, global redesign problem of education as a whole, of course; but because of today's special focus, particularly in relation to those individuals whose special needs, like Craig's, are of such a generalized nature that perhaps in order to make it possible for him to have a full life, full access to culture, to communication with people, we need to think in much wider terms. We need to think in terms of computer networks, in terms of his getting access to books that will be in centralized electronic form, where in terms of opening possibilities of professions where he can have an independent vocation of a routine sort or of a very creative sort, depending on his choice and aspiration level. And this is what I'd like to put on the record.

I'll be happy to answer questions.

Mr. SCHEUER. Very interesting, Professor. George?

Mr. MILLER. For the reasons that you cite, and a lot of other reasons, I suggest that we're basically in violation certainly of what is possible, that various programs might be done—not just what we've seen here, but in change of the system, educational system. I appreciate your remarks very much.

Mr. SCHEUER. Dale?

Mr. KILDEE. I have no further questions. I just want to answer the rollcall.

Mr. SCHEUER. Yes. All right.

Dr. Papert, you have stimulated us again and guilt ridden us again.

Mr. KILDEE. Do that again.

Mr. SCHEUER. We are way behind where we ought to be. I guess it's our job to push us all forward in sort of a quantum jump.

We'll take your words very seriously, and I'm sure we'll be in touch with you to get additional advice and counsel from you. Thank you very much for your testimony.

Is there anything else we can learn from looking at your technology that we haven't had a chance to see?

Dr. PAPERT. Well, you see, I think something about the computer technology is the way it interacts with you and becomes something personal between you and the computer.

Mr. SCHEUER. Yes.

Dr. PAPERT. And to get a real feel for it, what you have to do is go and sit down and be in communication with it. And so I invite everybody to—the young lady and the machine will be here this afternoon.

Mr. SCHEUER. Very good.

Dr. PAPERT. We'll be able to show more.

Mr. SCHEUER. Excellent. We'll be seeing you later.

I'm going to turn over the Chair to Dale Kildee, a distinguished member of our Subcommittee on Select Education.

Thank you, Dale.

Mr. KILDEE. Thank you, Mr. Chairman.

Our next witness is Mr. Dustin Heuston, chairman of the World Institute for Computer-Assisted Teaching in New York.

[The prepared statement of Mr. Heuston is as follows:]

EDUCATING THE HANDICAPPED
THROUGH THE USE OF THE VIDEODISC

Prepared for a Joint Hearing
of the
Subcommittee on Select Education
and the
House Science and Technology Subcommittee
on Domestic and International
Scientific Planning, Analysis, and Cooperation

October 18, 1977

Dustin H. Heuston, Chairman
WICAT Incorporated

Room 29E
111 East 85th Street
New York, New York 10028
(212) 876-1144

Suite 10
1160 South State Street
Orem, Utah 84057
(801) 224-6400

EDUCATING THE HANDICAPPED
THROUGH THE USE OF THE VIDEODISC

An Ideal Educational Device for the Handicapped

In the next few years the videodisc will become a familiar entertainment and educational device. Because of its unusual characteristics, it promises to be an extremely useful educational aid for the handicapped. This would be a propitious time for some projects using prototypes of the videodisc in experimental programs. Then, when the videodisc becomes an inexpensive commercially available product, it will be usable immediately for the handicapped. The first test commercial models should be appearing in the fall of 1979 and the disc will probably be distributed nationally on a regular basis by 1980.

One of the advantages of beginning work on the device immediately would be the possibility of influencing the development of its design specifications. At this moment the commercial vendors are in a state of flux in their videodisc keyboard and interface design, and should pilot projects demonstrate to them some educational uses of the videodisc for the handicapped, then undoubtedly the potential for these specifications would be retained in the final product. To the extent that this is possible, it is an important consideration. If these unique specifications are present in the models that are released for the mass market, those devices that are used by the handicapped will cost a great deal less than if they are expensive modifications of the standard units. Undoubtedly some of the requirements for educating the handicapped will be so unique as to force expensive modifications, but to the extent that standard units may be used a great deal of money will be saved.

In order to understand the potential power of the videodisc as an instructional unit for the handicapped, we should consider the design specifications of an ideal educational device. Such a device would have the following characteristics:

(1) The device should utilize as many of the senses as possible. The videodisc does this because it will be able to present color movies or still frame pictures with sound.

(2) The device should be able to offer interactive instruction that can ask questions in sound, print, or by a manual device, process the answer through computer control, and then offer a response to the answer to clarify the student performance. This constant sequence of trials and responses is particularly useful for handicapped students who may be trying to upgrade a marginal skill. The infinite patience of the machine in giving the needed trials is one of the great advantages of technology.

(3) The device should be able to offer a maximum artistic and emotional impact in its presentation format. There should be color, sound, motion, plot and character identification, etc., to inspire, stimulate and motivate the student to interact and gain mastery of the educational tasks. Since the videodisc uses the color television screen as one of its output formats, it can incorporate all the latent drama of a movie or television production.

(4) The device should be as little teacher-dependent as possible so that the education of the handicapped will be attainable where marginal teacher skills are available. Students will always need the example, identification, inspiration and modeling that teachers and adults provide; but to the extent that the device can ensure flawless educational instruction, the student will be protected from the vagaries of uneven teacher performance. Since the videodisc will have the capability to offer individualized interactive instruction better than any other known technology, it will meet this specification.

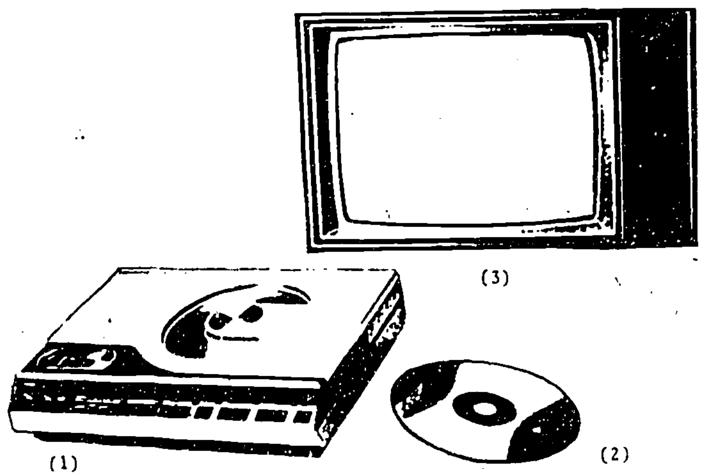
(5) The device should be portable and usable in a home as well as institutional environment. Since the videodisc uses the color television screen as its normal output format, it is an ideal device for this purpose. This means that many of the handicapped students who have difficulty in traveling between their homes and centers of education, or information centers such as libraries, will have an astonishingly prolific resource center and instructional device to be used in their home environment. Furthermore, handicapped workers who desire further training in their skills will be able to take instruction at their place of employment rather than be transported to special professional schools for this additional training.

(6) The device should be inexpensive, reliable, and maintainable by normal repair facilities. The videodisc should fit these

specifications very handily since it promises to be a standard consumer item that will be repaired through the replacement of simple boards much as a modularized television set is at present. If it does achieve consumer acceptance, then many standard repair facilities should be able to maintain the device. The videodisc player will sell in the $500 to $1,000 range, depending on the characteristics desired in the player. It looks like a large record player and will connect directly to the antenna of a color television set.

The Videodisc Components

In discussions of the videodisc, the reader should be aware that in the early, or consumer model, videodisc there are three components to the package: (1) a videodisc player, (2) the videodisc itself, and (3) a color television set connected by wires to the videodisc player:



A short time after the consumer model is introduced, a microprocessor will be added as a fourth component to allow the player to be driven under computer instead of manual control. For the purpose of this paper the two systems will be distinguished by calling the first the consumer model and the second the educational model. Actually, both models will be usable for education, but the addition of the microprocessor will make the videodisc a much more powerful educational device.

The Videodisc in Perspective

The educational potential of the videodisc can be heightened by comparing the videodisc to other technologies. The three most important technologies that education has attempted to harness are:

(1) The book.

(2) The motion picture (television).

(3) The computer.

Each of these technologies has enormous strengths and weaknesses as an educational device, and before we examine the videodisc in relation to them we must see them in perspective.

The book. Most people have forgotten that the book is a product of technology, and indeed to date is by far the most successful use of technology in aiding education. It is portable, relatively inexpensive, and has random access abilities. It can be easily replicated accurately and distributed. There are some major disadvantages of the book, however:

(a) It is not interactive.

(b) It lacks motion and sound.

(c) It cannot be personalized or modified very easily.

(d) It produces only fair learner productivity because of the first three points. The book is inherently a passive device which requires a well trained, highly literate and highly motivated user to be effective. Unfortunately, the population that needs to be trained the most is functionally illiterate and, therefore, has difficulty using the book.

Television (the motion picture) once appeared to have the greatest potential of any of the media for instruction. It has many obvious advantages including the expense of the equipment, the lack of communications costs, and the fact that it is already present in almost every home. After a number of years of usage, however, there are some fundamental shortcomings in the use of television broadcasting as an instructional technology. While the technology increased the productivity of the teacher, it is not a very productive approach for the learner. Some of the shortcomings from the productivity of the learner are as follows:

(a) He must arrange his time to be available at the moment the material is being broadcast.

(b) The presentation is in a serial form so that he must wait patiently for the appropriate significant moments. Even in reading a newspaper one has random access ability that television lacks.

(c) He cannot stop the material and review it if he has suddenly found it too difficult.

(d) The materials being presented rarely are at the appropriate level for his individual needs at that point. He cannot have an easier or harder version of what he is studying, and he cannot go into any aspect of it in any depth.

(e) He cannot interact with the materials and get a response as he attempts learning trials.

The strengths of a standard computer assisted instruction approach with either CRT or teletype terminals are well known. Instruction can be individualized and made highly interactive. There have been some graphics materials added with special graphics terminals, but for the most part the standard CAI approaches lack the ability to use the motion picture sound and color format that can be so appealing to a student. To date these systems have been expensive and also require high communications costs when the materials are placed at a distance from the host computer.

The Videodisc: A Combination of Strengths

The single most important insight to retain about the videodisc in education is that it combines the strengths of these three previous technologies. Since it combines these strengths it helps eradicate their weaknesses because, as we have seen, each technology's strengths complement the others' weaknesses. A chart should help to clarify this:

BOOK	
Strengths	Weaknesses
1) Random access.	1) No interactivity.
2) Low expense.	2) Lack of motion and sound.
3) Availability.	3) Requires literacy.
4) Replicability.	4) Fixed level of difficulty.
	5) Usually in one language.
	6) Requires high learner motivation.
	7) Low learner productivity.
FAIR LEARNER PRODUCTIVITY FAIR PRESENTATION FORMAT	

TELEVISION (MOVIES)	
Strengths	Weaknesses
1) Audio capability.	1) Serial presentation, no random access ability.
2) Visual format allowing photography.	2) Inability to freeze a frame.
3) Motion capabilities.	3) Inability to give trials with feedback.
4) Use of plot & characterization.	4) Passive system. User cannot initiate any materials.
5) Ease of availability.	5) Limited depth of instruction.
6) Low expense.	6) Extremely poor learner productivity.
POOR LEARNER PRODUCTIVITY EXCELLENT PRESENTATION FORMAT	

COMPUTER	
Strengths	Weaknesses
1) Random access ability.	1) Lack of audio.
2) Ability to give trials with feedback.	2) Poor presentation format; primarily black & white.
3) Active system. Ability to compute & run programs.	3) Lack of motion and photography.
	4) Lack of characterization & plot abilities.
	5) Expense.
POOR PRESENTATION FORMAT EXCELLENT LEARNER PRODUCTIVITY	

→ VIDEODISC WITH MICROPROCESSOR

(STRENGTHS OF ALL THREE TRADITIONS)

As the chart indicates, the videodisc combines the strengths of the other technologies. But the videodisc as a technology, however, has two potential weaknesses:

(1) It is a ROM (Read Only Memory), like an LP record, that cannot be modified by the user. Unquestionably many consumers will prefer a tape cassette unit which will enable them to tape any program they desire for just the cost of that tape. The videodisc cannot be modified by the consumer, and thus enough exciting material must be developed independently of standard television fare and kept at a low enough cost to make the player attractive for the consumer.

Even this apparent weakness has a positive aspect to it, however, because a Read Only Memory offers some protection from piracy for the commercial developers of educational and entertainment materials. Many of these commercial producers are reluctant to use a device such as a videotape cassette as a storage medium for their materials because they can be readily copied and pirated without paying royalties or purchasing additional copies from them. As we have already discussed, the format of the videodisc will most likely have motion picture sections alternating with many still frames, and any taped copy of this for a videotape player would only present fragmented movie clips followed by a blur of jumbled still frames going by the screen at 30 frames per second. Even in cases where videodiscs have very few still frames in them, the tape cost for the copy may very likely be more than the cost of purchasing another videodisc.

(2) It is an unproven technology that must be sold in sufficient volume in the marketplace to keep its cost at a reasonable level. During the next few years there will be an interesting marketing struggle between the cartridge tape and videodisc manufacturers. The manufacturers of the tape players hope to place their products in great volume in the home market before the videodisc player manufacturers can complete their market testing and bring their product to the marketplace for the consumer. Their hope is that if the consumer is only going to purchase one playing device to attach to his color television set and if the tape cassette player is available sooner, they will wrest away most of the available market. In truth, since each device has unique abilities, both will probably find a niche in the consumer marketplace over the next few years.

The tape cassettes have one distinct advantage and six serious disadvantages in relation to the videodisc. The advantage is that the consumer can tape any program he wants from the television screen and retain a copy for his files. The videodisc must be pressed at a factory, so the consumer will only be able to play program materials that he has specifically purchased in videodisc form.

The disadvantages of the tape cassette approach are:

(a) The tape system cannot currently be accessed randomly, and although there will undoubtedly be some attempts to rectify this in the future, it will always lack the simplicity, speed, and reliability of the videodisc technology.

(b) The cost for the tape itself will exceed the cost of the videodisc materials. Thus the videodisc should always cost less in raw materials to manufacture than tape cassettes.

(c) The mechanics of handling tape are inherently more complex than those of handling the videodisc. This means that the equipment will have to be more complex and will have more reliability problems.

(d) The tape will always wear out after extensive usage, whereas the videodisc, using a laser stylus, will for all practical purposes last indefinitely.

(e) Unless unusually high volume is achieved, the price of the tape player will also be more than the videodisc player because of the equipment's complexity.

(f) The tape system cannot currently handle a still frame without extensive modification.

A discussion of costs in developing educational materials will be found in the next section on authoring. At this juncture we can make some reasonable guesses that will serve as general guides:

(1) The videodisc consumer model player will sell in the neighborhood of $500.

(2) The cost of the material used to press a videodisc will probably be in the 20¢ to 50¢ range.

(3) The records are likely to sell commercially in the $10 to $20 range per set, although it is conceivable that the cost could drop as low as $5 for some markets. A two-hour movie would require four discs, and the movie would be sold as a set.

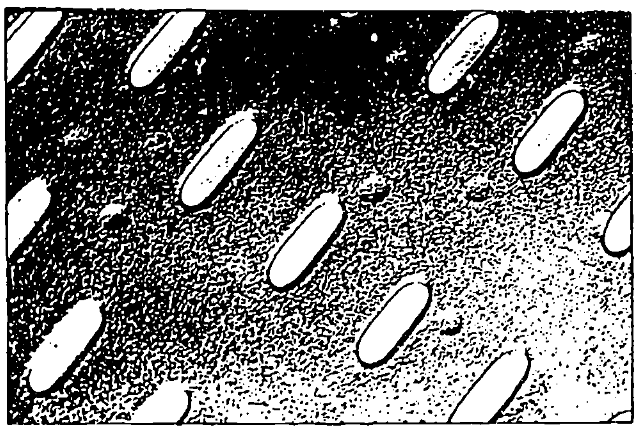
(4) The more sturdily built educational model with the microprocessor will probably retail in the $1,000 range.

Summary

Each of the technologies has special strengths and weaknesses, but overall the videodisc should have the ability to combine the best features of a number of the others. The hardware will be inexpensive and yet, while retaining the emotional impact of motion and sound inherent in a film or television medium, it will also add the ability to offer individualized and interactive instruction for the students that has been available only with computer assisted instruction.

A Closer Look at the Videodisc Technology

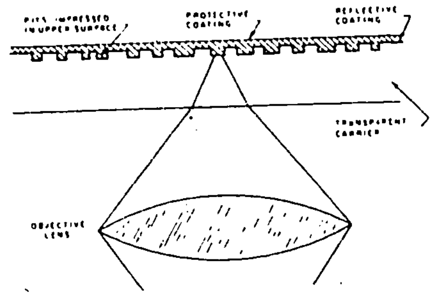
The videodisc looks very much like a shiny silver-colored LP record. Unlike the LP record, however, the videodisc has its information stored on it by burning tiny pits with a laser on a metal master, as the following diagram indicates:



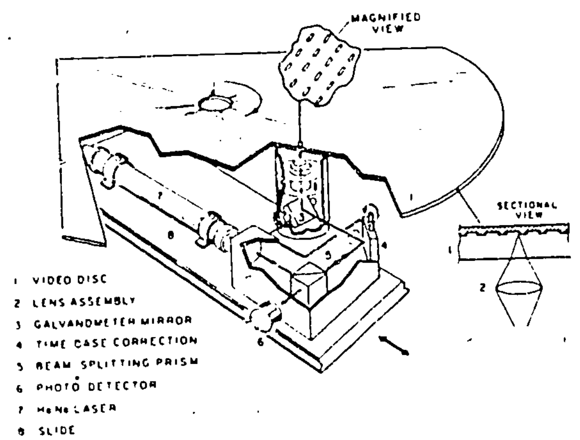
The density of the pits is quite extraordinary with approximately 650,000 of them being stored in an area the size of the head of a pin.

Then, following a procedure similar to that used to produce LP records, a nickel stamper copy is prepared from the master disc. Plastic discs are then replicated from the stamper and are given a reflective aluminum layer to enable them to be read more easily. Then a protective coating is placed on top of the videodisc and a protective transparent coating, which can carry light, is put on the bottom of the disc. A laser light, acting as an "optical stylus," reads the disc from below.

Cross-section of disc being read in a videodisc player



The following diagram is a portrayal of a videodisc being read by a laser:



The arrangement of the laser pits that carry the information in the videodisc is dictated by use of the device for a color television format. The pit information is stored in a series of tracks that have the following characteristics:

(1) Color television still frames (54,000). There are 54,000 tracks on the early versions of the videodisc, and each of these tracks contains enough information to generate one full color television frame. The way the figure was determined is as follows. In order to give a semblance of motion, color television frames are played at 30 per second, and since the design goals for the early discs are 30 minutes of television, the record has

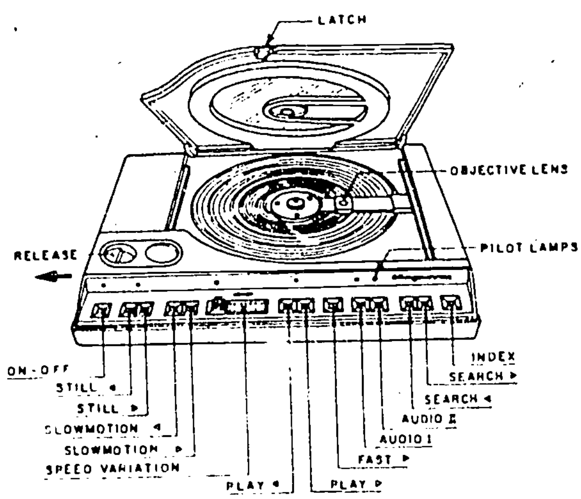
1 circular track for each color television frame
x 30 for each second = 30 tracks
x 60 for each minute = 1,800 tracks
x 30 for 30 minutes of playing time = 54,000 total tracks

(2) Sound (two channels). Also encoded in the pits of each track is sound information that allows two different sound channels to be stored. They can be played simultaneously to provide stereophonic sound, or one channel at a time. Because of synchronization problems the audio is silent when the record is being viewed in a still frame, slow motion, or reverse order sequence. Thus the audio only functions when the record is playing in a normal 30 frame-per-second forward motion sequence.

(3) Frame numbers (54,000). Also encoded in each track is the particular frame number of that track. When playing the videodisc, the user has the option of either displaying the number of the frame in the corner of the screen or omitting it. If the number is omitted, there is no hole in the screen, and the portion of the picture that has been overlaid by the number returns to the screen.

(4) Automatic stop devices. Information is also encoded on the disc which tells it when to automatically go into a still frame mode. As we shall see later, this can be a very useful educational device.

The player, as the diagram below indicates, looks like a record player with many additional controls on the front panel.



The triangles in the diagram next to the control labels point in the direction the control will be driving the disc read mechanism.

Videodisc information is read from the disc by shining a laser through an objective lens, where it comes in contact with the spinning disc and is reflected back through the objective lens, having been modulated by the aluminum coated pits on the underneath side of the disc. This modulated signal is amplified and sent to an unused channel of the color television set.

Two important points about the laser need emphasis:

(1) The objective lens focuses the light beam inside the transparent protective coating (carrier). The advantage of this inner focus technique is that dust particles, fingerprints, and scratches on the outside of the disc's protective coating will not be in the plane of focus, and hence the disc will have a long and accurate lifetime.

(2) Similarly, since the laser is acting as an "optical stylus," there is no physical wear as the disc is read. Thus, unlike an LP record, dust, fingerprints and scratches on numerous planes will not degrade the performance of the videodisc.

The controls in the above diagram are almost self explanatory:

(1) Still. Touching the Still control holds the current frame in a still position on the television screen. It accomplishes this by reading the same frame track 30 times a second.

(2) Slow motion runs the disc at the speed set by the Speed Variation control at some rate "between" the Still frame position and the Play (normal speed) setting.

(3) Fast allows a 3-times normal forward speed to be applied.

(4) Audio I and II allow for a choice of the audio channels.

(5) Search allows a rapid search of the disc in either direction.

(6) The Index key either displays the frame number or omits it.

Some Educational Implications of the Characteristics of the Videodisc and Videodisc Player

The physical characteristics and capabilities have some interesting educational implications:

(1) Automatic frame stop. The normal color motion picture presentation will have an important instructional feature added by this ability. After an instructional sequence using motion pictures, the disc will freeze on a frame that begins a formal instructional sequence which requires response from the student.

(2) Frame numbers. Because each frame has a code number, or address, the students will be able to branch rapidly to find specific information. In the consumer model this will be done manually, but when the educational model appears with a microprocessors, this address becomes critically important since it will allow for automatic interactive instruction. If a student responds to a question improperly, the computer will not only process his answer, bu' 'ill be

able to go automatically to a preassigned frame number that will begin a proper sequence of instruction as feedback to the student answer.

(3) Dual audio tracks. The audio capabilities will allow the student to listen audio in one of three ways:

(a) in stereo, or

(b) in any one of two languages, or

(c) in an elementary or advanced version in his native tongue.

Thus the student might view the material first in English and then a second time in Spanish, or he might hear an elementary description first, and then view the same material while listening to a more advanced and complex description. One version could be for a layman and the other for a scientist. Publishers might use the same visual material and reserve one sound track for high school students and the other for a presentation for advanced college students.

(4) Adjustable forward and reverse timing. Slow motion (timing) sequences will be used by students who want to follow the motion continuity of the materials they are viewing at a pace they can comprehend. There are some other interesting possible uses of this timing mechanism, however, because the same timing device could also be useful for building timing and pacing potential into instruction. Some classes, such as reading, might want to pace students in their exercises.

Another obvious subject matter area that could use a pacing device would be a typing class.

(5) Manual fast forward and reverse search. At first glance these controls seem like a utilitarian necessity, but a close analysis of the potential they produce suggests some important instructional implications. The fast forward and reverse feature will encourage the student to search through the disc in a discovery mode. The appeal, and hence motivation, that this feature carries with it is most impressive. A visual color motion presentation with sound is inherently the most interesting to view, but never before has a viewer been able to race through the material and pause, by choice, to assimilate or review sections of interest. After using this feature for a few moments, a user discovers:

(a) The excitement of visually exploring the unknown in color, sound and motion.

(b) The pleasure of being able to skim past the unwanted. Viewers traditionally are held hostages to time when viewing movies or television, and the videodisc emancipates them from this burden.

(c) The speed with which the materials can be viewed. This speed of traversing the disc should create an enormous market for new materials.

(6) Still frame. Conversely, the still frame device will lead to a much more profound depth of learning than television

or movies currently allow because this characteristic encourages the viewer to focus and dwell on discrete units. Obviously, freezing a single frame from a motion sequence allows a more careful look at a detail, but the real significance of the still frame will follow from its ability to allow supplementary material to be added to the motion sequences in graphic and textual formats.

The addition of these graphic and text slides is significant because they allow an extraordinary in-depth treatment to be made for any subject that has been portrayed during the motion sequence. In ten seconds of viewing time of a motion picture, a commentator cannot describe a great deal to the viewer. Those same ten seconds can support 300 individually different slides full of specially constructed graphics and prose materials to lead the viewer through a complex learning experience which describes in great detail the implications of what the viewer has seen during the motion sequence.

One of the interesting lessons the still frame device is teaching the first authoring teams about the motion picture sequence is how inherently poor an instructional device a motion picture can be. A picture may be worth a thousand words, but there is no way for a commentator to offer even a fraction of the information the viewer needs to understand what he is viewing to any profound degree. In fact, motion picture and television technology have provided an extremely unbalanced teaching mechanism. Visual material has stunning import and potential, but because of the time restrictions, the verbal commentary tends to be extremely superficial.

Another way of describing the contribution of the still frame capability is to say that it will allow a motion picture sequence to have thousands of pages of interactive textual material and graphics to be added to it. In fact, as the authors design and write the individual frames to complement the powerful motion picture sequences, they comment that they feel as if they are writing chapters of a book around various motion picture sequences.

(7) Chapter stop. The chapter stop is a fast forward or reverse tab key that goes rapidly to predesignated locations in the videodisc that may be thought of as chapters. Obviously such a capability will allow an index to be used to help move a reader about the disc with great efficiency. But it will also encourage the use of glossaries, minor dictionaries, and reference sections. Thus some features of the book will be added to the disc.

(8) Adding audio capabilities to still frame formats. After the development of the consumer manual model, and the subsequent construction of the educational model with the

microprocessor, a third logical evolutionary capability will probably involve the addition of audio capabilities with still frame formats. If the information stored by the pits in the tracks is reserved for audio alone instead of also including the television information, then each track of the videodisc could store about 10 seconds of speech. One way of using this capability might be to reserve an audio track after each still frame where 10 seconds of speech would be useful. Pushed to its maximum in using this strategy (reserving every other track for audio), the capacity of the disc would drop to 27,000 still frames, but would now include 75 hours of audio that could be played during still frame presentations. Such a disc could mix regular motion picture presentations with the still frame commentary. One obvious use of such a disc would be to have a talking encyclopedia presentation.

Ultimately, authors will view the videodisc's capabilities as a series of options that they will use in terms of their particular instructional needs. The basic unit will be the individual track which will be used in one of three ways in relation to different time requirements:

(a) In a normal motion picture sequence with audio where 30 frames (tracks) per second will be used.

(b) In a still frame mode where any one of 54,000 frames (tracks) can be addressed and held in a frozen position for as long as desired.

(c) In a still frame audio mode where tracks will be sacrificed to give audio capabilities to still frame presentations at the rate of 10 seconds of audio per track.

(9) The use of movies and television tapes that have already been developed. There is an enormous body of tapes and movies previously developed for education or with educational potential. By adding interactive instructional frames to these materials, educators will be able to draw upon millions of dollars' worth of materials that have already been produced. Publishers will be able to upgrade instructional movies, television networks will be able to draw on their existing materials (including videotape news presentations), and commercial filmmakers will be able to offer some of theirs.

(10) Productivity. Perhaps the most impressive contribution of the videodisc as it is coupled with the microprocessor will be its dramatic increase in learning productivity (the productivity of the learner instead of the teacher). In the first section of the paper this point was touched on, but the point is so important that it needs amplification. Using a videodisc with an interactive keyboard, the student's productivity will soar because:

(a) He can interact with the material at a time of his own choosing. He will be able to go to those sections of the material which he chooses to work with at that moment, and if he has problems he will be able to review the materials with excellent interactive instruction. The material that is presented to him will be exactly at the appropriate level for his individual needs, and should he choose he can explore aspects of it in great depth. As he does interact with the material he will have numerous trials at mastering it with immediate feedback as to how he is doing with each trial.

(b) As we move beyond the domain of the young learner, the videodisc will save enormous amounts of travel time for the adults who must now commute to centers of learning with the attendant cost in time, money and energy.

(c) The videodisc will also help employees get on-the-job training without having to drop out of the work force for protracted periods at distant company training sites. An interactive videodisc station could exhaust a learner with one to two hours of daily training that would require just a portion of the working day. Thus the learner could basically stay on the job while still receiving excellent training with a minimum of productive and social disruptions.

(d) Another productive use of the videodisc will be its use by workers and students to help refresh them and retain the skills that they have just mastered in previous training. Frequently an enormous investment in time and finance is required to train someone, and then when he goes back to the work force or ends a semester he quickly begins to lose the knowledge he has mastered. Short interactive sessions with the videodisc will be an excellent way to help the learner retain, and indeed enhance, the original learning experience.

(e) The videodisc stations will also be an excellent way for handicapped workers to receive instruction updating their skill or knowledge areas.

STATEMENT OF DUSTIN H. HEUSTON, CHAIRMAN, WORLD INSTITUTE FOR COMPUTER-ASSISTED TEACHING

Mr. HEUSTON. Thank you.

The videodisc looks very much like a home record player, and will connect to a color television set. It will probably be the most revolutionary educational device for the rest of this century, because it has a great many advantages. I'd like to call your attention to them, since it will have so much of an impact, in terms of potential for education.

If you look inside the brochure that has been distributed, you will see that the videodisc looks like an LP record. It stores, basically, 50,000 color frames. It works the way a television set works; it runs 30 frames a second past the screen. Therefore, you're going to have about 30 minutes of television if you put a single videodisc record on, and you'll see it playing on the player.

You can label those 54,000 individual frames from the videodisc, and you can address any one of those frames and stop it on the screen. So, by simply touching a button, you can pull any one of 54,000 frames to the screen and have it freeze. You cannot do this with television.

Second, you can randomly access any one of the frames very quickly. We'll be able to do this with a computerized model shortly, so the student would be able to take instruction on a terminal, be asked a question, respond, and the computer will calculate, immediately go to the videodisc, feed on the television screen an answer, talk to the student, respond, and give him interactive instruction.

Now, the reason this is so powerful and so important is that it's going to combine the three most powerful technologies that have ever been used in education. The first, and most familiar that we've been using for 500 years, is the function of the printing press and the book. The book stores information, is very portable, and inexpensive.

The second great hope we have in terms of technology was with television. We had hoped that television would be able to be of great service to our Nation, and we put a great deal of money in educational television.

On page 9 of the report I've given you is a chart which you might want to look at later. I don't want to take you through it in any great detail. It discusses the differences between the book, television, and the computer. These are the three technologies, that are the most significant. Each has strengths and weaknesses.

The book, of course, is inexpensive, and it's portable, and it's available, highly replicable, and therefore, very helpful.

Television's awesome impact is that you can get it to people's homes or classrooms. It has color, sound, and motion, which is very useful—a book does not. It can use plot and characterization; people can identify with this. If we turned the lights out, turned the television set on, you would all become mesmerized in relation to my talking to you, or handing you a book or a pamphlet to look at.

We're raising a generation of people who absolutely are locked on television. As you know, I'm sure, from statistics, the average student by his midteens has seen more television than he has spent time in school—about 1,000 hours a year of television. Therefore, we're raising primarily a visual generation.

There are some extraordinary weaknesses to television as an educational format. In terms of learner productivity, it's a disaster. A student has to sit and wait for the information to come through in serial sequence. They cannot stop it, they cannot interact with it, and therefore they become very passive. It cannot give trials to the student, cannot freeze a frame, and has limited depth of instruction in terms of what a narrator is saying. Therefore, it's very poor for learning productivity.

Computer productivity is outstanding. It has random accessibility. It can ask a student a question; the student responds. The computer calculates, feeds back an answer immediately, and starts pulling the student into some fierce interactivity. By getting this, the student gets the trial necessary to learn the information.

We all need trials to master. A slow learner may need 50 trials; a fast learner may do it in 3. We have to, ourselves, become actively involved, as Dr. Papert has just pointed out. Therefore, television has in a sense failed.

The computer was much stronger. But the computer output format is a disaster in terms of emotional excitement. It's simply print on the screen, or print on a paper. So, compared to the excitement of a television or movie format, the sound, motion, et cetera, the television is far more valuable.

Now, what the videodisc will do basically is to combine these three in one device. You will be able to be taking instruction with, say, 3-, 4-, or 5-minute bursts of a movie, with a narrator talking about it. Then the videodisc will stop and the user will start an instructional sequence by using special keys.

If, for example, to give you an idea of the power of that information we'll be able to use here, by taking out 10 seconds of a half hour production, we'll be able to insert 300 individual still frames in color, with excellent learning theory behind it, and with special keys to take students through it. So we will be able to salvage the power of the television production, with color, sound, and motion; then it will freeze, and the user can go into a very interactive instructional format with drilling practice.

The second generation videodisc will have a computer built inside so as the student responds, the answer will be processed automatically. There will be automatic feedback. The student will be given responses back predicated on their previous trials. It will be an ideal instrument.

Now, there are some other aspects to this which are very exciting. A record will cost about 50 cents to make. It will not wear out, because it's read by a laser beam. Therefore, we will be able to distribute in great quantities these disks throughout the country.

The consumer model player, which will be on the market a year from now, will play up to one hour with one-half hour on each side. It will be played manually. It will not have the computer. It should retail in the neighborhood of $500. They will be selling records for maybe $10 or $15, which will be able to flood the schools, homes, and wherever people want instruction in this format.

That's the general description of the videodisc.

We have been working on the first educational videodisc for the McGraw-Hill Co., and have been terribly impressed by the process of putting this together, because it was only through doing this that we discovered that we were basically putting the book back right into the possibility of a movie. We found, in analyzing an outstanding movie that was McGraw-Hill's best science seller, that the instructional theory in a movie such as that has to be very limited.

It turns out you're putting an image on the screen with a tolerance time that a student can look at it, and a narrator talks about that image. The narrator then sets the level, the language, the cultural feelings, and gives you the information. In 10 seconds of narration you cannot say very much. Subtract 10 seconds and you can put 300 still frames in. It's like putting a book right in to back up what you've been seeing. It's an astonishing combination.

Therefore, we see that we're going to have a very moving opportunity in the future. Now, the videodisc, as it stands in the first model, will take two sound tracks; so you could have an English version and a Spanish version, or a French version. You could also, with careful instructional theory, make a videodisc almost culturally blind, and just insert your sound. Both tracks may be in English. One could be an elementary school description of what you're looking at; the other might be a college description.

Now, questions on it?

Mr. KILDEE. Mr. Heuston, you talked of working with McGraw-Hill and utilizing this for education.

Have you had any evaluations of utilizing this for educating the handicapped, as such?

Mr. HEUSTON. No. I put in my report that it's an ideal device for the handicapped, because it touches on so many senses. And, since it will have the computer ability, you will be able to use this in a number of areas.

For example, the computer cannot store very much sound as a rule because it requires digital breakup and storage on a disk. Therefore, you suddenly have a sound capability with the videodisc.

If you talked to somebody involved with working with the handicapped, one of the central problems is how many of the senses the device can cover. The videodisc will cover the maximum amount of senses, and therefore it has that remarkable potential.

Mr. KILDEE. Congressman Miller?

Mr. MILLER. No questions.

Dr. SWANSON. Mr. Chairman——

Mr. KILDEE. Yes?

Dr. SWANSON. We've heard other testimony, Mr. Heuston, and we're aware of cassettes and videotape recorders.

How do you assess the performance capacity of this system, especially in terms of mass marketing of the videodisc versus video cassettes which are already on the market?

Mr. HEUSTON. It will probably be somewhat like the difference between buying an LP record and buying a tape cassette. You'll have an option.

But the trouble with the tape cassette is that it cannot randomly access sections easily. It cannot freeze frames. And it's restricted to again, the verbal comment.

Dr. Swanson. But the videodisc has instructional advantages, whereas the tape cassette has entertainment advantages in a sense.

Will there be a technology where you can videodisc programs right off TV?

Mr. HEUSTON. No. You will not probably in the near future be able to take a TV program off and put it on a videodisc.

Dr. SWANSON. Is that in the future at all possible?

Mr. HEUSTON. It depends on the laser technology. They have to burn it on metal now. They actually put pits on metal, and it would be hard to erase that and they re-do it. But, of course, in the advanced labs they're working on problems such as this.

Dr. SWANSON. Ok. Thank you.

Mr. KILDEE. Any other questions?

Mr. WELLS. One general question Dr. Papert raised, which I might address to the witnesses, if they wished to comment, and that is: Instead of looking at these individual problems as discrete problems, and you come up with a discrete piece of equipment for that particular problem, that perhaps we should be thinking in terms of some conceptual framework of education that is not solely confined to the handicapped but is generally useful, and therefore you can then move to the kinds of mass production which will solve the high-cost problems which are so associated with these very fragmented markets that each of you have told us about.

Mr. HEUSTON. In my report I address that. One of the important points is the phrase used in the industry, technically called a learning curve. Every time you double the production of an item its price drops 28 percent, so that, as your hardware increases in volume, the price relentlessly goes down.

If some work is done right now with the videodisc and in some of these new areas, the manufacturers are still in a state of flux in terms of setting standards for interfaces and how to work with it.

If they wait until the consumer market alone dictates what the standards are, then they will not be very modifiable in a year or two from now, when people start using them. Once, manufacturers are at a high-volume production, one then has a very difficult time modifying anything.

Mr. WELLS. I was thinking, just in terms of myself personally, Ms. Gillsepie, the Optacon user—with the massive amount of material which I personally have to read each day, I would very frequently love to close my eyes and just simply not—I mean continue reading—but not have to end up bleary-eyed at the end of the day. And whether this kind of a use would have application throughout society, rather than simply for the blind.

Mr. HEUSTON. Yes.

Mr. KURZWEIL. With respect to Dr. Papert's testimony, I think there are some very specific communication problems that different handicap populations have that have to be addressed with specific devices, otherwise handicapped persons just aren't going to be able to compete in any way.

Particularly, we're interested in mainstreaming deaf and physically handicapped and blind children in the ordinary classrooms; they're going to have to be able to read the same text with the same facility; they're going to have to be able to understand what the teacher says; and they're going to have to be able to prepare written reports. These are very specific problems which have to be broken down and addressed individually.

I think there is a way that this type of technology; despite the limited market—and it's really not as limited as you might think;

but it is more limited than the general consumer market—that can be addressed by using computer technology as much as possible.

What we're doing and what other researchers are doing in this area is applying the advances which are being used by all consumer products in our particular applications, and as new computers come out that only cost a few hundred dollars, and as powerful as the $50,000 computers that existed 5 years ago, we can take advantage of those in our device and pass that cost savings on to the handicapped consumer.

So products for the handicapped, even though they're produced in smaller volume, definitely do take advantage of this revolution in computer component fabrication techniques.

Mr. WELLS. Thank you.

Mr. KILDEE. Mr. Vanderheiden?

Mr. VANDERHEIDEN. Also, a lot of the interfaces and special techniques we're talking about are aids to interfacing or allowing the individuals with specific severe handicaps to use materials that are normally used by the general population for education.

So, in trying to develop this general model for education, we need to bring the individuals with severe specific handicaps to a common ground so that they are able to use the same materials others use. And this, again, can reduce the cost of education to special individuals. If you can allow them to overcome their specific handicaps to the point where they can begin using the materials that everyone else does, we can run a more unified program, such as that.

Mr. KILDEE. Mr. Heuston, would you like to respond?

Mr. HEUSTON. Yes. I want to make a recommendation if I might—and I'd like to hear what Dr. Papert feels too, because he's been involved in this area a long time.

As I review the errors of the past, it seems to me that the single most blaring one is the way the agencies are now so constituted in a competitive bidding sequence, and are not going out commercially to market, but say for projects for NSF, or NIE, or something like this. We're ending up with a multitude of small groups of people getting $100,000 grants, $50,000 grants, et cetera.

High technology requires a high minimum mass of capital in a sustained position for a long time.

It seems to me that the only way that you'll really make the quantum leap necessary to implement the technology and its potential properly is to produce a number of centers where you're going to have a $2 to $3 million minimal amount of capital per year available to those centers, whatever they're specializing in—a center for artificial intelligence, and the kind of work that Dr. Papert's doing; a center for working with the videodisc: a center for working with the handicapped; interface in special problems; or standard computers.

But if we don't get the capital to minimal amounts then we're squandering, in a sense, lots of teams of people who are just trying to keep alive, and unable to do the project properly.

If you look for examples where it works in society, if you look at technology and weighting it with problems, you come to such things as the Manhattan project, NASA, channel 13, and CTW Children's Theater Workshop, et cetera. Always they have to pull out of a formal academic structure, set up an independent organization, and have firm funding for a number of years at a high enough level. You have to collect engineers, technicians, specialists, and learning psychologists specialists. You have to have all kinds of people involved.

I'm not an advocate of setting up a special agency. I think the Government has adequate structures in position.

You have the NIE, the NSF, you have a number of outstanding organizations with excellent civil service personnel who have been working for a number of years for the technology. But they're all handicapped now because they're not given a budget, which allows them the opportunity to work with a high enough minimum mass.

I think that's probably my single most concern.

Mr. KURZWEIL. I think I could comment on that. The one agency that we've worked the most closely with is the Bureau of Education for the Handicapped.

Despite the fairly limited resources they have available for research, they have taken this attitude of providing minimum critical mass needed to get projects off the ground. They have done that with our project. There's been about $2 million in funding over the past year. They've done that with such projects as the Optacon, of trying out the smaller grants to try out a wide variety of projects and see what team seems feasible, which ones are responded to positively by the field, and then these projects are carried through with enough critical mass to get them out into the field and become viable and self-sustaining projects.

Mr. KILDEE. Mr. Vanderheiden?

Mr. VANDERHEIDEN. Also, at least in the field we've been working in, we've found that a lot of the really good work has come from smaller groups. Again, they need to be interdisciplinary and have the critical mass.

But I think the model whereby you provide funding to groups smaller amounts of funding for shorter periods of time, and then, when a good idea comes out, then you can provide larger funding to back it up, to try and carry it through, is the better model. Then it takes a fair amount of muscle to get technology really applied.

But I would disagree with the idea of setting up large centers to do the research in an area. Essentially, I think that most of the really good work is done by people who in kind of a "scrappy" situation.

And I also believe that you can't ever collect in one area a large mass of all the best minds. You get too many of them too close together and you get a supercritical mass, and it blows apart.

So you sort of go around funding groups I think on projects and moving money around to the innovation, and then providing the large funding to follow through on specific projects that are proven.

Even good people come up with a lot of bad ideas, and I think large groups that stay around for a long time have problems that way.

Mr. KILDEE. Dr. Papert?

Dr. PAPERT. I think this is a very serious point, and it will be terrible to have a situation where the small guy with a simple idea can't get funding for it.

Nevertheless, I disagree radically with the statements that were made by the last two speakers. I think it is true—I think it's very true that the best things, the best work, comes from people with scrappy resources starting on a small scale, but that's because of the way things are set up, that you can only get scrappy resources to work on a small scale on certain kinds of projects.

I think the emphasis has to be on certain kinds of projects. You see, I don't—I agree some things can be done like that, and some things should be done. However, I think that the funding policy determines very greatly and in an ill-considered way which projects are going to be done and which directions research is going to go in; and in particular, it determines it in a way which is strongly biased toward what I was calling local and incremental as opposed to global and holistic changes in the educational system.

And, if I may, I'd just like to just throw at you some images, some metaphors, for that point.

First of all, looking at that technology around there—like the metaphor I used last time, in this report—I said the way a lot of funding is done it's like trying to jump over a 3,000-foot canyon by lining up 3,000 people, each of whom can jump one foot, and saying jump. I think to get to the Moon we have gotten 250,000 people, which is just about enough, and said jump, and each one would jump 1 foot, and it all added up to the distance to the moon. We wouldn't get there.

I think another—if you look at the history of technology, there are many such examples. You did not go from the ox cart to the automobile to the first airplane to the jet plane, by taking the ongoing system and improving a part of it.

Now, I think some of the very good work on education and on education for handicapped is of such a nature that it's an improvement in one part. I think that concept of Optacon, a reading machine, is a beautiful classic example of a case where you can take the system as it is and you can produce an improvement by making a discrete object that fits into it. And it's fantastic, and we ought to do that.

But the danger is for us to be locked into only doing those projects which can be formulated as local improvements to produce incremental, measurable improvements, to the ongoing system. Not all changes are of that sort.

The jet engine would have been ruled out if it had been proposed to add it to the Wright Brothers' airplane to show how it improved the flying; it would have destroyed the plane, and there would have been no improvement, and by all usual validation and evaluation techniques it would have decided that jet engines are a disaster—besides which they're expensive, besides you can't disseminate them, besides nobody knows how to use them.

Mr. KURZWEIL. But the jet engine is a very specific device with a specific goal, and I think you're mistaken that these critical masses have not been provided. They have been, and groups have been put together at our laboratories and at other laboratories.

Dr. PAPERT. Well, I think——

Mr. KURZWEIL. Where a lot of very bright people have been put together with the necessary skills and harnessed to solve a particular problem.

Dr. PAPERT. I'd like——

Mr. KURZWEIL. To develop a wholly new approach to the problem, like a jet engine——

Dr. PAPERT. If I could just comment on that. I wasn't—I didn't introduce the critical mass. Somebody else did. And I made a different distinction between low-cost and global, between incremental and holistic.

It's not a question of a sum of money; it's a question of the kind of redesign of a system that we're talking about. I don't—you see, I don't—let me say it again by another example: The problem could be formulated like this, how can we mainstream, say, the blind people into the current school systems as they are? Now, I find what's schizophrenic about that—of course, from the point of view of the individual blind person, given the schools as they are now and the world as it is now, that's what he needs to be mainstreamed into that. And to say he doesn't need that would be criminal.

On the other hand, I believe that schools as they are that mainstream you're going to mainstream into has got maybe 5 or 10 years to survive at the most. The presence of the computer by the end of this decade is going to so transform the whole educational process, maybe even shifting it from the schools into the homes, that that thing you'd like to mainstream it into won't exist any more.

So there's something paradoxical about using the computer to mainstream somebody into a kind of education which the computer is about to mainstream out of existence.

Mr. KURZWEIL. You're——

Dr. PAPERT. And I think it's this kind of thinking that I find holistically designed, and it's this kind of thinking that the system is naturally strongly biased against.

Mr. KURZWEIL. You're not——

Dr. PAPERT. It's not merely a matter of——

Mr. KURZWEIL. You're not familiar with the principal problems that——

Mr. KILDEE. I think we probably recognize the two points of view here, and I don't think we'll probably settle it today at the committee meeting.

I will personally remain open. I can punt by saying we'll keep things in a dual track and things like that with you both, but I don't think we'll probably settle it by debate at this point.

The staff is always available, too, for receiving attitudes and information and points of view on this.

I think Mr. Gallagher has a question.

Mr. GALLAGHER. Thank you, Mr. Chairman.

Mr. Heuston, as I understand it, there are two basic systems: That is the system which is school-oriented, and then the TICCIT system which lends itself to home-oriented; there's more student control, more user control.

Mr. HEUSTON. That's right.

Mr. GALLAGHER. The other system is coming in from a central computer.

Well, what I'm leading up to is the feeling of the teacher, given teacher, on both systems. Initially there was a teacher resistance for PLATO but now they're living within the system. All right.

Now you have this new innovation, and as Dr. Papert said, this may all end up in the home and make the school system obsolete. How do teachers feel about a system now used at home, very sophisticated, which comes up with answers—not the physical sciences, social—which are really in conflict with what they're teaching at

23-082 O - 79 - 15

school? So when a child goes home at night he's got his regular homework to do, and then he turns on these machines and he's getting input from them. He goes back the next day and he's contradicting what the teacher is putting out because he has another teacher, so to speak, at home.

Well, how does the teaching community feel about your system, assistant system?

Mr. HEUSTON. Well, the teacher community will get used to anything that will help them. And, I think, probably the way to enter with materials like this is to choose areas where the teachers are being overloaded with too much work.

What a computer basically does in a million instructions a second is give you the ability to do an awful lot more work. So the teacher would be backed up with interactive help.

People have learned the hard way for the past 15 years. There have been 15 years of extensive probes into the educational system, and a great deal has been learned. And one of the lessons learned in how you can help the teacher is not to start by just saying, "I'm going to replace you."

I think the technology can come onstream slowly and to schools, helping the teacher in key areas. The younger faculty will get excited about it; they'll begin to look to do more things with it. They'll go in the direction that Dr. Papert pointed out. They'll have much different relationships with the students and the technology and themselves, and then, gradually, it will infiltrate into the system and be used properly.

Mr. GALLAGHER. One followup on that.

Mr. HEUSTON. Yes?

Mr. GALLAGHER. Why is it, since you're reaching sort of the breakthrough point, why is it the companies are pulling out? For example, textbook manufacturers are no longer interested. NSF I understand it no longer funds either PLATO or——

Mr. HEUSTON. Yes. Well, what happens is that it's a cyclical affair and people that bet on something sustain all their political capital in the interim, and there's always a counterattack. To break TICCIT and PLATO out of NSF took huge percentages of their funds, so that everybody else was pushed out. It was left without for a period, and then those envolved ganged up and came running back in.

If you have a fixed amount of capital in a competing kind of organization, you can sustain a piece of the capital for awhile and then they will come shooting back in from another direction.

But TICCIT and PLATO are very much out right now. But there'll be a turnaround again, and some more big system approaches will come back in.

But it's really very inefficient because at the very point that TICCIT and PLATO have learned how to do their lessons, all the funding was withdrawn because of the political problems.

Mr. GALLAGHER. Thank you.

Mr. KILDEE. All right. Thank you very much.

Thank you all of you for your attendance and your testimony here this morning. I personally have been impressed by both the testimony and the demonstrations, some of which I've seen before; and they do give me personally a sense of hope for breakthroughs for the handicapped.

I speak only for myself, but I feel the Federal Government has an obligation to help make these and other devices possible and also available to those that they can help.

I thank all of you.

The room will be open and available this afternoon, and people will be dropping by. I want to thank you for that also.

At this point we'll stand adjourned.

[The hearing in the above-entitled matter was adjourned at 12:50 p.m.]

COMPUTERS AND THE LEARNING SOCIETY

THURSDAY, OCTOBER 27, 1977

HOUSE OF REPRESENTATIVES, COMMITTEE ON SCIENCE AND TECHNOLOGY, SUBCOMMITTEE ON DOMESTIC AND INTERNATIONAL SCIENTIFIC PLANNING, ANALYSIS AND COOPERATION,

Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10:05 a.m., in room 2325, Rayburn House Office Building, Hon. James H. Scheuer (chairman of the subcommittee), presiding.

Mr. SCHEUER. The subcommittee known as DISPAC of the Committee on Science and Technology will now come to order. Today is the last day of our hearings on computers and the learning society. We have had computer firms here who have shown us computer-managed instruction and computer-assisted instruction.

We have heard form public officials about the research trends. We have heard the agency views and their applications of technology to the learning needs of the handicapped. And we are turning today to the special problems posed for educators by the gifted child on the one hand and the disadvantaged child on the other.

We are going to try to enlarge our knowledge on how these two groups at the nether ends of the education spectrum can benefit from the application of the computer to their learning programs.

In the past decade or so we have invested large amounts of money in learning programs for the disadvantaged, literally billions of dollars under titles I and III of the Elementary and Secondary Education Act. I had the privilege and honor of serving on the Education and Labor Committee for 8 years. That 8 years was a very enriching experience and I suppose we have learned a few things from titles I and III about how to zero in on the learning problems of the disadvantaged. But there is still a great deal we do not know.

This is demonstrated by the repeated stories in the newspapers about how learning scores are dropping and about how the kids of New York City are as much as 2 years behind grade level. The court could take judicial notice of the fact that a large percentage of young people who graduate from high school are, in effect, functionally illiterate. They do not have reading and writing as everyday tools of life.

How this could be is something I don't understand. One hundred years ago we were doing better than that, or 50 years ago they were doing better than that. When I was a kid, the kids graduated from high school and they could read and they could write and how we could have come to the state we are in now baffles my understanding.

So there is a great deal that can be accomplished. The business of raising functionally effective people who can perform in a society that is increasingly demanding higher and higher levels of sophisticated skills is an absolute must for this Congress and for our society.

On the other hand, it seems to me that we have far too long neglected the educational needs of our IGC's—the intellectually gifted children. Not many years ago I was in Russia. I spent January of 1972 in Novosibirsk at the special facility for the gifted. This is the center of postdoctoral studies in the Soviet Union where young people from all over the Soviet come for their postdoctoral studies. And those kids are identified 20 years before, at least 20 years before, in schools at age 4 and 5 and 6 and 7.

When an exceptionally talented youngster is identified in the Soviet Union he or she can almost be assured that two decades later they will be studying for their postdoctoral degree in whatever field their talents lead them, somewhere in the Soviet Union.

There is much in the Soviet education system that is not relevant to us and much that we don't consider superior to us. There are many ways in which they lag behind us, but let's face it, in some areas they are outperforming us. One of the areas in which they are outperforming us in a spectacular way is their identification of gifted children and the resources they lavish upon them.

I dare say that in the future one of the things we have to do in a society where we are becoming increasingly convinced that we have finite resources and that there are no free lunches and where there are finite resources in the public and private sector and a pie that cannot be very much enlarged—there is a finite education pie. Education has to compete against a lot of other things for resources.

In our education system we have to achieve some kind of more sophisticated decisionmaking on how we allocate resources. We have put several billion dollars per year into the education of our disadvantaged children. How can we do it better is one question we have to ask and then we have to ask another painful question and this is: From the point of view of our society at what point do we stop pouring thousands and thousands of dollars per year per child into the education of a child who seems to resist the learning process? At what point do we say as a society we have spent $2,500 or $3,000 per year on this child for many years. It seems that he or she has reached his maximum potential and there doesn't seem to be much of a payoff for further educational expenditures for this particular child, at least not in this learning environment. Maybe we have to balance further investments in this child as against further investment in the National Science postdoctoral fellowship, and try and evaluate where and how society will allocate these finite resources.

Let us come to the realization that educational funds are finite. I think we have not achieved the right decisionmaking process and we have not learned how to factor into the decisionmaking process some kind of cost-benefit estimate as to where the next dollar of education is going to produce the greatest payoff in our society.

Having said that, it is a great pleasure to welcome today Dr. Pat Suppes from the Institute for Mathematical Studies and the Social Sciences of Stanford University. I must confess that when we first decided to have an additional day on specifically the education of the intellectually gifted children and disadvantaged children, everywhere we inquired as to where the outstanding witnesses would be, the finger was invariably pointed to Pat Suppes of Stanford University. So we are delighted to have you here.

Your paper will be printed in its entirety at this point in the record, so perhaps you would simply want to chat with us and we will undoubtedly have questions.

[The complete prepared statement of Dr. Suppes follows:]

THE FUTURE OF COMPUTERS IN EDUCATION

Patrick Suppes
Institute for Mathematical Studies in the Social Sciences
Stanford University

My purpose today is to focus on the many and varied potentialities for the use of computers in education throughout the remainder of this century. It is important, however, that what I say not be based simply on general speculation but that it be firmly founded in past experience. Consequently, I shall spend a considerable part of my time in reviewing my own experiences and those of others in the instructional use of computers since the early sixties.

History of Computer-assisted Instruction at Stanford

Elementary-school Level

In January 1963, with a grant from the Carnegie Corporation of New York, the Institute for Mathematical Studies in the Social Sciences at Stanford University began a program of research and development in computer-assisted instruction (CAI). During the first decade, most of the work was concerned with the development of computer-based curriculums for elementary schools, especially in mathematics and reading. The work in reading was under the supervision of my former colleague Richard C. Atkinson, and the work in mathematics was my responsibility. A general history of these efforts is to be found in Suppes (1972). A large number of publications have resulted from this work; it would be inappropriate to list all of them here. Extensive details about the work in mathematics are provided in two books, Suppes, Jerman and Brian (1968) and Suppes and Morningstar (1972).

Although the initial support for this work came from a private foundation, shortly thereafter support was received from the National Science Foundation and the United States Office of Education. There are many vignettes to tell about the extensive work we conducted in the sixties. One of my favorites is that the first school system in the world to have the opportunity of every elementary-school child's doing daily work at a computer terminal was in McComb, Mississippi. The terminals in McComb were connected to our computer at Stanford by telephone lines, and the research and development effort at McComb was supported by Title III of the Elementary-Secondary Education Act of 1965. Results of these efforts at McComb were evaluated rather carefully and the results were quite positive. A detailed analysis is given in Suppes and Morningstar (1969).

It is perhaps worth noting that almost ten years later this work in McComb has been followed by a fairly extensive use of computers for instruction in Mississippi. The computer systems and curriculum are provided by Computer Curriculum Corporation, with which I am also associated, and the funds used to support these operational efforts, which are no longer in the category of research and development, are provided by Title I allocations to the various school districts.

Disadvantaged Students

It is important to emphasize that a large part of the work on the instructional use of computers in elementary schools has been focused on disadvantaged students, and over the years we have worked with a variety of populations, ranging from inner-city schools in various parts of the country to rural populations in Appalachia as well as American Indian students in New Mexico. A report, for example, on the performance of American Indian students in CAI in elementary mathematics is to be found in Suppes, Fletcher and Zanotti (1975).

Handicapped Students

From July 1, 1970 to June 30, 1973, the Institute was deeply involved in the use of CAI for hearing-impaired or deaf students. This large project was funded by the Bureau of Education for the Handicapped, United States Office of Education. Using our computer at Stanford, more than 1,000 deaf students were reached during 1970-71, through a national network of terminals located in residential deaf schools and special classes for deaf students in ordinary schools; during 1971-72 and 1972-73, this number rose to more than 2,000 students.

The curriculum for these students was primarily concerned with elementary mathematics and language arts. Extensive evaluation of this work has been published (Suppes, 1971; Suppes & Fletcher, 1974; Searle, Lorton, & Suppes, 1974; Suppes, 1974; Suppes, Fletcher & Zanotti, 1976; Fletcher & Suppes, 1976). Perhaps the best evidence of the success of this work with handicapped students is that almost without exception the schools have continued to use CAI more than four years after the research and development project came to an end.

University Level

Beginning in the late 1960s, work at the Institute began to focus more on the possibilities of CAI for university-level courses. The first major effort was under the direction of Professor Joseph Van Campen of the Department of Slavic Languages at Stanford, and was concerned with the development of two years of elementary Russian at the university level. The very positive evaluation results of the first-year Russian course are reported in Suppes and Morningstar (1969). The work in Slavic languages has now shifted from the beginning courses to intermediate courses that have small enrollment. CAI is offered in such relatively esoteric topics as Old Church Slavonic and the linguistic history of the Russian language.

One of the earliest curriculum efforts for the elementary school was the development of a course in logic for gifted elementary-school students, discussed in more detail below. In the late 1960s, efforts turned to the development of a corresponding course in logic for university students. Over the past few years the continued development and improvement of this course has been one of the central efforts in CAI at the Institute. Recently, the efforts in logic have moved to the intermediate, as well as the introductory college level as a focus of research and development. A substantial effort is now being put into axiomatic set theory, foundations of probability, and similar courses of a rather technical scientific nature.

Courses in music and computer programming have been developed for use at the university level as well. Individualized CAI in music has been applied to theoretical and instructional investigations in a number of different courses. Previous CAI work in programming has included courses in the BASIC, AID, SIMPER, and LOGO languages; current projects deal with an entirely new approach to teaching BASIC and the integration of a CAI course in LISP into the university curriculum.

Summary information on the courses mentioned is shown in Table I (taken from Suppes, Smith and Beard, 1977). It will become apparent at once that the enrollment is quite small in a number of courses that we consider as a primary focus of our research and development efforts. Contrary to some of our thinking a few years ago, it is now our deliberate choice to develop CAI for such courses rather than for the large-enrollment elementary courses.

The reason for the emphasis on small-enrollment courses is to a very considerable extent a matter of productivity (Suppes, 1975). The initial impetus for the course in axiomatic set theory was the loss of a faculty position in this area due to budget cuts at Stanford. In the face of declining or fixed budgets, it has become apparent that faculty sizes will probably decrease during the remainder of this century. Some state universities require that a specific level of enrollment be maintained for all courses offered, and there is considerable pressure against specialized courses with low enrollments. Still, such courses represent an important function of the university in transmitting intellectual knowledge and skills from one generation to the next.

One of our main aims in CAI research and development at the Institute is to show how these specialized courses can be maintained at reasonable cost in the future by appropriate use of computer technology. Our aim is to increase the teaching load of faculties in terms of courses offered, and one of our subsidiary aims, consequently, is to improve the ability of CAI to provide effective instruction with little or no intervention required of the instructor. A few teaching assistants, available at scheduled hours through the day and evening, work in conjunction with each course; the instructor himself is free to supervise further development of CAI courses or to consult on an individual basis with students and teaching assistants.

Gifted Students

Work with gifted students at the elementary-school level began in an informal way in the late fifties but got under way in a more formal fashion under the sponsorship of the National Science Foundation in 1963, when a longitudinal accelerated program was undertaken. The objective of the program was to accelerate and enrich the mathematics instruction of gifted elementary-school students throughout Grades 1 to 6. Details of this program are described in several publications, so that I shall only mention certain salient points here (Suppes & Hansen, 1965; Suppes, 1966; Suppes & Ihrke, 1967, 1970). At the beginning of the second year of the project, the 34 children who were bright second-graders in 1964-65 received supplementary drill and practice in arithmetic at computer terminals and also an experimental course in mathematical logic especially prepared for gifted elementary-school students.

Because of the availability of logic at the computer terminals, the students were able to advance at a surprisingly rapid rate, and during the several years of the project they became quite proficient both in understanding and using the basic principles of logical inference. Perhaps the most important point is that, although this work began in the second grade, some of the experimentation was undertaken at the end of the first grade and if the programs had been available a year earlier could already have been used at that time. It is also important to emphasize that this work was natural and easy for the students. The range of mathematical topics that can be taught to gifted students is not easy to overestimate. In addition to the work in logic, extensive work in geometry as well as in the standard curriculum was offered to these gifted students. They made rapid progress through a variety of topics, including the elementary theory of symmetry groups. The geometry was taught by staff members of the Institute, not at computer terminals, [illegible] than a decade later, it would be feasible to offer the geometry at computer terminals and thereby to provide rich instructional resources for gifted students that would not ordinarily be available in standard elementary schools.

It is also worth noting that we continued through the six years extensive work in standard drill and practice with these bright students. Some people ask why this was necessary, given their obvious gifts. Over the years I have developed an attitude and an answer that makes sense to me and to most of the people to whom I talk about the continued need for drill and practice in basic skills, even for gifted students. The analogy I use is a simple one--it is that of the training and perfection of physical skills. Most of us accept without any question that professional athletes continue to train and practice even after their particular skills have been thoroughly developed. The same is true of intellectual skills. The kind of performance we expect of gifted students can only be obtained, in my judgment, by a continued regime of drill and practice, and such a regime is just as much a desirable aspect of their intellectual training as it is of their physical training.

Home-based Computer-assisted Instruction for Highly Gifted Students

I turn now to description of a more recent experiment in the Institute. The objective of this program was twofold: first, to use not merely gifted but, in the main, highly gifted students, and, second, to investigate the feasibility of home-based computer terminals that would deliver instruction to the students, rather than having the students assemble at Stanford or some other focal point. It is especially important to recognize that highly gifted students, defined for this purpose as students with IQs of 165 or above, are very sparsely distributed and consequently there is a severe logistic problem of offering them advanced instruction. It is, in fact, my judgment that the use of distributed computer terminals is probably the best way to offer a variety of advanced instruction to such students. I also note that it is one of the scandals of American education, in my own judgment, that so very little is offered as advanced instruction for such students. Relative to their enormous potential, they are perhaps the most neglected population of students in our entire educational system.

Our project has been described in detail in a monograph on home-based instruction (Macken, van den Heuvel, Suppes & Suppes, 1976). I cover some of the more important aspects.

Procedure. Eight school districts in the areas surrounding Stanford University were invited to submit the names of students whose IQs as measured by the Stanford-Binet intelligence test were at least 165 and who seemed to have a wide range of outside activities; the latter condition was stipulated so we could determine how well a home-based CAI curriculum would compete with other established interests. The districts were asked to include with each name a statement describing the student and indicating why he or she was being recommended for the program. Some districts did this; others submitted short autobiographies of the students, and some submitted only the test scores. From this information, members of the Institute staff selected a total of 16 students; there were some from each district and an equal number of boys and girls. We made four exceptions to the criterion of having a Stanford-Binet IQ score of at least 165: Three of the children measured "superior" on the WISC but had not taken the Stanford Binet, and the fourth child measured only 132 on the Stanford-Binet but was an outstanding achiever in his district. Children who were not selected were placed on a waiting list. All selected children were in the sixth, seventh, or eighth grade with the exception of one girl in the third grade and one in the fifth grade.

In November of 1973, letters of invitation were sent to the parents of each child selected for the program; copies were sent to the cooperating school districts. The letters provided a description of the program, including the available curriculums and necessary equipment, and indicated that there would be no cost to the family. All families agreed to participate. Installation of teletypes in the homes began as soon as permission was given by the parents; all were installed by January of 1974. The students were shown how to dial the computer at the Institute, how to use the terminal, and how to sign on to the elementary logic course. With this minimal explanation all students were able to begin their CAI work.

A meeting for parents and students was held at the Institute on January 14, 1974. This was a general meeting to answer questions about the program and the curriculums and to provide a tour of the Institute facilities. Parents were encouraged not to urge their children to work on the teletypes; instead, students were to pace themselves and work as much or as little as they wished. The meeting was well received and follow-up monthly meetings were planned. However, because of the gasoline shortage, no further meetings were held until June when the 10 new students had been selected.

A proctor was available at the Institute four days a week during scheduled times so students could telephone for help. Some students, who indicated they felt too shy to telephone, were called once a week by the proctor to see if they were having any problems.

The summer program was similar to the spring program. Letters of invitation and explanation were sent to the 10 new students and a meeting was held June 17 for old and new students. This time the parents were not encouraged to come. Summer students were told they could take a programming course, BASIC, along with the logic course by writing or telephoning the Institute to request a BASIC manual. This left the initiative with the student: Six students requested the manual and began the BASIC course, and two finished the course by January 1, 1975.

By midsummer it was apparent that eight students--four new students and four old students--were not working regularly toward completing the logic course. Weekly individual goals were set to encourage regular study. The students expressed approval of the goal setting but, in fact, did not change their work habits. By January 1, 1975, four of these students (two old and two new) completed the logic course, two (new students) were still working very slowly and irregularly, and two (old students) had dropped out.

Two students, who were friends attending the same school, seemed to enjoy competing with each other on the CAI curriculums, and this competition apparently stimulated progress. After further inquiry, telephone lists of all participating students were mailed to the students. However, the students did not make much use of the lists, possibly because they were too shy to telephone peers they had not met.

Conclusions. Without entering into the details of the curriculum, let me summarize here the main conclusions we reached.

First, the high dropout rate experienced with this very special and very bright population of students is characteristic of the high dropout rates observed in other home-study courses. We left the structure of the program very free in order to test whether very able students of the kind we were working with would be able to sustain an interest in relatively difficult material over a long period of time. It should also be remarked that all of these students had very busy programs both in and out of school. We were in fact surprised, after the program began, to find the amount of time some of them were devoting to it.

Second, on the basis of the high dropout rate experienced, we would conclude that a sustained program of home study for gifted students would require the introduction of considerable structure and also, probably, clear arrangements about academic credit for the course work done. Perhaps the best arrangement would be to replace part of the routine school courses by the advanced courses available at computer terminals for home study, or at the very least to arrange for advanced credit for the courses completed.

From our extensive survey of the literature and from this intensive experiment, we believe that arrangements for introducing structure providing short-range goals for students, feedback on their progress, telephone conversations with proctors, and other forms of guidance and interaction need extensive experimentation in order to determine the optimal mix for home-study instruction. Our search of the literature indicates that there has as yet been very little serious experimentation on these matters. In view of the very large number of students engaged in home-study work in one form or another and given the technological possibilities for the future in terms of more intensive interactive courses available in the home, it seems most desirable that an extensive program of experimentation on the appropriate structures for such courses be undertaken.

Third, in ordinary studies of achievement of students in different technologies, for example, in the extensive survey of Jamison, Suppes, and Wells (1974), pretest and posttest achievement measures have been the primary instrument of assessment. The extensive data from correspondence courses and the restricted but detailed data from the group of very gifted students described in the present section indicate that, in the case of home-based instruction, the dropout rate is a more significant measure of assessment than actual achievement. This is meant in the sense that the primary problem of home-based instruction is to find ways to reduce the very large dropout rates encountered. Although the literature is extensive, in one sense, with regard to analysis of the causes of dropout, it is on the other hand clear that detailed quantitative and statistical analysis using relatively sophisticated models has not as yet taken place and would almost certainly yield a better understanding of the phenomena than we now have.

Let me end my remarks about work with gifted students by a comparison with what I have observed first-hand in the Soviet Union. In the early summer of 1972, I served as a special consultant to the United States Educational Exhibit touring the Soviet Union. My allocated time was spent while the exhibit was in Novosibirsk in central Siberia. One of the things I had an opportunity to learn about was the special secondary school for gifted students, located in Novosibirsk. A similar school exists in Moscow and one in Leningrad. I had the opportunity to discuss extensively the curriculum of the school and also to learn about the procedures for selecting the students, who were brought from all over Siberia to the school for three or four years of secondary-school work as full-time residential students. The main courses in mathematics, physics, and chemistry were taught by university staff, and the residential school itself was located as part of the university and Soviet Academy institute complex called Academe Gorodok, that is, Academic City, not many kilometers from Novosibirsk. Without entering into the details of what I learned there, it is fair to say that there is no comparable effort in the United States, although some of the very best secondary schools, as for example the Bronx High School for Science, come close. What is especially missing, however, is the kind of systematic effort at selection and identification of the brightest and ablest youngsters. There is most certainly nothing comparable to this procedure of selection in any program for highly gifted students in the United States.

Considering the amount of money that is spent on education in the United States, both at state and local levels as well as at the Federal level, the relative neglect of providing adequately for the special needs and enormous potential of our highly gifted students is, as I have already said, something of an educational scandal. I would strongly urge the Congress to consider giving special attention to the educational needs of the gifted. Because of the sparse distribution of highly gifted students in particular, the instructional use of computers for such students seems especially appropriate. Moreover, what would be learned from highly experimental work with these students would almost certainly have an enormous payoff in the years to come for a larger population of students.

Future Technological Possibilities and Their Problems

I hope that the numerous examples drawn just from our Stanford experience indicate that the instructional use of computers can serve students of all ages and of all varieties of capacities and interests. What I would now like to turn to are some of the possibilities and the problems of these possibilities that need attention in the future. I have organized my remarks under the four broad problems of talking, listening, knowing, and learning.

Computers That Talk

The first problem is simply that of talking. What does it take to get a computer to talk? The fact is that the technical issues are already pretty well in hand. In our computer system at Stanford we have eighteen channels of independent simultaneous audio and the computer talks independently and differently to eighteen students at the same time. We have the capacity for the computer to talk. What we need, however, is a better theory about what is to be said. For example, when I serve as a tutor, teaching one of you, or when one of you is teaching me, intuitively and naturally we follow cues and say things to each other without having an explicit theory of how we say what we say. We speak as part of our humanness, instinctively, on the basis of our past experience. But to get a computer to talk appropriately, we need an explicit theory of talking.

Computers That Listen

Long ago, the sophists of Ancient Greece objected to the use of written records for instruction because they eliminated the intimate interaction between tutor and student. In Plato's dialogue Phaedrus, Socrates asserts "only in principles of justice and goodness . . . taught and communicated orally for the sake of instruction . . . is there clearness and perfection and seriousness." The aspect of dialogue that is technically difficult for us at the present time, even more than talking, is that of listening. Without any question, the problem of defining computer hardware and software that can listen to a student talk is much more difficult than having the computer talk to the student. Indeed, I want to emphasize the great difficulty of having computers that adequately listen. I recognize that it will be many years before fully satisfactory solutions are available.

On the other hand, already several years ago we were able to experiment successfully with ten-year-olds' talking to the computer in order to give answers to elementary mathematical problems. Exercises given at home over ordinary telephone lines and consisting of both elementary mathematical problems and such standard topics as spelling are feasible at the present time from a technical standpoint.

The great importance of extending the capabilities of computers that listen in order to give us more powerful educational tools cannot be overemphasized. I am sorry to say that almost all of the work that has been done up to the present on the technical problems of computers' understanding spoken speech has been sponsored not by any of the educational agencies, as for example the United States Office of Education or the National Institute of Education, but by the Department of Defense, especially the Advanced Research Projects Agency. In my own mind, the educational case is a very much stronger one than the defense case for the interest in computers that listen.

Computers That Know

The third part of my discussion concerns the problem of understanding the knowledge base. To have an effective computer-based system of instruction, we must transcend mindless talking and listening and learn to understand and use a large knowledge base. For example, if we were simply to require information retrieval from a knowledge base, it would be relative simple in the future to put the entire Library of Congress in every elementary school. The capacity to store information is increasing so rapidly that we will be able to store much more information than could ever possibly be used by any one individual.

A different and more difficult question is how to get the sizable knowledge base to interact with the student. As we come to understand how to handle such a knowledge base, the school computer of the future should be able to answer any wayward question that the student might like to ask. Moreover, as we all know, once a student uses such a capability, he will have a strong tendency to pursue still further questions that are more difficult and more idiosyncratic. It will, I think, be wonderful to see how children interact with such a system; in all likelihood, we will see children give to learning a high degree of concentration and the sustained span of attention they now give to commercial television.

There is one related point I want to emphasize. From the very beginning of school, students learn quickly the "law of the land" and know they should not ask questions the teacher cannot answer. This task of diagnosing the limitations of teachers begins early and continues through college and graduate school. So, once we have the capacity for answering out-of-the-way questions, it will be marvelous to see how students will take advantage of the opportunity and test their own capacities with a relentlessness they dare not engage in now.

Computers That Aid Learning

The fourth problem, and in many ways the least-developed feature of this technology, is the theory of learning and instruction. Even if we can make the computer talk, listen, and adequately handle a large knowledge data base, we still need to develop an explicit theory of learning and instruction. In teaching a student, young or old, a given subject matter or a given skill, a computer-based learning system can record everything the student does. It can know cognitively an enormous amount of information about the student. The problem is how to use this information wisely, skillfully, and efficiently to teach the student. This is something that the very best human tutor does well, even though he does not understand at all how he does it, just as he does not understand how he talks. None of us understand how we talk and none of us understand how we intuitively interact with someone we are teaching on a one-to-one basis. Still, even though our past and present theories of instruction have not cut very deep, it does not mean that we have not made some progress. First, we at least recognize that there is a scientific problem; that alone is progress. One hundred fifty years ago there was no explicit recognition that there was even a problem. In the education literature of 150 years ago it was not recognized as important to understand the nature of student learning. Only in the twentieth century do we find any systematic data or any systematic theoretical ideas about the data. What precedes this period is romance and fantasy unsubstantiated by any sophisticated relation to evidence. So at least we can say that we have begun the task.

I want to emphasize that, in the four possibilities and their associated problems that I have mentioned, namely, those of computers that talk, listen, know, and aid learning, the primary problems are not matters of hardware or technology in a narrow sense but of general intellectual investigations of a fundamental kind that will not, in the course of ordinary aff[illegible] be undertaken by industry but that must be addressed by Federal programs. Our rate of progress on these matters will be determined almost entirely by the level of Federal support and the wisdom of management of [illegible] [illegible] programs that are targeted on the possibilities and [illegible] I [illegible] discussed.

Some Possible [illegible]ral Programs

I would like to end on the practical note of stating what, from my own viewpoint, would be important and feasible programs of support for the Federal government.

1. Gifted students. The United States Office of Education or some other agency, such as the National Science Foundation, should have a special program of support for the use of instructional computers with gifted students, especially the highly gifted. These sparsely distributed gifted students should be brought individualized programs, especially in basic skills of mathematics and language, at an early age and throughout all their years of elementary and secondary education. The returns on a program funded at a substantial level would, in my judgment, exceed the return on any of the other Federal programs of educational support at the present time.

2. Handicapped students. The extensive support programs in the Bureau of Education for the Handicapped should be targeted, even more than they are currently, on the use of computer technology for the education of the handicapped. In many ways, excellent programs of support are now already under way at the Bureau. I would urge Congress to review these programs from time to time and to insist that appropriate advantage is taken of the increasingly sophisticated technology that is available for instructional purposes.

3. Disadvantaged students. There is an increasing use of computers for supplementary instruction in basic skills, especially basic skills of reading and mathematics, with disadvantaged students. The use of instructional computers for this purpose should be encouraged and enhanced in the revision of the Elementary-Secondary Education Act of 1965, now pending in Congress.

4. Home based instruction. The proposition that we are becoming a nation of learners deeply committed to continuing education is supported by a variety of current data. For example, in some of the community-

college districts in California more than twenty percent of the entire adult population--not just the college-age group--are enrolled in at least one course. Direct electronic delivery of a wide varie of courses to the home is increasingly feasible. A program of support to accelerate current efforts would be timely.

5. Research and development. Finally, I strongly urge th consideration be given by Congress to a program of research and development dealing with the four main problems I discussed earlier. A program at a substantial level could accomplish a great deal to rapidly facilitate the extensive use of computers for instructi The total R&D dollars now being spent by the Federal government for re ach on the instructional use of computers is very small indeed. A much program would not be excessive and could be practically absorbed b, the research and development community. I would also emphasize that D programs falling within such a general framework would, cases, be concerned with highly developmental experimental that would in themselves have direct educational benefits. I believe it is fair to say that much of our work at Stanford has been exactly of this character.

We are sitting on the edge of a revolution in the way in which instruction is delivered to students of all ages and varieties. It has been one of the great pleasures of my life to have been a part of the beginning of this revolution. I hope that the Federal government will provide strong support for this constructive direction of change throughout the rest of this centur

References

Fletcher, J. D., & Suppes, P. The Stanford proj[illegible] on computer-assisted instruction for hearing impaired students. Journal of Computer-Based Instruction, 1976, 3, 1-12.

Macken, E., van den Heuvel, E., Suppes, P., & Suppes, T. Home-based education: Needs and technological opportunities. U.S. Department of Health, Education, and Welfare, National Institute of Education, April 1976.

Searle, B., Lorton, P., & Suppes, P. Structural variables affecting CAI performance on arithmetic word problems of disadvantaged and deaf students. Educational Studies in Mathematics, 1974, 5, 371-384.

Suppes, P. Accelerated program in elementary-school mathematics—The second year. Psychology in the Schools, 1966, 3, 294-307.

Suppes, P. Computer assisted instruction for deaf students. American Annals of the Deaf, 1971, 116, 500-508.

Suppes, P. Computer-assisted instruction at Stanford. In K. L. Zinn & A. Romano (Eds.), Computers in the instructional process: Report of an international school. Ann Arbor, Mich.: Extend, 1974. Reprinted from Man and computer (Proceedings of International conference, Bordeaux 1970.) Basel: Karger, 1972.

Suppes, P. A survey of cognition in handicapped children. In S. Chess & A. Thomas (Eds.), Annual progress in child psychiatry and child development, 1975. New York: Brunner/Mazel, 19[illegible]. Reprinted from Review of Educational Research, 1974, 44, 145-176.

Suppes, P. Impact of computers on curriculum i[illegible] the schools and universities. In O. Lecarme & R. Lewis (Eds.), Computers in education, IFIP (Pt. 1). Amsterdam: North-Holland, [illegible].

Suppes, P., & Fletcher, J. D. Computer-assisted instruction in mathematics and language arts for deaf students. In AFIPS conference proceedings (Vol. 43). 1974 National Computer Conference. Montvale, N.J.: AFIPS Press, 1974.

Suppes, P., Fletcher, J. D., & Zanotti, M. Performance models of American Indian students on computer-assisted instruction in elementary mathematics. Instructional Science, 1975, 4, 303-313.

Suppes, P., Fletcher, J. D., & Zanotti, M. Models of individual trajectories in computer-assisted instruction for deaf students. Journal of Educational Psychology, 1976, 68, 117-127.

Suppes, P., & Hansen, D. Accelerated program in elementary-school mathematics--The first year. Psychology in the Schools, 1965, 2, 195-203.

Suppes, P., & Ihrke, C. Accelerated program in elementary-school mathematics--The third year. In R. B. Ashlock & W. L. Herman, Jr. (Eds.), Current research in elementary school mathematics. New York: Macmillan, 1970. Reprinted from Psychology in the Schools, 1967, 4, 293-309.

Suppes, P., & Ihrke, C. Accelerated program in elementary-school mathematics--The fourth year. Psychology in the Schools, 1970, 7, 111-126.

Suppes, P., Jerman, M., & Brian, D. Computer-assisted instruction: Stanford's 1965-66 arithmetic program. New York: Academic Press, 1968.

Suppes, P., & Morningstar, M. Computer-assisted instruction. Science, 1969, 166, 343-350.

Suppes, P., & Morningstar, M. Computer-assisted instruction at Stanford, 1966-68: Data, models, and evaluation of the arithmetic programs. New York: Academic Press 1972.

Suppes, P., Smith, R., & Beard, M. University-level computer-assisted instruction at Stanford: 1975. Instructional Science, 1977, 6, 151-185.

TABLE I

University-Level Computer-Assisted Courses at Stanfo:d 972–75

Course	Number of Students per Academic Year			Avg. Number of Student Hours at Computer Terminal
	1972–73	1973–74	1974–75	
Philosophy 57 Introduction to Logic	56	160	209	70 for A 54 for PASS
Philosophy 161 Set Theory	–	–	12	51 for A 31 for PASS
Slavic Lang. 211 Old Church Slavonic	5	2	1	30
Slavic Lang. Bulgarian	3	0	1	35
Slavic Lang. 212 History of Russian Literary Language	4	4	4	30
BASIC Instructional Program	–	100	200	10[a]
Computer Science 206 LISP	–	–[b]	79	93[c]
Music (ear-training)				
Music 21	–	42	41	d
Music 22	18	19	23	
Music 23	5	26	8	
Music 103	5	6	–	
Music 27	–	–	33	

[a] BIP students were limited to ten hours of time for experimental reasons. During unlimited pilot runs, students have taken up to 30 hours to complete the course.

[b] During 1973–74, LISP was taught at Stanford using the IMSSS machine; but students logged in as users, and there was no special CAI for LISP.

[c] LISP students spent an average of 69 hours in the LISP interpreter, and 24 hours in the LISP CAI system.

[d] The students had restricted terminal time.

STATEMENT OF PATRICK SUPPES, INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES, STANFORD UNIVERSITY

Mr. SUPPES. Thank you very much.

It is my intention to put my written statement into the record and just discuss the major points of my testimony here.

First, I would like to remark about the use of computers for educating either the disadvantaged or the gifted. One of the most encouraging things in terms of cost/benefits are the increasing cost reductions in the delivery of instruction by means of computers.

One of the hopeful things that should be a clear element of the testimony here is that over the next 5 years continued improvements of a fairly drastic kind can be anticipated in terms of the cost of delivering education by this means. This fact is independent of its merits, but if the case for the merit is established separately, the fact that there is a clearly anticipated improvement in cost is an important consideration.

Some of the programs that could not realistically have been thought of 10 years ago are feasible programs of instruction today. This is an important first point I would like to emphasize that I really did not emphasize too much in my written testimony.

Since 1963 I have been engaged in the use of computers for instruction with a variety of special populations, disadvantaged, handicapped, and gifted. I won't enter into the details of the handicapped this morning because the focus is on the disadvantaged and the gifted.

We have been using computers for instruction since January 1963, which is nearly a decade and a half. We began at the elementary school level, and fairly early we concentrated on disadvantaged youngsters because of the focus of the Elementary-Secondary Education Act of 1965 on the problems of the disadvantaged.

One of our earliest large-scale efforts was in working from Stanford in southwest Mississippi, in McComb, Miss. I think it is one of those strange combinations of technology and politics that the first school system in the world to have every elementary-school child at a terminal for some supplementary instruction in basic skills by computer was McComb, Miss. You wouldn't predict that if you looked at the record of innovation in the United States in general.

Mr. SCHEUER. Who initiated that? Did the educational authorities there initiate that?

Mr. SUPPES. It was a combination of the superintendent, Julian Prince who was very active in new educational ventures, the Office of Education, title III, in Washington and our interest.

Mr. SCHEUER. Was a university involved?

Mr. SUPPES. Stanford.

Mr. SCHEUER. You are helping some of us Yankees break down some of our prejudices which is a healthful process

Mr. SUPPES. There is a continued fairly good effort in Mississippi in relation to title I, continued work with basic skills and computer-assisted instruction. We also worked shortly thereafter in rural Appalachia which has a very scattered population. I will have some thing to say about that in the case of the gifted. We also did extensive work with minority populations, which children were classified mainly as disadvantaged. And in all of these cases we were working on basic skills, primarily reading and mathemetics. I have put into the record a lot of references and there are a lot more references than I have put into the record, that one can do a great deal that is important and significant in terms of improving these basic skills of disadvantaged students.

I don't want to give you a siren song that computer-assisted instruction is a complete panacea. I don't suggest that. It can be an effective means of instruction for disadvantaged youngsters in basic skills. And I think the references I have put on the record and a large body of work, not only at Stanford but in many other places, really do establish that computer-assisted instruction can be effective. And I think the reasons should be clear. It is individualized, and it is highly interactive. It is addressed exactly to the need and level of achievement of the student at a given time.

In a computer-based framework, I think one can do a very considerable amount with the problem of raising competence in basic skills.

Let me say something now about our early work with the gifted, because at the same time we were working with the disadvantaged, with funding from the National Science Foundation in 1963, we selected in the first grade a group of gifted students: The cutoff point essentially was an IQ of 130. I won't go into all the details of the process of selection.

Mr. SCHEUER. I am very keen to know what the process for selection was.

Mr. SUPPES. OK.

Mr. SCHEUER. One of the reasons I am thinking of is how do the means of selection impact the disadvantaged child who is intellectually gifted but who because of a not very enriched home environment, not a very stimulating peer group, may not have developed the verbal facility or the reading and writing or counting facility that he or she might have developed if they were an intellectually gifted middle-class white child. How do you spot the black or Puerto Rican or Mexican-American youngster with real intellectual talent?

Mr. SUPPES. Let me speak to that directly.

Mr. SCHEUER. It will not be reflected by their speech.

Mr. SUPPES. Let me answer that in terms of a practical method of a second experiment I want to describe in which we were interested not in gifted students but highly gifted students. The initial idea was a cutoff of an IQ of 165 which is way up there. I would like to describe that experiment because I think it is significant.

Mr. SCHEUER. How early can you spot a kid who is falling into that category?

Mr. SUPPES. Certainly in the elementary school.

Mr. SCHEUER. Not in first grade.

Mr. SUPPES. I think with care—you see, I think one of the problems of the highly gifted is that they are sparsely distributed and so identification can be expensive in the first grade. After they have built up some school records, the school will have identified them. The school will not have identified students of that ability on entrance.

Mr. SCHEUER. You say they will?

Mr. SUPPES. They will not have identified them, whereas, by the time the student is in the fifth or sixth grade, a large number of schools will have identified extremely able and highly gifted students.

Mr. SCHEUER. You take a black or Puerto Rican kid with real brilliance but school doesn't turn him on very much and he isn't doing all that well in his studies, but if you give him a test that could measure his ability to reason intellectually, to reason cerebrally, to plan and to distinguish, I suppose, and to collate and engage in wholistic reasoning his line would go off the chart.

How do you identify the kid who is brilliant but who has not gotten very much in the way of outstanding test scores simply because the work turns him off? Maybe society has turned him off.

Mr. SUPPES. I don't have a simple method of doing it. I will tell you how we did it in the present case. Although we were mainly selecting, as you might suspect, from white middle-class areas, due to the fact that we had long experience in working with disadvantaged and minority students, we made a special effort to include in this group some minority students.

The way we selected them was to go to the school system at the elementary school level and ask: Who appear to be your outstanding students? We got good recommendations. The test scores were not quite as high, but they were very good. They were very good by ordinary middle-class standards.

Mr. SCHEUER. Were they identified because of their test scores or because of the fact that the teachers knew?

Mr. SUPPES. They were identified by their recommendation on the basis of their school performance, rather than the test scores. The test scores were below what we were looking for, but they said that these students looked to be extremely promising.

I think it is a hard problem to identify gifted students from minority groups. I think with effort it can be done.

Mr. SCHEUER. I think it is something we have to do.

Mr. SUPPES. I would agree with that. It is an example of something where there needs to be a specific effort in connection with that identification.

One thing I think is important is to make the identification early. There is a broad basis of experience that indicates that the very young minority child is not as much at a disadvantage. His disadvantages widen as the school experience continues. If we can identify them early——

Mr. SCHEUER. At what age?

Mr. SUPPES. At first or second grade. I think there should be specific programs for that.

Mr. SCHEUER. Will you give us details as to what you think they should be?

Mr. SUPPES. Yes.

Mr. SCHEUER. It seems to me our country has an enormous interest in exactly that kind of program, identifying them and lavishing educational opportunities on them. I suppose you are talking about a fraction of 1 percent.

Mr. SUPPES. Yes; a very small percentage. So modest funding in relation to some of these large programs will have an enormous benefit.

Mr. SCHEUER. You took the words out of my mouth.

Mr. SUPPES. I think on this point a case could be made that gifted students are the most neglected population of students in the

United States in the sense of the resources that are being spent to permit them to realize their potential.

Mr. SCHEUER. The handicapped children would come a close second.

Mr. SUPPES. We now are mounting massive efforts with respect to the handicapped, and I think it is very important to deal with the handicapped. I myself have been involved in large-scale programs of computer-assisted instruction for handicapped students, and I have a high opinion of the kind of people involved in the education of the handicapped in this country. I think these efforts are in every way commendable, but it is very clear there is no comparable effort for providing any special facilities for the gifted, either identifying them or providing resources that are adequate to their potential.

Mr. SCHEUER. If you could give us your detailed recommendations on what should be done both as to identification and what we do with those cases and how we treat them: Do we take them out of their schools or their communities? I don't know. And specifically we would like any thoughts you have on how we could identify the IGC minority child.

Mr. SUPPES. You mentioned visiting Novosibirsk in Siberia in January 1972. I visited there in June 1972 and had the same experience you did. In fact, I went into the details of the curriculum at the special school for the gifted and also the method of selection. The school selects from all of Siberia. It is very clear there is not anything comparable in the United States.

There has been an effort of Julian Stanley and his group in Maryland to identify gifted students in the State of Maryland, but there is not anything of the magnitude of effort corresponding to what takes place at the special school in Novosibirsk or the one in Moscow or Leningrad. It is not only the identification that is important, but it is the depth and character of the curriculum that is given those students; able scientists, physicists, chemists and mathematicians from the academic complex in Novosibirsk are responsible for their instruction.

Mr. SCHEUER. How old are these children?

Mr. SUPPES. The ones that come in as residential students come in at about the age of 14, around the ninth grade level, and they are given 4 years of residential instruction in the special school right on the academic campus.

Mr. SCHEUER. An outstanding scientist at MIT or Harvard would consider it totally beneath his dignity to be teaching 14-year-olds.

Mr. SUPPES. I don't think so. I think it would be a piece of cake to get able academic scientists to teach those youngsters. I have had some experience at that, not only myself, but at getting some of my colleagues to do it, and they found it a real pleasure. I do not think it would be any problem at all. I think the problem is organizing the logistical effort and the institutional setting to make it happen.

Mr. SCHEUER. What kind of institutional setting would you recommend?

Mr. SUPPES. I think it is typical of our society that we probably want a pluralistic approach to that so that we don't mandate one fixed arrangement. In some cases there could well be on a university campus a special set of classes for gifted youngsters. In other cases the education would take place in conjunction with the school system the students are in, which might depend on the size of the school system.

To give you an example of this highly experimental effort with gifted students, I described in my written testimony how we put computer terminals in their residences so that they were able to take instruction directly at home. I also report on some of the realistic aspects of that. We know a lot about home-based instruction and the reasons for not completing home-based courses.

In many ways these highly gifted students showed all of the behavior that is characteristic of the difficulties adults encounter in completing home-based courses. Our students were doing this work in addition to their regular school work.

Mr. SCHEUER. Should it be in place of?

Mr. SUPPES. It should be in place of and should be substituting for. Very possibly the efficient thing might well be to have the terminals in the school. One of the problems we face, expecially if we move from the gifted to the highly gifted, is the sparse distribution of those students.

So, for example, in a population of 1 million people you maybe will collect in the 10- to 14-year-old range a group of 50 youngsters.

Mr. SCHEUER. You mean a million school students?

Mr. SUPPES. No. A total population.

Mr. SCHEUER. So in a total population of 8 million such as we have in New York, with 1 million kids, you might have 300 or 400?

Mr. SUPPES. In the age range 10 – 14.

Mr. SCHEUER. Is that the earliest age at which you would take them out of their local school?

Mr. SUPPES. In the earlier experience what we did was to identify, in a group of schools that were reasonably close to each other, a class of 30, and those students were then bused just for 1 hour per day for their mathematics instruction, beginning in the first grade. They were bused to two shcools and were taught by a special staff just in mathematics. They then went back to their regular classrooms for the rest of the day. That is one kind of scheme.

Mr. SCHEUER. This is for the very intellectually gifted?

Mr. SUPPES. Yes. In the case of the highly gifted we actually put terminals in the homes of the students, and they were able to work at home. In fact, we were working with districts of medium size in California, and there were not more than three or four highly gifted students in any one district in the age range 10–14 years.

Mr. SCHEUER. In a population of what?

Mr. SUPPES. The base population would have been on the order of say 750,000.

Mr. SCHEUER. And you had how many?

Mr. SUPPES. In the 750,000 population consisting of maybe six school districts we had about 24 youngsters, as a rough number.

Mr. SCHEUER. That is a large enough group to make it economical to bring in special teachers and all that?

Mr. SUPPES. By decentralizing it this way and providing terminals in the home for the student to engage in individualized work

Mr. SCHEUER. So you are saying in any metropolitan area say of over a half million that it makes economic sense to collect these kids and put the terminals in the home?

Mr. SUPPES. In fact, it undoubtedly would be economical in any area above a couple hundred thousand.

Mr. SCHEUER. You said in three-quarters of a million population you had 24?

Mr. SUPPES. We had about 24. I don't want to be committed to any exact statistic, because one wants to be careful.

Mr. SCHEUER. I am trying to think in the context of New York City, which is about 7.5 million, that we would have about 250 or something like that.

Mr. SUPPES. Easily.

Mr. SCHEUER. Let us say you identify them in the first grade, what do you do? Do you take them out for that first hour in math?

Mr. SUPPES. Yes. I think what is required and what is important is understanding how to institutionalize the educational effort. If you look at the literature, the power to conduct an experiment or to have an educational effort for gifted students in the full 12 years from first grade through high school is a complicated thing to put in place, as I'm sure you realize. That is, to institutionalize the effort is complicated, so that it really does happen over the full length of the 12 years and it's not just an experiment that comes to an end halfway through.

Mr. SCHEUER. One of the basic problems of institutionalizing is how do you get Congress to look at a 12-year time frame. We operate with a 2- or at most a 3-year piece of legislation and there are school districts that hesitate to go through major structural reorganizations of the kind you are talking about here without some kind of assurance of continuity. Part of the problem lies with us. How do you get that longitudinal effort when we can't function longitudinally. There is no way at present that we can fund a longitudinal program like that and give absolute assurance. I think we can give some kind of assurance because we keep funding an Army, a Navy, an Air Force, and a State Department.

Mr. SUPPES. Don't you think such a Federal effort for the gifted would end up rather like title I, for example. Title I does not have a longitudinal guarantee of what the level of appropriations will be.

Mr. SCHEUER. One of the problems with title I is that we treat our successes the way we treat our failures and some programs are smashingly successful and some don't work at all and they end up just sort of expiring by natural causes. We haven't distinguished in titles I and III between our successes and failures. We haven't treated our successes in a longitudinal way and tried to quietly bury our failures with appropriate ceremonies and give additional resources and fortification to our successes. That is the point I'm trying to make and we have failed to do that in a spectacular way. Let's face it, if we had done it, wouldn't we have institutionalized the Head Start program by this time? Wouldn't we have extended elementary education down to age 2 or 3 in the public school system. Everybody knows that Head Start was a spectacular success. It was the gem in the crown of the poverty program, the gem. What have we done about it? It has expired. We treated that the way we treated the Job Corps and the way we treated all of those troublesome projects that grew out of the poverty program. Can you rebut that statement? I wish you could. Try, please.

Mr. SUPPES. No. I certainly agree with you.

Mr. SCHEUER. If there was any rhyme or reason to the poverty program which was an experimental program, we would have taken whatever successes came out of it and institutionalized them in the American society. If our American school system had the brains it was born with, looking at it as a corporate thing out there, they would have grabbed the concept of Head Start and every school system in America would have extended public education down to age 2. Middle class people do it anyway. We have our prekindergarten. I went to prekindergarten 52 or 53 years ago. My folks got that for me and for my four brothers and sisters. Now we have proved it works for poor people just the way it works for middle class people. That should not come as any great surprise to anybody, but what did the public school system do with all of that evidence as to the spectacular success of the Head Start program?

Mr. SUPPES. What I want to say is——

Mr. SCHEUER. You are evading my question.

Mr. SUPPES. Oh, no. I want to put a comment on your remarks. I don't disagree with you, but I do think there is a positive element to it, looked at over a long period; namely, the enormous concern for the disadvantaged——

Mr. SCHEUER. But that flows from title I. That's still a Federal program. Local school systems themselves aren't doing that kind of work. I wish they were.

Mr. SUPPES. I want to give you one piece of data to comment on that. You mentioned 100 years ago; 100 years ago in 1870 only 2 percent of the age population graduated from high school. It was easy to train those students. They were the best students going—2 percent.

Mr. SCHEUER. They were really learning ready.

Mr. SUPPES. They were ready to learn. They would have learned anything.

Forty years ago it was still the case that we were only getting through high school somewhat less than two-thirds of the population.

Mr. SCHEUER. How about junior high schools? Weren't there a heck of a lot of kids in America who became literate without going to high school?.

Mr. SUPPES. Yes.

Mr. SCHEUER. Didn't we have virtually 100-percent literacy 40 years ago from the kids by the time they finished their education, be it 6th, 8th, 10th grade or high school.

Mr. SUPPES. I don't think we'd want to overplay that. I don't think we can make a real case that in terms of the total population——

Mr. SCHEUER. That there has been a lesser percentage of effective literacy today?

Mr. SUPPES. Right.

The other thing about the problem of Head Start is this: The public school systems have a financial problem with the available resources to simply plunge into it.

Mr. SCHEUER. It is a question of how they are spending their resources. In New York City we spent 60 percent of our education dollars ourside of the classroom and 40 percent in the classroom. Now that takes a certain kind of genius.

Mr. SUPPES. But you know what has happened. Because of the high percentage of women that are working, the arrangements for a much wider category in the society to have young children in day care centers—there's been a big change in our society over the last two decades. I'm not saying it is all done satisfactorily or that we have an appropriate follow-on arrangement to Head Start, but the arrangements are still moving in that direction.

Mr. SCHEUER. I drew you a little bit away from your subject and I'm sorry.

Mr. SWANSON. I will try to draw him back.

Mr. SCHEUER. OK.

Mr. SWANSON. I just wanted to raise this question. We have had the obvious spinoff of the Computer Curriculum Corporation, drill and practice, we saw the PLATO system and we had Seymour Papert talk about some of his experimental work. All three of those methods, drill and practice, mainline teaching and then Papert's argument that they really learn concepts by doing programs, I wonder if you could comment about your own line of reaserch now and what you're looking at and what you think the major research questions that we should be focusing on are for the near term and the long terms.

Mr. SUPPES. I think one of the things we want to focus on that is very promising is cost of hardware. The limitation will be the sophistication of the software. We will be able to have the hardware to deliver very sophisticated instruction programs over the full range of basic skills. And I think on basic skills the real attack should be on mathematics and language skills as the most important with secondary efforts in science and other areas.

Mr. SWANSON. This is mainline teaching provided by the computer or in conjunction with the actual teacher.

Mr. SUPPES. I don't want to give a simple answer because, for example, if we're talking about first graders I would think of it as supplementing the regular classroom instruction. At the university level—and I have elements of that in my written testimony—I think we can offer full instructional facilities by computer.

For example, I am doing that myself at Stanford. The only way you can take introduction to logic at Stanford is by full-time use of computer terminals. The course is taught entirely at computer terminals interactively and I run about 200-and-some students per year through the course. We have additional courses above that in complexity, more technical courses in mathematical skills. So when we ask—is it supplementary or is it complete instruction—the answer depends on the level. In the case of the highly gifted students I mentioned we gave them a course in logic that was self-contained that they took on terminals at home.

To give you an anecdote of what you can get from such students, the best student in that group—of course, we are talking about a group already that is exceptional—the best student in that group at 11 years old went through my college logic course at Stanford, which ordinarily takes 11 weeks, in 4 weeks. And Stanford students, of course, are no slouches.

Mr. SCHEUER. And this kid was 11 years old.

Mr. SUPPES. Yes.

Mr. SCHEUER. Was this a middle-class child?

Mr. SUPPES. Yes. One of the black students went through it at about the same pace as the Stanford students.

Mr. SCHEUER. What happened to that black kid after that?

Mr. SUPPES It is the usual case of such funding matters; it's been about 4 years and I cannot say where he is now.

Mr. SCHEUER. Did he continue in a track for educationally gifted children?

Mr. SUPPES. There was no special facility for him.

Mr. SCHEUER. What happened after you identified him?

Mr. SUPPES. We identified and worked with him for a couple of years and our funding stopped so our project stopped.

Mr. SCHEUER. How old would that child be today?

Mr. SUPPES. There were a couple of minority students and they would be about 16 or 17 now.

Mr. SCHEUER. Wouldn't it be interesting to find out how they are doing today in the absence of any special help?

Mr. SUPPES. I could probably identify those students. I will see if I can.

Mr. SCHEUER. Why don't you try to do that.

Mr. SWANSON. The ETS has evaluated TICCIT and PLATO and the results were very mixed in terms of performance. Do you think that was just limited to the kind of level of technical development of those systems? Would that be the case for the future? What kind of results have you achieved with your system?

Mr. SUPPES. Of course, in the case of TICCIT and PLATO, PLATO especially, was working with a very heterogeneous group of students. They were doing some work with university students, some work with community college students, and some with elementary school students.

To ask about the evaluation of PLATO is almost like asking about an evaluation of television. I think you want to talk about some particular targeted course and population. The effort itself was very heterogeneous. Now TICCIT was more focused at the community college level and it was more a matter of focusing on a particular population. I think that in the case of the work I have been involved in that we have had some highly successful experiences. I don't want to say that we have any magic for doing that. I think producing positive evaluations and having the institutional atmosphere in which to do it is a complicated problem. I think much can be done by means of the use of technology for instructional purposes, especially for individualization. But I think it is complicated. I think much is probably going to come out of the PLATO efforts, but they are very heterogeneous in character. I don't know whether you want a more detailed pursuit of that.

Mr. GALLAGHER. You mentioned difficulty of evaluation. We had a witness, Dr. O'Neil from DARPA, and they did in fact evaluate PLATO 4 and decided while it met all performances they rejected it, because it was not cost effective for DOD purposes.

Of course, DOD had other circumstances such as turnover of instructors and so forth. They rejected it because of the high cost of terminals and the telecommunications system.

Mr. SUPPES. To make a comment on the cost effectiveness, if we want to focus on this question we want to separate the cost of research and development efforts from operational efforts. If we want a strictly operational effort where we have a program developed, we use it in an operational way and we are not using it in a context of research, then th· · of using computers for instruction can be made very efficient. The ·· k I have done in association with Computer Curriculum Corp. is an example of that where we are not conducting research but we are offering standard instructional services using many comput·s and terminals that are not expensive. The cost can be brought way down. In a dynamic field like this that is changing all the time we ·n't want to say that everything has to be totally operational and ·ght at the bottom line in terms of the cost per terminal and cost per student. We need a variety of effort.

But the thing I would like to say and emphasize strongly is that all of the evidence is that the technology will be increasingly efficient in terms of cost. From a research standpoint the problem is to learn how to deliver increasingly better instructional products. It is estimated that in any complicated computer project the hardware is soon going to have a cost of about 20 percent of the total cost of the project. One of the things we need and which we don't have much of in Federal programs at the moment is research over the next decade as to how to have effective efforts. I would separate the cost of that research from operational costs. You have exactly the same thing at DOD. It is one thing to have research at DOD and another to ask how can you have effective use of instructional methods in the training commands. I want to make that sharp separation. I have been involved in that separation myself.

Mr. GALLAGHER. Why isn't industry playing a role and why have they not brought to bear their facility in finances and know-how into this whole operation and instructional training? They seem reluctant.

Mr. SUPPES. I think we will see some fairly dramatic changes in the next 5 or 6 years. There are a number of reasons I think. One is that it takes a while for the technology to mature and second, the cost accounting in industry, as far as industrial training goes, tends to hide the cost of training. It is a very standard practice not to put up front what the actual cost of training is. So identification of a capital acquisition budget for training and the like is a difficult matter. I think we are now beginning to see major efforts and will see major efforts in terms of using technology, not just computers but also all of the videotape technology, et cetera, for industrial training.

Mr. GALLAGHER. When it moves to the home environment, sort of a recreational system in the home adapted for education, do you think industry will then move? One of our witnesses implied that industry would do this with or without the permission of the schools and that it was going to come to pass in 10 years—this equipment in the home for recreational purposes.

Mr. SUPPES. We just wrote a couple of years ago for the National Institute of Education a monograph on home-based instruction. There is a very long history and a lot of knowledge about the problems of instruction in the home. In my own view the new technology can deliver very attractive and powerful packages of instruction into the home.

But in order to have sustained and large-scale successful efforts, it will take more than simply attractive packages. I think the evidence is overwhelming that for home-based instruction to be effective in a massive way it has got to be formal instruction. If you look at the efforts of home-based instruction over many years, there are a few key elements of success.

One is that when people are engaged in such instruction for purposes of certification or formal advancement the results are much better. So there will need to be a framework of certification, a framework of formal credit in order to properly motivate extended efforts by the individual.

There is no reason we cannot have that. In fact, we already see it in California. Television instruction is part of the community colleges, partly because there is an increasing demand to service the entire community, and partly because of problems of transportation and problems of additional capitalization of the campus. It is easier to deliver courses at home.

Mr. GALLAGHER. How many homes will buy this equipment. The mplication is that this will be absorbed into a computerized system. How many kids will actually do it on their own. Human nature being what it is, they will turn to "Sesame Street" and other entertainment.

Mr. SUPPES. This is why I'm emphasizing that you need some kind of formal structure. If you have a formal structure, it will take place. I will give you an example of a beautiful experiment at one of the universities maybe 10 years ago about faculty learning foreign languages that they did not know but needed for scholarly purposes. They were doing it on a volunteer basis but they had two different groups for experimental purposes. One group committed themselves to a formal schedule and the other was left to come in when they had free time and thought they had an opportunity to study. I'll bet you can guess which group did better, those who made a commitment to formal instruction.

Mr. GALLAGHER. It is a human factor.

Mr. SUPPES. We had the same thing with the highly gifted students when we had terminals in the home. We found it became important to set short-term goals with them as to what they would do over the next 2 weeks. Somebody would call them up and talk to them about how they were making progress.

I think that kind of setting of goals and putting it within a structure is essential to make this massive movement we foresee of instruction in the homes successful. I do not mean to say it can't happen. Let me give you an example of what is going on right now and what is indicative. In Orange County 20 percent of the entire adult population, not just college age, but 20 percent of the adult population in Orange County is involved in at least one course at the community college level. It almost seems unbelievable.

Mr. SCHEUER. It is fantastic.

Mr. SUPPES. It is a learning society in a real sense.

Mr. SCHEUER. How can you explain that? How did that ever happen?

Mr. SUPPES. Well, the community colleges are effectively marketing instructional courses that people want, whether it is knitting or how to repair a television set or an automobile or how to become a dental technician or whatever. It is obvious that they provide a service that completely responds to a felt need on the part of the population. I think that 20 percent of the adult population is unbelievable. It is important to remember that practically no countries in the world, outside of the United States and the Soviet Union, have 20 percent of the college-age population in some form of higher education.

Mr. SCHEUER. What about the British?

Mr. SUPPES. A low percentage in Britain.

Mr. SCHEUER. That is a mind-blowing figure.

Mr. SUPPES. In response to your question, I think that having that formal structure is an important element and industrial efforts separate from that certification procedure will not be successful in offering any depth of instruction.

Mr. GALLAGHER. I think there will be difficulty again because of the human factor. You have a houseful of kids and somebody wants to watch the super bowl game, like dad or something, and the equipment is tied up on that. And mom wants to watch something else, "Loveboat," or whatever.

Mr. SUPPES. There is a move to the second television set. That is moving down in the economic strata, the number of homes that now have two sets.

Mr. GALLAGHER. What will this cause, vis-a-vis our regular formal education system today?

Mr. SUPPES. I think what is happening is reflected in these figures for Orange County. For example, at San Francisco State University which is part of the California State University system, the average age of undergraduates is about 28. The research of people like Fritz Machlup has shown that our ideas about education beyond the secondary level are somewhat mistaken in the sense that there is a tendency for a much bigger segment of the population to simply continue. Even if they drop out and don't go to college or they go only 1 year, there is a strong tendency for them to reenter the system. So what is happening in the society is that they stay in the formal structure in terms of getting education, even if they don't stay in it continuously. The pattern is increasingly for a large segment of the population to be in and out of the educational system.

The pattern of completion of educational requirements does not correspond, for a large part of the population, to anything like the classicial conception of 4 years of college and graduation at 21 or 22. This pattern of continuing education is simply taking over the society as a whole and it is a very different pattern from anything we experienced 30 or 40 years ago. The kind of technology we are talking about provides an opportunity to facilitate such education in ways that simply that exceed anything we have had in the past.

Mr. GALLAGHER. One witness pointed out that the problem was 10-percent hardware and 90-percent programing in the future and the need for certain types of programers with insight and creativity to program those machines in such a way as to handle the vast increase in knowledge and so forth and so on.

This is what several witnesses pointed out as the problem.

Mr. SUPPES. I say very much the same thing in my written testimony. There is probably a broad consensus on this point among people working in the computer industry that the problem really is a conceptual one now, the creation of appropriately sophisticated software. It is going to require a massive effort for the rest of this country.

Mr. GALLAGHER. Will this equipment be self-programing too? It programs itself in its interaction with a student so that it can stay up with the student in the dialog?

Mr. SUPPES. Certainly an objective is to have an adaptive computer program, but it is important to distinguish various levels of adaptation. Most current programs adapt in some form to the individual student. Such individualization is an important feature of current efforts.

On the other hand, it is also very clear that we by no means have got as far as we can get in terms of the concept of adaptation.

Mr. GALLAGHER. I understand that's all ahead of us.

Mr. SUPPES. For example, the student is doing something in mathematics or science and the student gets hung up and is having difficulty. There are certain things that will be standard, but to analyze the difficulties of a particular student at a particular time on a particular problem is a very difficult intellectual thing and we have a lot to learn about how to do that as effectively as possible. We will be working on this matter for a long time.

Mr. SCHEUER. Thank you very much.

Just a couple of quick questions. How about the 34 young people, these bright second graders in 1964 and 1965 that you worked with. You worked with these kids for 6 years and that would take them up to roughly 1970. Now it is 1977. Could you compare where these kids have arrived compared to a comparable control group who did not have the benefit of all this stuff and see if they are a little bit further on in their educational achievement and then can you give us an estimate of where they would have been if you had kept right with them through 1977? That is 10 years later. They would have been about 6 or 7 then and if you had kept on with them they would have finished high school.

Mr. SUPPES. They graduated from high school a couple of years ago.

Mr. SCHEUER. You haven't had much to do with them since the sixth grade?

Mr. SUPPES. Right. So our information about them is limited—our project was funded for the elementary-school period.

Mr. SCHEUER. It should have been funded to take a class of kids and give them the full treatment and track them right along.

Mr. SUPPES. But it is the 12-year problem we were just discussing. At the time we identified a comparable group in ability a year younger and we followed them along also for several years, in order to compare the two groups, but we did not have the resources and have not been able to track the two groups after they entered secondary school.

Mr. SCHEUER. That's a crime.

Mr. SUPPES. But we were able to make the comparisons at the time. It is a typical problem. It is really complicated and expensive to conduct such longitudinal work.

Mr. SCHEUER. Can we afford not to do it. That's the basic question. As I read through this, it is apparent that in terms of the home study instruction you had trouble keeping these kids involved and there was a high dropout rate.

Mr. SUPPES. Absolutely.

Mr. SCHEUER. In other words, their basic intellectual competence exceeded their motivation and commitment at least in terms of doing the homework.

Mr. SUPPES. Two comments. First——

Mr. SCHEUER. How come they weren't really excited and challenged.

Mr. SUPPES. One of the things we found out about highly gifted students is that they have incredibly busy programs in school, such as going to music lessons and ballet classes.

Mr. SCHEUER. This stuff didn't replace something.

Mr. SUPPES. When we started working with them they were already committed from 7 in the morning until 10 at night. And the second thing that is probably more important they did not receive academic credit for the work with us—it was an addon to the regular academic program. We wanted to study simply how much would they become involved with purely intellectual incentives.

Mr. SCHEUER. Without their substituting for something in school and without their getting credit and that was a mistake?

Mr. SUPPES. What we did was perhaps to confirm the obvious.

Mr. SCHEUER. But it should have been in lieu of something and they should have gotten credit for it.

Mr. SUPPES. That is one of the recommendations that very strongly comes out of the study that even though we may be dealing with intellectually very gifted individuals the pattern of rewards has to be similar to what we know about successful home-based instruction for all kinds of people.

Mr. SCHEUER. As you very well know, when the Soviets identify one of these kids and presume he does good work at school he gets a Stalin prize, or a Lenin prize, or a Trotsky prize, and he brings home the equivalent of his parent's pay. He brings home approximately what his parents make if they are professional people. And that happens throughout his career, if he keeps his nose clean and works hard. That's a pretty clear incentive. These kids basically weren't coming from disadvantaged homes. They basically weren't from the Asiatic Russian population.

Mr. SUPPES. It is the same phenomenon in this country.

Mr. SCHEUER. These are mostly middle class or upper middle class kids, but they still got a very substantial financial incentive. When you talk about incentives, I suppose you are talking about incentives that would include academic credit and would mean this work was in substitution for some other work. Would you consider a financial incentive as being an appropriate incentive for these kids?

Mr. SUPPES. That would be a fairly radical departure. We just don't have such a system in place as a method of reward for students in elementary and secondary schools. It is another matter, if we are talking about scholarships at the university. My honest opinion is that it would not be required for elementary and secondary students.

Mr. SCHEUER. If they got credit for the work and it was in lieu of something else that would be sufficient to cure this dropout problem?

Mr. SUPPES. Yes. To give it a structure and a formal place in their academic progress would do it.

Mr. SCHEUER. Was this home instruction done in close cooperation with the local school district? Did you bring them into the local school district? You may have explained that here.

Mr. SUPPES. The students were attending the local schools and we placed the terminals in their homes.

Mr. SCHEUER. Did the schools play a role?

Mr. SUPPES. The schools concurred in the whole sequence of events, but they did not play a role from the instructional standpoint. We were offering material not offered as part of the regular curriculum.

Mr. SCHEUER. And what you are telling me is there has to be a greater interface between the kids and the school and they have to give him credit and know what he is doing.

Mr. SUPPES. Right.

Mr. SCHEUER. So the thing has to be more——

Mr. SUPPES. It has to be orchestrated in a very deliberate way with the school. I don't think, by the way, that it is a complicated problem to do. That can take place, but it does need to be orchestrated.

Mr. SCHEUER. Well, professor, as usual with a witness like you we have gone way over our time allotment, but thank you very much.

Mr. SUPPES. Thank you very much. It was a pleasure to be here, and I will try to send in an additional statement, as indicated, on the selection and programs.

Mr. SCHEUER. And how you would structure such a—assuming we wanted to put out two pieces of legislation, one on further research—and you talk about the research here—and that could come out of this committee, and a second piece of legislation which would come out of the Elementary and Secondary Education Subcommittee of Education and Labor Committee and that would be how you would structure a research and demonstration project across the country—not research, but actually doing it.

We will hope to talk to you about both of those things.

The next witness will be Dr. Sylvia Charp, director of instructional systems for the Philadelphia school system. Thank you very much for being with us.

[The complete statement of Dr. Sylvia Charp is as follows:]

A STATEMENT IN BEHALF OF COMPUTERS IN THE LEARNING SOCIETY

Submitted To

SUBCOMMITTEE OF THE COMMITTEE ON SCIENCE AND TECHNOLOGY

October 27, 1977

SYLVIA CHARP
Director of Instructional Systems
School District of Philadelphia
Philadelphia, Pennsylvania

Mr. Chairman, distinguished members of the Committee on Science and Technology...

I am speaking to you today as Director of Instructional Systems, School District of Philadelphia. I am also Secretary of AFIPS (American Federation of Information Processing Societies), and chairman of a Working Committee of IFIP (International Federation of Information Processing) concerned with the Instructional Uses of Computers.

INTRODUCTION

The School District of Philadelphia, a large urban school district with a student population of approximately 280,000 students, is concerned with meeting the needs of not only those students who may be identified as typical, but more critically, those students whose achievement or potential place them at either end of the educational or cultural spectrum. The so called disadvantaged student in Philadelphia is a label given to 1/2 of the student population who are economically deprived and 2/3 of the students who are educationally deprived. Those students who have been identified as gifted or academically talented number about 2%.

The Division of Instructional Systems of the School District of Philadelphia attempts to meet the needs of those students by applying the unlimited potential of the computer for instructional purposes.

ILLUSTRATIONS OF THE USE OF COMPUTERS FOR INSTRUCTION

The main thrust of the application of computers in instruction in Philadelphia is directed to helping students improve their basic skills through programs designed to enable each student to work at his or her own rate, provide self-direction for learning and thereby improve the known deficiencies. Results from the mathematics and reading programs last year with over 3,000 elementary school students have shown that the educational gains of disadvantaged students using the computer not only match but surpass the gains of children taught in regular classes. On the secondary school level, using the computer in the subject areas of mathematics, science, social science, and business subjects has last year assisted about 10,000 students in analyzing, exploring, and solving problems which arise in these disciplines. Many students, particularly those whom we have called "disadvantaged", are often non-participants in classroom discussion. We have observed that many "reluctant learners" who are involved in computer supported programs begin to lose their hesitancy, respond, and become more active and interested learners.

Inner city students are most likely to be unaware of the tremendous impact the computer will make on their lives. The computer to them is a mysterious entity, an enigma, the ultimate in automation, a treat to job security and a perpetrator of collosal errors. Computer Literacy, a course introduced at the Junior High School level, last year provided over 11,000 students with an introduction to computer concepts, an understanding of computer operations, some information on how computers are used, and the basics of communicating with the computer.

Career information, knowledge of occupational opportunities, availability of higher educational institutions, and financial aid information are of particular value to the disadvantaged student. Last year, over 20,000 students in Philadelphia and suburban communities benefited from a program designed, implemented and kept current by the Division of Instructional Systems, using the computer to present the above information.

For the past several years, the School District of Philadelphia has been involved in a state mandated program which requires that "gifted children shall have an education that meets their needs". The computer has been used for the past 3 years with approximately 1500 academically talented students who are in grades 3 - 8. It has opened many areas of exploration for these students as they examine alternatives and produce some very sophisticated programs. Third and fourth grade students are producing interesting computer generated poetry and using the computer to advance their knowledge in mathematics, science, etc.

POTENTIAL

The uses of the computer for instructional purposes has still not been fully explored. A national focus is needed to avoid unnecessary duplication, to make the best use of the scarce resources that seem to be available, and to disseminate the results of what has been successful. Back in the early 60's, there was great hope for technology. Too much was promised in that it would remedy all the educational ills. Many of us have put forth great efforts in developing various programs that would best help our students. Not many of us have survived, and those that have, are battling against growing financial problems and lack of support both local and state.

With public frustration over the low productivity of our schools growing, and a climbing drop-out rate, poor attendance, and low achievement rate, we must explore in greater depth what has potential for curing some of our educational ills. It has been shown that students using the computer do better work than those students in the regular classrooms. However, there has not been a total concentrated effort to build on what we have learned and to decide how we should continue. Federal monies have been spent in research and development, but research and development of an innovation does not lead to automatic adoption. Means have not been provided whereby the educator can adopt the innovation in his own school or district. As much systematic effort is required to investi ıte how to disseminate an innovation to schools, as is required in its initial development. Both must be backed by firm financial commitment.

WHAT IS NEEDED

* Greater flexibility and coordination in Federal Guidelines - At present monies are available from Title I, Title III, Title IV, etc. and the Vocational Education Act. These are specific on who can and cannot benefit from the funds. It must be recognized that the computer is a common resource and artificial guidelines drive

up cost. What resources and materials are needed are best understood at the local level.

* Much more curriculum material or courseware to be used with the computer - resources are needed at three levels.

   1. National funds - to supply high quality packages for general use
   2. Regional funds - to prepare material where regional needs are similar
   3. Local funds - to meet the needs of the particular local situation

* Training programs - means must be provided to upgrade the staff in the area of technology. This may necessitate the return of the National Science Foundation Institutes.

* Support for research - the programs that are presently in use need to be evaluated and plans to be made for dissemination if these programs are successful.

* To amend the ESEA legislation to include funds on application of computers to instruction with a large component for R & D.

* Creation of a Technology and Education Act of 1978 to help solve the problems of urban education with sufficient funds to examine best uses of existing and future technologies for instructional purposes, including the exploration of an all technology school, the training of teachers and administrators, development of courseware, and how to institute instructional change.

* A firm commitment to truly explore how to best use technology for instruction.

STATEMENT OF DR. SYLVIA CHARP, DIRECTOR OF INSTRUCTIONAL SYSTEMS, PHILADELPHIA SCHOOL SYSTEM

Ms. CHARP. I want to thank you for the opportunity of being here. I am speaking to you today as director of instructional systems, school district of Philadelphia. I am also secretary of AFIPS—American Federation of Information Processing Societies—and chairman of a working committee of IFIP—International Federation of Information Processing—concerned with the instructional uses of computers.

I am director of instructional systems for the school system in Philadelphia and I am concerned primarily with the use of the computer for instruction. That is my main charge in the school district. We first became involved with computers in 1966 when we received a title I grant of $1.3 million to investigate how to use computers in the educational environment.

Since then we have grown, and last year, we had 70,000 students involved with about 400 terminals in elementary and secondary schools. We have investigated various approaches on how to best use the computer in the classroom.

We work primarily with the disadvantaged, since Philadelphia has one-half of its population disadvantaged economically and two-thirds disadvantaged academically. We also have programs for the gifted, who constitute about 2 percent of the total population. For the past 3 years, there have been 1,500 gifted students using the computer.

Mr. SCHEUER. How do you identify the gifted children?

Ms. CHARP. There are various tests that are given.

Mr. SCHEUER. At what age do you give these tests?

Ms. CHARP. To enter the computer program, the gifted students are usually identified in grade three, at approximately 8 years old. The program we are working with is for students from grades three through eight.

Mr. SCHEUER. What percentage of your total school population are gifted children?

Ms. CHARP. About 2 percent.

Mr. SCHEUER. Your total school population is about two-thirds disadvantaged.

Ms. CHARP. Right; two-thirds academically, yes.

Mr. SCHEUER. Are most of them minority children?

Ms. CHARP. It's now about 60 percent.

Mr. SCHEUER. So you have 60 percent minority children and about two-thirds, another 6 to 7 percent, or whatever, would be white low-income children?

Ms. CHARP. Yes.

Mr. SCHEUER. How does your 2 percent break down in terms of black and white?

Ms. CHARP. I'd say it's about 60 to 40, 60 constituting the black population and 40 constituting the white population.

Mr. SCHEUER. That's very interesting. So, apparently, you are reaching the black children who are intellectually gifted even though one might presume that they wouldn't show up as well on a test as the white children?

Ms. CHARP. That's true.

Mr. SCHEUER. Professor, do you have any reaction to that?

Mr. SUPPES. That is about what I would expect to happen.

Mr. SCHEUER. I would have expected the tests to have identified a lesser percentage of black kids as intellectually gifted than in the population at large, simply because, even though I would presume there would be the same percentage of intellectually gifted children, I would not have expected that to show up in routine tests.

Ms. CHARP. Many of these routine tests may not be pen and pencil. Identification also results from teacher recommendation.

Mr. SCHEUER. That's not a test but a teacher's perception.

Ms. CHARP. A teacher may recognize exceptional ability.

Mr. SCHEUER. The teacher perceives that little Johnny——

Ms. CHARP. Is too smart for this class.

Mr. SCHEUER. He may not function at such a level——

Ms. CHARP. Students are given an IQ test. Over 130 IQ is being used as one of the criteria for the identification of the gifted, along with a psychological examination.

I wanted to share with you today, since I've been involved in this field for so many years and since I have had so much experience, some of our problems in using computers for instruction and some of the things we've learned.

One of the primary problems I have had in trying to promote the use of computers is a lack of understanding on the part of the top administrators as to what computers can do and what they cannot do. In order to put computer programs into the schools (we do have some kind of computer program in every one of our senior high schools, and we have programs in almost all of our junior high schools), we must educate the administrative staff.

When there is a money crunch, I'm sure you are aware of what is happening in Philadelphia right now with the schools probably being closed on Friday—it's the computer program that's one of the first programs that gets dropped because people don't understand the full significance of the value of computers in the classroom.

That has been one of our big problems. The administrators lack the knowledge of the computer capability.

Mr. SCHEUER. You're only talking about 2 percent of the school population.

Ms. CHARP. I'm also talking about the 60—the other programs. We have 70,000 students who are involved using computers in some way.

Mr. SCHEUER. Out of——

Ms. CHARP. Out of 258,000.

Mr. SCHEUER. So that's one quarter.

Ms. CHARP. We do have many students who are using computers, but if you think of 60 percent being disadvantaged, there are also many students who are not involved in our programs.

Our program at the end of last year suffered, because when the budget crunch came, and programs had to be eliminated, some computer programs were dropped because money wasn't available.

But that is, I think, maybe our fault in that we haven't educated our administrators.

The other part that you brought up, Mr. Chairman, is that we have no long-term commitment from the various funding agencies. We get title I moneys for a year. We get title IV for a year and there's no continuity.

Mr. SCHEUER. I wish I could give you some comforting words.

Ms. CHARP. But that's still a problem.

The other problem is that there really is little courseware—and Dr. Suppes brought this up—for the disadvantaged or the gifted. The hardware has developed to the point where it can be acquired fairly economically, but we have to develop most of our own courseware. So whether we're working with the gifted or whether we're working with the disadvantaged, whether it is using computers for the tutorial approach, or whether we mean computer-managed instruction, we've had to do our own development.

And then, of course, the next problem is the lack of teacher preparation. That is a big problem. The teachers really don't know how to use them efficiently in the classroom, and they are sometimes afraid of the computer.

Mr. GALLAGHER. Are they fighting it?

Ms. CHARP. We really have to do an education process, which we do continually.

Mr. SCHEUER. We had the testimony of Dr. Harvey Garner who is the superintendent of schools in my district, the First Congressional District in New York City. He has an extensive computer program in his area. He described to us how hostile and threatened the teachers felt before it came in, but after they had some experience working with the computer program for a year or two, they were enormously supportive and actually bargained collectively to keep it. They began to perceive it as totally a support for them as well as a learning opportunity for the kids.

Ms. CHARP. We've started a course which I think really should be in most schools, and that's computer literacy, where every student who is in the eighth or ninth grade would learn about the computer, how it affects the world around them, and what are the implications of computers. This program is introduced in the junior high school.

When the students enter senior high school, they say to their teachers, "We know something about computers, how is it you don't?" So we get the reaction from the teachers, who say, "Help us to learn about computers so we can work with the students."

Of course, knowing about computers has to be part of everybody's life.

Mr. SCHEUER. A whole generation of Americans, let's say, 25 years and older have had no exposure to them at all. And I would say 90 percent of the Members of Congress know absolutely nothing about computers and we ought to.

We are now beginning to get computer terminals in our own offices and after a couple of years I guess we'll be more personally aware of the opportunity——

Ms. CHARP [continuing]. Of what they can do.

Mr. SCHEUER [continuing]. Of the facilities and services and sup t that omputers offer us. We'll be able to imagine a little bit more creatively how they can be used to support the kids.

Ms. CHARP. We've shown increased gains in course areas. I mean just as you said, the superintendent from Brooklyn does have records. We do. We have records where we've shown youngsters——

Mr. SCHEUER. But that's not the point I'm making. The point I made is that teachers who felt hostile and threatened before the computer entered their lives, after working with it, began to perceive it as a support to them and a way of extending their own capabilities and enhancing their own teaching situation.

Ms. CHARP. I want to come back to the point of educational progress because people always ask me, "You spend all this money on computers, how do you know how good it is?" We do have research to show that students have increased two and three grade levels in reading and mathematics, in the course of 1 year.

Mr. GALLAGHER. You point out that educational gains of the disadvantaged students using the computer not only matched but surpassed- —

Ms. CHARP. That's right.

Mr. GALLAGHER [continuing]. The gains of children taught in regular classrooms——

Ms. CHARP. That's true.

Mr. GALLAGHER [continuing]. Not only in school district 18 in Brooklyn but the west coast out there at Whittier, they turned around a 16-year drop and reversed that drop and they're getting up almost to the national norms now by use of this computer which the witnesses said gave a lot of the disadvantaged kids who had been beaten down all their lives a chance to realize that they had a little bit of input and now they had a little role to play with this machine and apparently it had a therapeutic effect beyond their anticipation.

Ms. CHARP. We have really learned that computers are very effective in the classroom. There's no question about it; the motivation of using computers is definitely evident. It has raised levels of reading and mathematics.

Interestingly enough, it has raised the reading level, no matter what the subject matter, because of the fact that students are reading; it raises their understanding of the subject matter. We also know that the traditional methods with the disadvantaged student and the gifted student consistently have not worked in education. We have learned that over the years, and what we are trying to do is give technology an opportunity.

What we really haven't understood is that developing any kind of program to be used on a large scale takes time and a long-term commitment. What really concerns me is that we really don't have a long-term commitment on exploration of technology in the classroom. There are quite a number of projects around the country and any coordination of effort is not evident. We know computers are effective and we know they can assist learning, but there isn't a long term commitment.

Mr. GALLAGHER. NSF has withdrawn support from both PLATO and TICCIT.

Ms. CHARP. Yes.

Mr. SCHEUER. Why

Ms. CHARP. First, PLATO is like the Cadillac of the computers. It is extremely effective and wonderful and I wish we could afford the terminal, but we can't. It is extremely expensive.

Mr. GALLAGHER. A witness did respond to that question that apparently other programs have been neglected because of the concentration of NSF on PLATO and they felt now was the time to get back and share the pie more with other programs.

Ms. CHARP. PLATO put out a fantastic piece of hardware, but they really did not develop much courseware. So now Control Data is trying to work with some research organizations to develop some course material. But not many school systems are going to be able to afford PLATO. I think it rents for $1,200 a month.

Mr. SCHEUER. For what?

Mr. CHARP. For the terminal and some courseware that they have.

Mr. SCHEUER. Is that enough for one class or a lot of classes.

Ms. CHARP. It is on a one-to-one basis.

Mr. SCHEUER. How many children can use that one terminal? Is that for a whole class?

Ms. CHARP. For one child.

Mr. SCHEUER. How many children could benefit from that per month.

Ms. CHARP. If you figure a student session is going to be 20 to 25 minutes per day, how many students can utilize the terminal during the school hours, maybe 35 or 40?

Mr. SCHEUER. Not 35 or 40, if it is two per hour.

Ms. CHARP. Three per hour.

Mr. SCHEUER. You are adding more hours.

Ms. CHARP. Sure.

Mr. SCHEUER. If I make it 2 per hour for 6 hours, that would be 12 kids per day.

Ms. CHARP. We found that students really can't sit there for a half hour. Maybe 15 or 20 minutes is all they need.

Mr. SCHEUER. Let's make it 15 minutes and say 20 or 25 kids per day. And they should have it every day at the same time?

Ms. CHARP. Depending, yes.

Mr. SCHEUER. So you are talking about 25 children per month benefiting from a terminal that costs $1,200.

Ms. CHARP. It rents for $1,200.

Mr. SCHEUER. You are talking about $30 per month per child. It's more than that.

Ms. CHARP. It's $1,200 per month per terminal.

Mr. SCHEUER. It's about $40 per child.

Ms. CHARP. It also depends on whether we are going to use it only for mathematics and reading. There are now materials developed for the basic skills.

Mr. SCHEUER. That's about $500 per year. It's a lot of money but, on the other hand, if there is a real payoff there in terms of educational progress, it is worth it—is this the kind of computer technology that, due to the new miniaturized circuitry, is likely to go down in price over the next couple of years?

Mr. SUPPES. Sure.

Mr. SCHEUER. We have heard from some previous witnesses that a computer that cost $1 million 10 years ago cost $50,000 5 years ago, costs $750 today, and will cost $50 5 years from now. Wouldn't it at least pay us to do the research and demonstration work now and hope that the price of computers will come down soon?

Ms. CHARP. Absolutely.

Mr. SCHEUER. And you are saying that we really haven't developed the course material?

Ms. CHARP. Right. In many cases we haven't. I would like to see, for example, an all-technology school where we could explore technology to the furthest and see how far we can go in education with the technology that is around today and which may be available later. How to make it cost effective and how to measure the gains of the student from the time he comes into the school until he leaves should be examined.

Right now it is all piecemeal, and nowhere have we looked at the total student. These are areas that are still missing. We have not even disseminated what is good into other places. There are a lot of good things around, but nothing is being done about it.

Mr. SCHEUER. This is why I said that we treat our successes lik we treat our failures.

Ms. CHARP. There has been too little effort. It is very frustrating for those of us who have been involved and have devoted quite a bit of our lives. We recognize the fact that though we really believe in computers and that they do work in education, we haven't been able to make much headway. We have just been scratching the surface. When there are financial crises in school systems, the computer is looked on as an add-on expense and is always in danger of being eliminated.

Using the computer is extremely effective for career information. It is effective in teaching reading skills. There are many uses. The whole area of computer-managed instruction—using the computers to keep a record of where the students are and issue individual prescriptions—is another area we haven't really explored. There are many areas that still need examination.

Mr. GALLAGHER. But the DOD couldn't afford PLATO. They rejected it.

Ms. CHARP. It's the old story. In the beginning people couldn't afford television, and as more people began to buy TV's they became lower and lower in price. We are hoping that more people will get involved in computers, and so the prices will come down. Right now we have a network of terminals with telephone lines. We hope eventually to decrease the cost of telephone lines.

We hope that the new technology will provide for self-contained computers. These will be in the classroom without need of communication lines.

Mr. GALLAGHER. That is only if industry starts to move in in a mass way like it did with television.

Ms. CHARP. Right. These are the kinds of things we are hoping. But I am interested primarily from the instructional standpoint as to how effective it is and will it work.

Mr. GALLAGHER. One of our witnesses said that the educational side that you are talking about will piggyback the entertainment side.

Ms. CHARP. I'm hoping it doesn't. To me the instruction is far more important, and I think we have done enough work in it now that we ought to have a mass effort to show what we can do.

Mr. GALLAGHER. That won't be done by industry because of the profit motive.

Ms. CHARP. It may be; but there are many Federal funds available, like title I and title III, which we should coordinate. If there were provisions for technology added onto each one of the titles, we could make progress.

Mr. SCHEUER. This has been stimulating and provocative, and we thank you very much, Dr. Charp.

We would next have Dr. Dorothy A. Sisk, Director, Office of the Gifted and Talented, Bureau of Education for the Handicapped.

[The complete prepared statement of Dr. Sisk follows:]

STATEMENT BY:

Dorothy A. Sisk
Director, Office of the Gifted
Bureau of Education for the Handicapped
U.S. Office of Education
Department of Health, Education, and Welfare

BEFORE THE COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

Mr. Chairman, I am pleased to be here today to tell you a little bit about how the Office of Gifted and Talented in the Bureau of the Handicapped is attempting to bring the benefits of computer technology to impruve educational opportunities for 2.5 million gifted children. The use of computers can present the greatest help and challenge to the gifted child and undoubtedly figure heavily in obtaining appropriate educational opportunity for all gifted children. The provision of appropriate education for all gifted children is the major educational goal of the Office of Gifted and Talented.

In helping to insure appropriate education for gifted children, the Office of Gifted and Talented has encouraged local agencies and state agencies to develop enrichment programs for the gifted and talented that involve the use of computers.

The most rapidly developing use of computers in the education of gifted children is computer assisted instruction in regular school programs and special gifted classes. The computer can perform two missions. First, it can provide the comprehensive indepth information that the regular classroom teacher cannot always provide for the gifted student and it can provide for intuitive thinking. Secondly, it can provide a gifted child who is particularly creative and adept in expressive abilities, a new way of expressing their ideas.

Thus, the computer can serve as a means for gifted students to acquire information at the rapid pace they are capable of learning and acquire the use of the computer as a viable and necessary skill for the coming age of technology.

In Los Angeles Unified School District, where there is a resource math teacher, there is computer equipment used with primary and secondary students. The students learn the rudiments of computer programming (Basic and Fortran). The instructors note that gifted children learn the programs much more readily than adults as they are less inhibited. Teacher, Sharon Mountford reports that not only does the computer allow the gifted elementary child to use their high level of thinking skills and learn math concepts such as integer division, 'real numbers', and exponential notation, but it helps to teach them the much needed skills of work. Children must 'bubble' (fill in) the proper blanks on IBM cards. They learn accuracy in coding which carries over into other studies.

Dr. Adrienne Samuels from Lake Bluff, Michigan states that their gifted 5th and 6th graders study the materials on an independent basis from a book entitled My Friend, the Computer, and thereby qualify for a two month workshop that introduces them to programming the 13M5100 Computer which is donated by IBM corporation.

Another elementary effort shared by Debbie Nolan from Carlsbad, California is the use of the newly marketed, highly versatile and economical IMSAI 80-80 computer and terminal which sells for under $4,000. It is being used in developing a program for 5th and 6th grade gifted students.

Still another example of elementary children successfully using computers is given by Nedra Harkavy from Hampton, Virginia. She states that they have been using computers with gifted children as young as second grade. The children use specific computer games and become knowledgeable about the mechanics of using terminals. Gifted children prepare and design simple programs in mathematics and creative writing. Students do indepth independent studies in physics, chemistry, algebra, and geometry at the secondary level. Mrs. Harkavy reports that simulations available on Cathode Ray Tube terminals enable gifted students to delve into complex activities because repetition of basic formulas are no longer a requisite for each similar activity. Each terminal costs $2,500 and there are 54 in the Hampton schools.

Many of the programs at the local level are on a time sharing basis such as the following: San Leandro, California uses computers on a time sharing basis which cost about $1,000 a year. Gifted students learn to program computers, develop programs for others on request for curriculum use, such as a highly popular 9th grade remedial speller. The students' attitudes and enthusiasm was very high in computer programming and the experience of helping others helped to build a sense of service in the students. In the San Leandro project there was only one terminal with limited amount of use for each student. The program existed for 2-3 years and had to be dropped because of cost.

Phoenix, Arizona has a computer programming course in seven of their 31 schools with computer terminals. Bobbie Shoob states that the computers are utilized on a lease purchase basis. The school district pays for the telephone service and the Honeywell corporation donates time sharing on their computer.

Many successful efforts in the use of computers with gifted were initiated through federal programs such as the following: Mission Viejo High School has a computer which was purchased under a Title III grant. They have developed courses for gifted students with special classes being held before school for gifted high school students and after school for gifted 6th, 7th, and 8th graders.

Anne Arundel Public Schools developed computer application in geometry and chemistry courses in the areas of: prescription and diagnosis of pre-test and post-test data, computer simulation of problem solving in chemistry and computation in both subjects as a result of a Title III grant. The director, Dr. Neal Fertitta, reported high enthusiasm on the part of students being taught. He stated that for the gifted student, opportunity for exploring and problem solving challenges must be provided. This project is a fine example of how computers maintain the high level of interest of gifted students.

Another example of how federal money stimulated program growth is Paducah, Kentucky which began a project under Title IV-C and cost less than $20,000. The use of computers helped the morale of the teachers and allowed them to be creative in establishing a course called Chemics at Paducah High School. Dee Beck the teacher, reports that seniors identified by achievement, IQ, and teacher nomination are involved in a class which combines physics, chemistry and computer theory. Three teachers are involved with the 36 students, one teacher in each of the three areas of physics, chemistry and computer theory. The goals are to learn basic and advanced chemistry and physics; to see relationships between the disciplines; write their own computer programs; to study application of computers for medicine, space and other areas of science and humanities; and to project future uses of the computer in their lives and for society. The program is also assisted by professors at Murray State.

The Paducah program is exciting and they want to do more by adding computer equipment; so they can have advanced biology and psychology.

Many fine :iversity Community Centers are available for gifted children in co-operation with University run gifted classes, for example there is the program at the University of South Alabama, the University of Wisconsin, Johns Hopkins University and the University of South Florida.

To spotlight the University and College effort, Clairmont Men's College in California could be examined. Dorothy Seiberling reports that Clairmont's Men's College works with gifted 5th and 6th graders who are taught basic computer language and learn to write their own programs. Clairmont would like to expand their program, but are hampered by lack of funds and transportation.

Community Colleges have also shown their support in providing computer time for education as reported by Norm Soderstrom in which 6th, 7th and 8th grade students in Arlington Heights, Illinois work with a professor from Harper College for 6-8 sessions. The students learn about computers, programming computers and other related areas. Soderstrom reports that the students create their own programs and are then scheduled time on Harper College computers to run them.

Arlington Heights would like to have their own computer terminal to expand their offerings for gifted.

Non-profit agencies such as parent groups have also shown interest in sponsoring computer use with gifted. Dr. Ellie Hall, professor at the University of Michigan reports that the Ann Arbor public schools have a computer program for gifted Junior High students in math. Computer time was donated by industry and the Ann Arbor Association for Gifted paid for materials. Students assembled computer circuits to earn computer parts and constructed their own computer. At Community High School the teacher Ed Hernstein states that far more is possible with more funds and support for an 'in school' computer program.

The Gifted Student's Institute at the University of Michigan also reports that students who participated in a career education program at the computer center were enthusiastic and excited about careers in computer science.

One of the serious problems that we have in education of the gifted has been recently re-examined and that is the talent loss of young people who do not use their potential. William George and Sanford Cohen from Johns Hopkins University report that there is considerable loss of the top talent interest in math and chemistry to biology as a career choice. Part of the hypotheses for this loss may be the way in which these high school and college courses in chemistry and math are taught. Gifted students need to be challenged with problems and see the fascination in the applied aspects of math as in physics and computer science.

The use of computer assisted education just may very well be the key to more satisfying teaching for teachers who are frustrated by not being able to adequately reach their gifted and talented students as well as being equally beneficial for gifted students who need the freedom that computer assisted instruction affords.

Many College students have taken advanced College courses on computers such as those offered in Houston. Peggy Krens reports that the High School level compound of Vanguard had PLATO for use with students for over a year. The students and teachers found it a very challenging, stimlating and creative teaching tool.

Computer assisted instruction is extremely important in sparsely populated areas where there may be a small number of gifted children requiring assistance. Peter Larsen reports that computers provide opportunities for intercommunications with their gifted children. In the Kenai Pennisula Borough school district, Kenai, Alaska, they are developing a program to have gifted science students communicate with other students in the areas of the State to explore common scientific problems.

This need for computer assisted instruction for gifted would be true in sparsely populated states such as Montana, Idaho, Wyoming, Nevada, South Dakota, Nebraska and other states having sparsely populated areas.

Needless to say as the examples described herein have shown, there is considerable interest and awareness on the part of educators for computer use with gifted students. However, one ongoing problem is the education of teachers to utilize computers. Gil Brooks from Cleveland, Ohio states that he plans to develop an in-service program for 20 teachers from various disciplines in co-operation with Cleveland State University and Dr. Samuel Spiro as there are terminals in elementary schools dealing with curriculum for gifted that are not being used because the teachers do not know how to use them.

Few Universities offer courses in computer assisted instruction and even fewer opportunities are available for teachers to take computer programming

23-082 O - 78 - 39

or a computer course in their training programs.

A crucial need is assistance for training teachers and training people to write programs. The awareness of the importance of computers to gifted education is well stated by a teacher in Phoenix who said, "gifted students live in a computer age and have definite need to understand the whole concept of computer programming and the many values it serves in our society."

An example of the fine materials that can be developed by educators is the Title IV project in Tallahassee, Florida. The format of the various manuals are attractive and appeal to gifted children. These types of materials would also be useful with teacher education as well.

In summary, computers offer a wide level of potential use for the gifted. In some instances the computer may be able to provide the assistance that the gifted child needs to remain in the regular classroom with their own age mates. In some instances the computer may provide the profession with the information and data required to help plan and deliver the education required by any gifted child. There are questions as to cost effectiveness of computers, however if computers can reduce the need for highly trained gifted specialists, and can assist the gifted child, the benefit to society of another Einstein cannot be calculated.

As can be demonstrated by the cited programs throughout the United States, we know gifted children can learn from computer instruction and that computers can help provide a more comprehensive curriculum for the gifted.

With the support of the Congress, the Office of the Gifted and Talented in the Bureau of the Education for the Handicapped will take the initiative to sponsor research and demonstration activities to develop applications of modern technology to educating gifted children and to assist states and local agencies in implementing these new techniques.

STATEMENT OF DR. DOROTHY A. SISK, DIRECTOR, OFFICE OF THE GIFTED AND TALENTED, BUREAU OF EDUCATION FOR THE HANDICAPPED, WASHINGTON, D.C.

Ms. SISK. I would like to introduce Robert B. Herman, who is with me today from the Bureau of Education for the Handicapped. He is the Associate Deputy Commissioner, Mr. Scheuer.

Dr. Sisk and Mr. Herman, we are very happy to have you here. We have heard about the absence of computer-assisted programs for the disadvantaged children and especially for the gifted children. What is your response?

Ms. SISK. First of all I would like to thank you very much for being able to come and explain somewhat what my testimony represents. When I was asked to appear before this committee I was attending a National Association for Gifted Children's Conference and had just given a presentation called "The Age of Technology: An Invitation and a Challenge to Gifted."

I would like to share the response that the Conference audience gave to the topic. There were about 1,000 educators involved with the gifted either at the administrative level, the teacher level, or the teacher training level. Many of them who were involved in computer education nodded assent to the importance of technology to education for the gifted. However, some of the educators began to look amazed as if they felt little impact of science and technology would ever affect the classroom.

Primarily, what boggled the educators' minds was the involvement that I was predicting in terms of the use of technology in the classroom. Much of the technology I was projecting for future use in the regular classroom is already in use in some classes throughout the United States; for example, computer-assisted instruction.

To my amazement and, I guess, dismay, many teachers evidenced fear in using computers. Many openly stated that they had never had any courses on dealing with computers at universities. As they learned that there were computer-assisted programs for elementary gifted children in physics, math, algebra, and chemistry, you could see many teachers shrinking back. The response that I received was that they were "elementary education majors" and that they did not feel adequate in responding to Computer-assis ed education.

Mr. SCHEUER. Do elementary education majors today coming out of our schools have a comfortable relationship with computer learning? Are they taught how to work with computers?

Ms. SISK. From the overwhelming response I have received from teachers, I would say most teachers have not had courses or formal instruction in the use of the computer or any familiarity with its impact in the classroom.

Mr. SCHEUER. People coming out of our teacher's colleges?

Ms. SISK. Coming out of university teacher training program.

Mr. SCHEUER. That's absolutely amazing.

Ms. SISK. One of the recommendations that is involved in the position paper on technology for gifted concerns, teacher training. It is recommended that there be courses in computer technology and courses in writing programs for computers for classroom teachers.

Mr. SCHEUER. How do we get those courses into being?

Ms. SISK. Let me give you an example of how that might happen. In Paducah, Ky., there was a program called CHEMICS. This program evolved out of a title IV project. In fact, one of the exciting things that I did notice at the conference as I spoke with the people in attendence, was the evidence of computer-assisted education for the gifted through Federal stimulation, either through title I, through former title III, or through title IV.

Mr. SCHEUER. Are you talking about computer programs in the elementary and secondary schools or in the teacher's colleges?

Ms. SISK. In the elementary and secondary schools.

The way computer-assisted education often becomes involved with universities is that when educators have an elementary school program, the teachers find that they need more expertise in the use of computers than they have within the bounds of the school, and they often go to university computer centers for assistance.

In fact, in my testimony I would like to point out that several universities are working cooperatively with local schools. For example, there is the University of South Alabama in Mobile, the University of of South Florida in Tampa, the University of Wisconsin, Johns Hopkins University in Baltimore, and others—so that by involving——

Mr. SCHEUER. Were any from the northern part of the United States?

Ms. SISK. The University of Michigan and Teachers College at Columbia University were also involved.

Ms. SISK. The testimony that I'm giving is drawn from expert witnesses, classroom teachers and professors, who were available at the NAGC conference.

In other words, knowing that I had been asked to testify, I wanted to know specifically what was going on in the field. Each specific situation given as an example of computer assisted instruction here was given by an individual in attendance at the Conference and consequently limited to that population.

However, one of the major points that I would like to make is that when computers are used in an elementary school which involves a university, that involvement in turn stimulates professors to offer computer courses. The other issue I would like to address is the importance of early identification of gifted youngsters. I would particularly like to respond to several of the points that were made in terms of how you might identify gifted children. Many of the programs that are currently involved in computer education on the elementary level, particularly one in Hampton, Va., one in Carlsbad, Calif. one in Lake Bluff, Mich., and others, involve gifted children as a result of demonstrated giftedness, that is high IQ and high achievement, but they also use peer nomination, community nomination and parent nomination to locate participants.

By using broader definitions of gifted and broader identification procedures educators identify many more gifted. Some benefits of gifted children working with computers are as follows: acceleration, for example—the Eastern Michigan University youngster who is 11 years old and who was just entered as a freshman is an example of a solution that schools may have for a child who is highly gifted. They often don't know how to provide for that youngster's ability in the regular school. I think the computers——

Mr. SCHEUER. In my personal opinion, from the point of view of that child's social development and relations with his peers, to send an 11-year-old child to a university with 17- and 18-year-olds is a very poor solution from that child's personal growth and development point of view.

Ms. SISK. Computer-assisted instruction well might help in that situation. It would give the highly gifted youngster who is far above his age mates a chance to study at his own level in his own school and yet remain with children of his own age.

Computer-assisted instruction also will help in terms of the States that are using Public Law 94-142 to serve their gifted, in other words, the language from Public Law 94-142. In approximately 20 of our States, gifted children are served under the rubric of exceptional child education. Consequently, Public Law 94-142 language serves the gifted as well as the handicapped. Two advantages are coming out of several of the programs that are using computers. One is that it helps in terms of individual programing for the children. In other words, as we become more skilled in diagnostic prescriptions of gifted children, knowing the child's ability level, the child's achievement level, the child's self-concept, creativity, strengths and weaknesses, and as we become more skilled in programing strategies, this information can be fed to computers, thus providing an individual plan for an individual gifted child.

Second, in serving the gifted child in the regular school there is spillover value to the total program. A concern that I see particularly in inner-city areas—and New York City is a prime example of that—where we would expect 3 to 5 percent of the school population to qualify as gifted. In New York City, for example, that would be about 50,000 children.

In the inner-city area, oftentimes with the extreme emphasis on the the problem of disadvantaged youngsters teachers in many cases have become disgruntled and mechanical about education, as a result concentrating on weaknesses and bringing students up to "standard."

Mr. SCHEUER. The teachers are often concentrating on keeping physical order in the classroom.

Ms. SISK. That again is a tremendous problem.

Mr. SCHEUER. If we could motivate these children and give them something that will excite them and stimulate them, we would have less of a problem of keeping physical order in the classroom.

Ms. SISK. Exactly. That was my next point.

Mr. SCHEUER. One of the interesting points that Dr. Garner made was that in schools where they have the computer, school vandalism has fallen tremendously. The kids don't view the school any more as a hostile environment, as the enemy. You might find that the cost of this computer instruction is a negative cost if you track the child's progress. If these children are not dropouts, with the cost to society, and there is a reduced cost of school vandalism, you might find that these programs more than pay for themselves on a current basis in other savings.

I hate to justify it on that basis, but, to some people maybe that's a compelling argument.

Ms. SISK. Another problem to address is teacher dropout. We are losing a large number of our brightest teachers. And I think Dr. Suppes indicated also that there are scientists who would be willing to come into the school as mentors.. One of the exciting points I learned from the educators utilizing computers was that when the schools involved scientists, mathematicians, behavioral scientists, and scientists in life sciences, the curriculum building and the program building was stimulating not only for the children but also for the teachers. These educators felt that we might keep more young bright teachers in education through the excitement of computer education.

Another factor that is tremendously important is the involvement of technologists in such a way that these computer programs would be of high quality to keep gifted youngsters involved and stimulated.

I would like to enter one piece of research in the testimony that was recently reprinted by Johns Hopkins University which is quite interesting. Bill George and Sanford Cohen identified high achieving youngsters on the SAT test from a five-State area, had the students indicate interest areas, such as math, chemistry, biology, or physics and then—by the way, this is a very interesting project in that it does do some of the things that the other speakers have alluded to in terms of longitudinal study.

Johns Hopkins identifies these gifted children at the eighth grade level and they are followed through their graduate work, with counseling and assistance available. It is probably one of the few examples of specific aptitude being challenged and developed.

Mr. SCHEUER. Why did they do it at the eighth grade rather than the first or second grade?

Ms. SISK. Primarily because their program is based on offering services to the youngsters. As these children are identified at the eighth grade level, they are given a free course at Johns Hopkins University and cooperating universities.

Mr. SCHEUER. We heard from Dr. Suppes this morning that you would get a great many more minority kids stimulated and involved if you started at the first rather than the eighth grade, because the gap in learning readiness and accomplishment grows.

Ms. SISK. Exactly.

The Office of Gifted and Talented is very deeply involved in early identification. We funded a gifted project in Guam. In Guam this highly innovative program is identifying gifted youngsters of 4 years. They are using behavioral identifiers such as curiosity, sense of humor, flexibility, and interest in cause and effect. They are also using demonstrated leadership. They are talking to community members and parents. Parents are encouraged to bring their children to schools and to community centers for assessment and interviews.

We are looking to this project for examples to follow in terms of identification and service delivery to young children.

Mr. SCHEUER. You might try it also in a large metropolitan or urban center.

Ms. SISK. Yes; I think that would be very interesting. We have a project in Philadelphia that is identifying Puerto Ricans in terms of Piagetian tasks. Primarily, as I observed the project, they are looking at behavioral descriptors that the child can demonstrate. These projects are getting away from what we traditionally think of as gifted, that is, highly developed verbal ability and demonstrated achievement.

Mr. SCHEUER. This is the point I was addressing earlier. Would that not also be appropriate for black and Mexican American youngsters and many other youngsters in general, who might not be quite as adept at verbal tests but who still have very superior intelligence?

Ms. SISK. The Philadelphia project does have many exciting implications for most minority groups. In conclusion, one of the major points I would like to make is that, as I view what is currently being done for the gifted in the use of computers, it seems to have two thrusts. One is that the computer provides what oftentimes the classroom teacher cannot provide and that is the in depth information and the pacing that the gifted child needs.

Mr. SCHEUER. When you say pacing, don't you mean interaction with the child?

Ms. SISK. By pacing, I mean providing opportunities for the gifted child to learn at his own pace.

Mr. SCHEUER. And the computer can establish that personal relationship and the sensitivity to the child's needs and pace better than the teacher?

Ms. SISK. Oftentimes better than one teacher who is responsible for a large group with many needs, yes, very definitely. Computers also help the gifted develop work skills, in terms of accuracy, programing, and being on task skill that gifted children may not exhibit. Gifted youngsters do underachieve and do not always come fully equipped with work habits, work studies, and work skills.

Mr. SCHEUER. And the computer can help build those skills.

Ms. SISK. Yes. Consequently for gifted education, computer-assisted instruction is an exciting area.

Mr. SCHEUER. To get back to my original question, why is the Federal Government doing so little in this area? I must say that your testimony has been very convincing, creative, professional, and impressive. If the Federal Government believed you, wouldn't they be doing a lot more in this field than they are doing now?

Mr. HERMAN. I think the Federal Government is doing quite a bit in this field. I think we are giving quite a lot of support. A lot of the work that Dr. Suppes has talked about—some of it emanates, as he stated in his testimony, from the Education of the Handicapped Act funds. The National Institute of Education has heavily invested in computer research.

Mr. SCHEUER. What are the total dollars you are spending in computer research in terms of intellectually gifted children?

Mr. HERMAN. I couldn't answer that question now.

Mr. SCHEUER. Well, we'll leave the record open. And you can submit it.

Mr. HERMAN. We'll do that.

Mr. SCHEUER. Would you also submit a similar memo on computer-assisted education for the disadvantaged and for handicapped children? Can you give us a ballpark figure for the total invested in computer-assisted education?

Ms. SISK. Mr. Chairman, are you asking for research money as well as service delivery?

Mr. SCHEUER. We'd like both.

Ms. SISK. One of the items of information that you are requesting, that of the amount of federal involvement in CAI—I was very pleased to see in the education projects, that were shared with me at the

NAGC conference involvement was from title I for inner-city areas, from former title III and title IV.

Mr. SCHEUER. Why don't you submit to us a report on how much money you are spending in total, broken down between the gifted, the disadvantaged and the handicapped, and broken down for research and, then, actual operating programs in Brooklyn, Mississippi and Alabama, and other places.

Mr. HERMAN. Well, we certainly could do that for the gifted. It will be a little bit more difficult for the broader range. We can talk about research and demonstration. I'm sure we can identify those dollars very accurately.

Mr. SCHEUER. Could you give us a ballpark figure of the total?

Mr. HERMAN. We'll see what we can do.

Mr. SCHEUER. What are we spending on titles I and III for disadvantaged?

Mr. HERMAN. $2.8 billion, approximately.

Mr. SCHEUER. Are we talking on the order of magnitude of 1,000 to 1? If one is $2½ billion and the other is $2½ million, that's a difference of a thousand times.

Mr. HERMAN. Of course, the title I program and the gifted and talented program were never meant to do the same kinds of things.

Mr. SCHEUER. I didn't say that. What we're trying to do is identify and then enrich the gifted child's course of study so that he will make the extraordinary contributions to society that apparently he is capable of making.

Don't you think that the relationship of 1,000 to 1 just doesn't stand the test of reasonableness?

Mr. HERMAN. I would hope that within the title I grouping of children that there are—I think we discussed this this morning—intellectually gifted children among that group and they are being served in fact by title I resources being utilized in favor of those children.

The same holds for physically handicapped children. I think there are physically handicapped childred being served under Federal and State funds for physically handicapped who are intellectually gifted.

Mr. SCHEUER. You are not suggesting that the average title I program is really designed to be meaningful to the intellectually gifted child?

Mr. HERMAN. It is designed to supplement the services the child would ordinarily get in the educational program and if wise and effective administrators could identify gifted and talented children at the title I target schools, then I think they would be able to supplement those services with support programs for gifted and talented children.

Mr. SCHEUER. Would you identify those support programs in title I, and also identify the assistance that you are giving to the schools in how they can identify these children? You have heard what is being done in Guam and in Mississippi and what Dr. Suppes suggests which is going on on the west coast, will you identify the kind of assistance you are giving to educational administrators in identifying the gifted child under title I or any program and then what kind of ongoing programs you are helping them to fund out of title I or title III or any other Federal funding?

Mr. HERMAN. Certainly.

Mr. SCHEUER. We will hold the record open for a week or 10 days. Thank you very much for your testimony.

Our final witness here today is something of a bonus. He is here to announce the results of his just completed study on the scope and type of application of computers in our Nation's schools.

These findings, incidentally, should be very helpful to us in our work and we are delighted to have him here today. Dr. Harvey J. Brudner, president of HJB Enterprises from Highland Park, N.J.

[The complete prepared statement of Dr. Harvey Brudner is as follows:]

HJB ENTERPRISES
333 MONTGOMERY STREET • HIGHLAND PARK, NEW JERSEY 08904 • (201) 828-9333

October 27, 1977

TESTIMONY OF HARVEY J. BRUDNER, Ph.D., president of HJB Enterprises before the Domestic and International Scientific Planning, Analysis, and Cooperation Sub-Committee of the Committee on Science and Technology of the United States House of Representatives. Washington, D.C.

COMMENTS ON INSTRUCTIONAL COMPUTERS

During the past twenty years, one of the most highly publicized and most misunderstood phenomenon in the field of education has been the introduction, and use of computers in the nation's schools and universities.

There have been high hopes on the part of some, and high hurdles put in place by others.

Obviously, time limitations prevent a full exposition of all the technicalities implicit in computerized education. To assist, I would like to introduce as background a detailed paper on "The Past, Present, and Future of Technology in Higher Education", which was first presented at the Conference on Innovation and Productivity in Higher Education, held at Carnegie-Mellon University in October, 1976. Much of the information in that paper is equally as applicable to all levels of education and training. (1)

I should like to point out that despite the introduction of many kinds of instructional computer support programs over the last two decades, there has not been comprehensive statistical summary data relating to the following:

- o Extent of Usage
- o Regional Distribution
- o Numbers of Students and Grades
- o Academic Subject Areas
- o Categories of Instructional Use
- o Types and Numbers of Terminals
- o And Other Significant Areas. (2)

This lack of correlated data is complicated further by disagreement and misunderstandings as to how the computer should best be used, e.g., Computer-Managed Instruction vs. Computer Assisted Instruction.

It is difficult to intelligently assess the potential, and the needed changes in government policy and funding, without the above information.

Therefore, HJB Enterprises has embarked upon a correlation and assessment study which attempts to provide a preliminary roadmap for government, industry, and academe in developing and realigning plans and policies. (3)

For example, note the three appended tables concerning the ratio of users to enrollment by: school levels, number of users, and by geographic regions.

Indicative of the need for this study are the following examples drawn from preliminary analysis:

(1) The states which currently have the highest support levels for traditional educational techniques are, for the most part, the ones which are also in the forefront of instructional computer usage. For example, Minnesota, which has at least 26 instructional computer facilities at high school and college levels, ranks fifth in the United States in its appropriations per capita for higher education as cited in The Chronicle of Higher Education, October 25, 1977.

One of the things that can be done in this period of rising educational costs is to make more cost effective use of educational technology. However, as the preliminary analysis indicates, many of the states which could benefit the most, are furthest behind.

(2) Although Computer-Managed Instruction (CMI) tends to be a cost effective implementation of the computer, adoption of this methodolgy has moved along haltingly.

(3) Early analysis also suggest that there is heavy utilization of some of the most sophisticated equipment for lower level drill and practice applications, as opposed to more advantageous uses that could be made involving simulations and individualized tutorials.

Additional areas where instructional computers could have significant impact are Special Education, Continuing Education, and Industrial Training. Yet, recent studies made by HJB

Enterprises indicate that none of these sectors have been adequately developed.

There are an increasing number of success stories being documented each year. The technology is advancing. Evidence presented at these hearings has revealed a significant potential for the improvement in learning on the part of a major segment of our nation's population.

The realization of this potential will depend not only upon increased financial support, but also upon full analysis of past and present programs, and accurate assessments and evaluations.

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333.

RATIO OF USERS TO ENROLLMENT BY SCHOOL LEVELS

INSTRUCTIONAL COMPUTERS STUDY TABLE ONE

	TOTAL	High Schools	Junior Colleges	Colleges	Colleges+Jr. Colleges
GREATER THAN 50%	30%	43%	11%	20%	19%
20% TO 50%	31%	25%	33%	36%	36%
UNDER 20%	40%	32%	56%	44%	46%
TOTAL Schools Surveyed	367	167	36	164	200

618

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333.

INSTRUCTIONAL COMPUTERS STUDY TABLE TWO

RATIO OF USERS TO ENROLLMENT BY NUMBER OF USERS	100 to 999	1000 to 2999	OVER 3,000
GREATER THAN 50%	2%	9%	42%
20% TO 50%	14%	20%	42%
UNDER 20%	83%	71%	16%
TOTAL Schools Surveyed	42	111	201

619

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

RATIO OF USERS TO ENROLLMENT BY REGION — INSTRUCTIONAL COMPUTERS STUDY — TABLE THREE

	North East	North Central	South	Far West
GREATER THAN 50%	19%	31%	35%	35%
20% TO 50%	31%	25%	30%	38%
UNDER 20%	49%	44%	35%	27%
TOTAL Schools Surveyed	93	114	89	71

620

North East	North Central	South	Far West
Maine	Ohio	Delaware	California
New Hampshire	Michigan	Maryland	Washington
Vermont	Indiana	Wash., D.C.	Oregon
Massachusetts	Wisconsin	W. Virginia	Nevada
Connecticut	Illinois	Kentucky	New Mexico
Rhode Island	Iowa	N. Carolina	Wyoming
New York	Minnesota	S. Carolina	Montana
New Jersey	Missouri	Georgia	Colorado
Pennsylvania	Kansas	Florida	Arizona
	Nebraska	Tennessee	Idaho
	S. Dakota	Mississippi	Utah
	N. Dakota	Alabama	Alaska
		Arkansas	Hawaii
		Oklahoma	
		Texas	
		Louisiana	
		Virginia	

STATEMENT OF DR. HARVEY J. BRUDNER, PRESIDENT, HJB ENTERPRISES, HIGHLAND PARK, N.J.

Mr. BRUDNER. Thank you very much, Mr. Chairman. I would like to quickly go through some preliminary remarks.

During the past 20 years, one of the most highly publicized and most misunderstood phenomena in the field of education has been the introduction and use of computers in the Nation's schools and universities.

There have been high hopes on the part of some and high hurdles put in place by others.

Obviously, time limitations prevent a full exposition of all technicalities implicit in computerized education. To assist, I would like to introduce as background a detailed paper on "The Past, Present, and Future of Technology in Higher Education," which was first presented at the Conference on Innovation and Productivity in Higher Education, held at Carnegie-Mellon University in October 1976. Much of the information in that paper is equally as applicable to all levels of education and training.

Mr. SCHEUER. I would like to put that paper in the record at this point.

[The paper follows:]

14

THE Journal
Technological Horizons in Education
Vol. 4, No. 3

The Past, Present, and Future of Technology in Higher Education*

Harvey J. Brudner†

The following article, written by a Senior Consultant to U S.O.E. and former president of Westinghouse Learning Corp., is a paper which summarizes where we are, what the new technology now makes possible, and some predictions of where we are going in using instructional "hardware" for education. It follows up on an earlier paper written by Dr Brudner ("Education—1984" T.H.E. Journal, Sept., 1975, pages 14–15). He is now a member of our advisory board

This article will deal primarily with educational technology, and projects what some of the new videodisk technology can mean. It will review our current status with the emphasis being on computer-based instructional systems. The article will also make some predictions about the future and, although some of its conclusions are similar to those in the 1975 article, the 2 year update has some surprises. It is interesting to compare this article as well with that of Dr Molnar (Nov., 1975, pages 25–30 T.H.E. Journal), one of our contributing editors, since although from independent observations of the field, they arrive at similar conclusions. We welcome your comments on their findings and encourage your development of short articles on the same topic.

Nothing — nothing at all — matters more than trained intelligence. It is the key not only to success in life, but it is the key to the meaning of life -- President Lyndon B Johnson, Cotulla, Texas, November 1966

Instructional processes in higher education basically have not changed during the past centuries, or even since the invention of printing. But a great change is likely during the next two decades. The technology of communications and data processing, which has had such a profound impact on American society in general, will also start to exert a powerful influence on our system of higher education. The new technology has already begun to transform procedures in educational research, administration, and large libraries. It has started to bring higher education to the handicapped, the sick, the aged, prisoners, and people located in remote areas.

Properly applied, the new technology increases the opportunity for independent study, and allows for a richer variety of courses and methods of instruction. These courses will include increased use of cable TV systems, videocassettes and videodisks, and computer-assisted and computer-managed instruction, as well as greater emphasis on multimedia learning kits.

The slow take-off of educational technology over the past decade suggests that there are many strong resisting forces. Obviously, instructional technology is not completely welcomed by the academic community. This situation has been aggravated by the fact that faculty members with talent and interest to design new, replicable learning materials are not always properly rewarded. Confusion has been generated by manufacturers offering incompatible systems of similar products, and there is the struggle between the local campus producers and the knowledge industry. Local projects often thrive even though faculty members may not have the combination of interest, subject-matter expertise, me... knowledge, and learning-theory knowhow that high quality learning material design requires. The overall situation has been extensively reviewed in prior reports, such as the Report of the Carnegie Commission on Higher Education; this presentation reviews highlights from the best surveys,[1] and attempts to project future directions.

In 1967, Godwin Chu and Wilbur Schramm of the Institute for Communications Research at Stanford University concluded that, properly applied, the learning effectiveness of instruction provided by technology is as successful as that of good professors and teachers using conventional modes of instruction. The two authors reviewed 207 published studies comparing TV with conventional teaching. Of 421 comparisons, 308 showed no significant differences, 63 showed TV instruction superior, and 50 found conventional instruction better.[2] Similar findings for computer-assisted and programmed instruction have been developed by Levien.[3]

Many academicians ask, "Why should there be technology and media use in higher education?" From the students' point of view, there are many reasons.

* This paper was first presented at the Conference on Innovation and Productivity in Higher Education, held at Carnegie-Mellon University on 14–16 October, and is in the conference proceedings, published by San Francisco Press, Inc., 547 Howard Street, San Francisco, California 94105

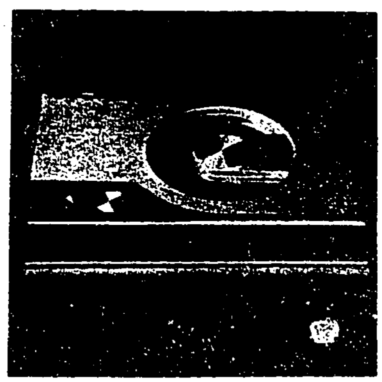
† Harvey J. Brudner is President of HJB Enterprises, Highland Park, N J

Obviously, no institution of higher education, no matter how well endowed or publicly supported, can afford to cater to the diversified and specialized needs of the present generation of multidiscipline, cross major students. Nor can even the strongest institutions offer 1:1 or even 1:5 teacher-to-student ratios. Moreover, students have come to expect personal and academic advising. Obviously, more of the professor's time in the future will have to go into advisory and managerial roles, and less into tutorial roles. It is precisely in the latter area that technology and media can play a quality role.

Flexible, modular scheduling, easily generated by computer systems, can expand learning options for the working student and even generate adapted time payment and credit spread schedules. Also, electronic and audiovisual developments allow the multicampus institution to extend available faculty talent of unique qualifications to remote locations. A trend may well develop to encourage nonresearch oriented faculty and professional staff members to produce technical materials via the new media.

Observations on the Present-day Status

Most examples of present-day educational technology are overly familiar to us. Books, for example, are basically technological learning devices, so are blackboards, maps, models, charts, and specimens. The stereograph dates back to 1885, the lantern slide, to 1900. Motion pictures were used for education as early as 1910 and radio, starting in Pittsburgh, in the 1920's. The early 1960's brought closed-circuit TV and the multimedia classroom, the mid-1960's, computer-assisted and (a little later) computer-managed instruction; and the 1970's, the videodisk.



The Philips and MCA optical videodisc system will play a pre-recorded 12" disc of 30 minutes in length. Connectless "reading" avoids wear on the information carrier.

The techniques have been improved and refined each year. Microfilm and microfiche are examples of high-density reduction technology. Dry copying has had considerable impact; so has electronic reproduction and facsimile telecommunications and reproduction. All that is no longer regarded with amazement on the college campus.

Indeed, although motion pictures are reaching their 70th year of educational use, colleges use them rather infrequently for instruction. Seeking out, acquiring, and setting up a good film is regarded as an annoying chore by the typical professor, whose department chairman probably regards films as relatively expensive and annoying, in that the class may have to be moved or rescheduled and arrangements may have to be made for a projectionist. Most universities use 16mm films, but Super 8mm film has started to make an impact. The history of 8mm films, first commercially introduced in 1932, goes back almost as far as 16 mm; it began as an amateur product for the general public, but in the early 1960's several companies introduced 8mm sound projectors and then, in 1965, introduced the new Super 8mm format. The loop projectors have found use in education in present short-film segments in "single-concept" format and have found additional application for students to study independently.

Much of the technology used in large multimedia classes is also used in self-instruction units. Indeed, the growth of *individualized instruction* represents education's most significant trend, even though it is still in its infancy.

The 1960's saw many installations of language laboratories.[5] Here, via audiotape lessons, individualization of instruction goes on with the teacher at the master console acting to monitor and guide each student on his or her own learning path. The Phillips type of audiocassette has made further development of the audio listening center as a relatively available and cost-effective approach possible, yet relatively few college departments have implemented the audiotutorial concept. Implementations such as those at Carnegie-Mellon and Purdue Universities remain exceptions.[6]

Another refinement of the concept is the utilization of computer equipment and telephone lines to select and deliver audio and audio-visual instruction via materials held at a central storage center. To date, such dial-access systems have proved to be too expensive and too limited in their software to be widely disseminated.

Radio broadcasting of lectures and instruction was at one time thought to be a major opportunity. By 1968 the original Ohio State University station that helped spearhead the program was only transmitting two programs a week to schools. Not even the availability of millions of car radios and transistor radios has changed this pattern. By 1970 only 12% of the originally licensed educational AM radio stations were still in existence. however. almost 500 capus FM radio stations serve local schools.[7] Such stations generally have a broadcast radius of only a few miles. and only 10% of them are used primarily for instruction. Yet radio has been extensively used in South Korea, Japan, and Great Britain for delivering education to remote areas. In the United States. only specialized networks such as those used for postgraduate medical instruction have found continuing application. New York State (via the SUNY-Albany facility). North Carolina. Utah. California. Wisconsin, and Ohio are among the best-known operators.[8]

Television has perhaps the greatest and most pervasive potential of any instructional technology. It comes in many forms. with various potentials and limitations. Most dynamic has been broadcast TV via public television networks. Such series as Masterpiece Theatre. Civilization. and The Ascent of Man have attracted wide audiences and have had considerable impact in continuing education. Another success is NYU's Sunrise Semester. Yet relatively few colleges and universities have been able to maintain broadcast facilities for instruction. Chicago City College and the Open University systems of Great Britain and of Japan are oft-cited examples. however. only about 30% of the instruction in such programs takes place by broadcast TV.

The closed-circuit or cable systems increase the range of instruction. and enable colleges to schedule instruction better. The so-called Instructional Television Fixed Service (ITFS) is a distribution system whose broadcasts at microwave frequencies are picked up with special receiving equipment for redistribution within, say, a school building. The range is limited to about 25 miles, which is more than adequate for most college and university systems. However, most ITFS systems are used by elementary and high-school districts. and by parochial-school systems.

The Community Antenna or Cable TV systems are extended counterparts of campus-wide closed-circuit television systems.[9] Here, specially designed antennas or high towers or mountain peaks pick up distant TV signals, amplify them. and redistribute them over special (usually coaxial) cables to homes. businesses. and schools. The importance for higher education rests largely in the large number of channels that are available.

We may divide recent nontraditional programs into those which provide a highly personalized and individualized form of education. and those which offer flexible access to courses through teaching at a distance. The personalized programs include that of Minnesota Metropolitan State College. the University Without Walls consortium. and the Empire State University of New York (now with about 3.000 students).[10,11]

The New York State Regents program offers bachelor's degrees solely on the basis of examination and transfer credits. at present in nursing and business administration. without residence on a campus and without formal course registration.[12]

We have also seen the use of the modified British Open University (teaching-at-a-distance) system in the United States. at Rutgers University. the University of Maryland. and the University of Houston. These programs enable students to undertake serious college-level study without the requirement of scheduled classes.[13] The Coast Community College in California has been a leader in the development of courses which utilize broadcast TV[14] and the University of California at San Diego Extension Division has created the idea of using special materials published in daily newspapers as a basis for course development.[15]

One of the most important recent programs has been that of the University of Mid-America (UMA). a consortium of seven large midwestern universities: Iowa State. Kansas State. and the Universities of Nebraska, Missouri, Kansas, Iowa and South Dakota. UMA carries out three major functions:

(1) preparation of multimedia courses.
(2) coordination of learning activities in the participating institutions. and
(3) research in the effects of various kinds of media presentation.

Although still young. with about 2,000 students. it has completed a course in Accounting and is working on courses as varied as Japan, The Great Plains, World Food Problems, Poetry, and Application of Pesticides.

Another interesting program. operating out of Evanston, Illinois, is the Learning Exchange. a match-maker organization to bring together individual teachers and learners for given subject fields. In such a program. learners then have an obligation to teach in the field in which they are qualified.[16] The above programs and others were recently reviewed by UMA's J. I. Lipson at an Interciencia conference in Brasilia.[17]

Many programs can be carried. some quite specialized and of interest to only a few people. Cable TV thus begins to approximate the dial-access capability mentioned earlier.

The latest TV refinements are videotapes and videocassettes. which permit storage of instruction for repeated, convenient use. In some institutions, such as Oral Roberts University in Oklahoma, tapes can be checked out or called up for viewing on special monitors. Some institutions have made use of such capabilities. in conjunction with TV cameras, to record classroom performance of student teachers. speech therapy students, athletes. musicians. etc., and have instant playback and analysis.[18] In 1973 Kremer and Compaan (of the Phillips Corp. in the Netherlands) wrote. "Although no other mass medium has undergone such rapid growth or made such an impact as television, it is technically true to say that in many respects, it is still in its infancy." They went on to describe their new laser videodisk system. appropriately called "On Printing Motion."[19]

Sociologists tell us that Americans watch on the average of over 30 hours of TV each week. The public in general (including students) has acquired a liking for it. What would be the impact of systems that would allow

System	*Phillips MCA*	*RCA*
Price of unit	$500	$500
Price of disk	Somewhat above LP costs for 12 in 30 min disk	$10 for 12 in., 60 min disk
Playing time of 12 in disk	30 min (recorded on one side only)	60 min (recorded on both sides).
Features	Picture can be speeded up, slowed, or frozen. Finger prints, dust do not distort. Disks can be made thick or thin, including a paperthin one to be sent through mails	Use of a grooved disk eliminates two of the control systems needed for optical systems. Production costs are lower. Slower rotational speed reduces vibration problems
Recording system	Laser beam	Electron beam
Disk material	Plastic coated with aluminum and transparent protective layer	Vinyl copolymer coated with metal, dielectric and lubricant
Speed of rotation	1800 rpm	450 rpm
Life of pickup element	Approx 10,000 hr	500 hr
Manufacturers	Phillips & Magnavox (player) MCA & Plyogram (disk)	RCA

for freedom of choice of program — as we have with books or records — at about the same price?

Unfortunately, magnetic tape is relatively costly and not too easily handled, which makes duplication complicated and program access somewhat slow. We are used to audio information being "printed" on records, why not have low-cost TV information printed on records? Utilization of laser technology for both master generation and playback could lead to such a "printed" system. The Phillips Video Long Play (VLP) disk has an optical readout (via a small helium-neon laser in the playback unit). It is therefore easily repositioned and can produce

- a still picture
- variable speed motion
- forward and reverse motion
- address readout of any one of the 54,000 frames in the 30 min disk
- sequenced or computer-controlled readout

The following table compares per-copy manufacturer's materials costs for a 30-minute motion visual program

	Quantity			
Medium	1	10	100	1000
16mm film	$417	$108	$84.52	$66.17
8 mm film	285	66	52.00	44.76
¾ in videocassette	70	31	21.25	18.50
Videodisk (projected)	450	46	3.01	0.63

Because of the high quality of the TV picture, one can even use the frames to store print and index banks. We shall return to this interesting development after a brief review is made of the related developments in computerized information systems.

Recently, RCA Corp. has adopted a new technique to produce a videodisk that can be played via a capacitive readout. There are many similarities of intent between the Phillips and RCA systems, but technologically they are quite different and probably only one of them will ultimately prevail. The RCA videorecord is also 12 in. in diameter; however, as in an ordinary LP record, a metal-tipped sapphire stylus rides in the record groove, senses tiny changes in electrical capacitance along the groove, and utilizes these changes to modulate the signal. The RCA record can be therefore recorded on both sides to produce an hour's output. The above table (adapted from Forbes Magazine[2*]) compares the two formats.

Past, Present and Future

Continued from Page 17

Computer Systems

Computers can be involved in higher education in many ways.[22] Computer-assisted programmed instruction (CAI) has received most attention. Here the computer system is used as a medium to present instruction directly to the student. Obviously, the computer attempts to assist or substitute for the instructor. We define programmed instruction as learning programs structured in terms of defined behavioral goals.

Time-shared CAI systems are available today at moderately high cost, several hundred dollars to $1000 per month per terminal. Until recently most CAI terminals have consisted merely of teletypes or typewriters. Such equipment, with associated communication gear, typically accounts for one-third to one-half of the costs of a system with a full complement of terminals. Cathode-ray-tube display terminals are beginning to replace the typewriter for many purposes. More advanced terminals, such as plasma displays with a variety of audiovisual features, are also coming into use, and even more advanced laboratory prototypes offer great promise for future low-cost, high-function terminals. In short, development of terminals is a long way from a standard terminal for CAI.[23]

Several programming languages and operating systems for supporting CAI work have been developed. With a few exceptions, each of these systems is oriented either toward conversational programming as a means of problem solving or toward use of a CAI language for more or less stylized programmed instruction. Of the systems now seen, none seems to be fully adequate possibly as an early prototype of a future CAI operating system.

As to instructional programs for CAI, experience to date shows that program preparation costs range from several hundred to a few thousand dollars per student hour. It is not yet clear how much an instructional hour will be worth in comparison with an hour of alternate learning activity. There is not even agreement on how to estimate eventual cost effectiveness of CAI.[24] There is urgent need for some good evaluation experiments to lay a foundation for cost-effectiveness evaluation. Some CAI programs consist of mere presentations and/or simple questions-and-answers testing; in short, of materials from some other medium displayed by means of a computer terminal.

The chief deficiency in most programs is not that the content is mundane or the sequencing of learning objectives conventional; elementary content can be quite suitable for CAI, and conventional structuring of the program content is usually valid. The fault is rather that poor use is made of the computer. To discuss this point adequately, we distinguish (following Adams[25]) among three technical aspects or dimensions of design of a learning program: content, structure, and mediation.

Content means something like the scholar's notion of the scope of the course, the corpus of information in it — in behavioral terms, the terminal objectives. *Structure* means the elements of order that make it a program in the learning psychologist's use of the term, the strategy of building up a complex skill, the hierarchy of behavioral objectives, the play of sequencing of learning tasks, the forms of messages, the esthetic value of the learning experience. A successful CAI program must succeed in both content and structure. However, if the learning program is to be deemed successful as CAI, the computer's function must be essential to the realization of some important instructional value. Clear identification of the value added by the computer should be the first step in the evaluation of a CAI program.

Although the computer is often regarded primarily as a communications medium, it can contribute to any of the three aspects of the program. It may contribute to content where the learning tasks involve formulation or use of computer programs as such. It may be essential to structure where the sequencing of learning tasks depends on the past experience of the individual student. It may contribute *mediation* values where immediate responsiveness improves the effectiveness of the learning program or where computer mediation permits changes in administration and/or logistics of instruction.

What we need is a set of established programming principles for preparing learning tasks that are suited to the medium, for example:

- Constructed responses are usually better than selected responses.
- Learner initiative and control are desirable features.
- Instructions should be held to a minimum; tasks should be formulated so that there is a "natural" way to answer, and so that the computer can deal with minor format variations.
- Service messages (correct, wrong, etc.) should be in general as few and as brief as possible.
- Where appropriate, programs should facilitate trial-and-error learning.
- Clarity should come before enrichment.
- It is more important for the learner to know what he is doing than for the learning psychologist to foresee and control the process in detail.

The unique promise of CAI is to give a learner conversational interaction with a body of information, especially structured for facilitating learning. The extent to which this promise can be fulfilled at present is limited more by poverty of programming technique than by the other technical limitations of the CAI systems. The foremost educational need for advancing the state of the art in CAI is thus to develop and demonstrate program designs and learning tasks that achieve effective communication between learner and learning programs.

That is not to say that there are not also great needs and opportunities to tie together CAI with new audiovisual techniques such as the laser videodisk. Such systems may ultimately allow low-cost, branching audiovisual CAI formats.

Apart from the tutorial mode and the more obvious uses in simulations, demonstrations, gaming, etc., the computer can be very valuable in the management of the total instructional process. Such techniques lead to what has become known as the Computer-Managed Instructional (CMI) system.[26] Here, as in the Westinghouse Plan* system, an electronic data-processing system becomes an aid to the teacher or professor. The computer enhances instructional efficiency. In a 1972 survey, Comstock found that the most common use is data processing and teaching computer science.[27] Fewer than 10% of present-day universities and colleges report any form of tutorial use, for various reasons: (1) the faculty is not well aware of the instructional potential of the computer, (2) effective and validated instructional software is lacking, or (3) most present systems (except in specialized areas) are not cost effective.

One of the best-known surviving systems is the University of Illinois PLATO series, now in its PLATO IV generation.[28] It is conceived to handle eventually some 4000 teaching stations. At the present time, an estimated 15,000 part-time students take at least some of their courses on a screen display, by printout, or (in some test situations) by synthesized speech. In April 1976, Control Data Corp., which builds the Cyber computer series, utilized by PLATO, announced that a major commercial push was expected, with additional customers among universities and in the military; however, the primary target was to be industrial training.[29] PLATO systems are being installed by universities in Florida and Quebec, and a modified package at Lowry Air Force Base in Denver, but the major thrust will be to offer industry terminals at $15/hr per student. PLATO promoters argue that it costs $5-10/hr to educate an undergraduate, $20-30 for a graduate, and $30 and up for a professional student. There will be no attempt initially to offer the system to secondary schools, since a typical school allocates about $1/hr for each student.

The designers claim that PLATO design overcomes some of the problems of earlier CAI systems. Instead of storing data on magnetic tapes or disks, PLATO relies on more conventional extended core memory, which allows data to be moved out of storage as much as 1000 times faster. Therefore, even when 500 terminals share one central processing unit, a student need wait only 0.2 sec. on the average for a response. Earlier CAI systems had long response times and some students lost interest as a result.

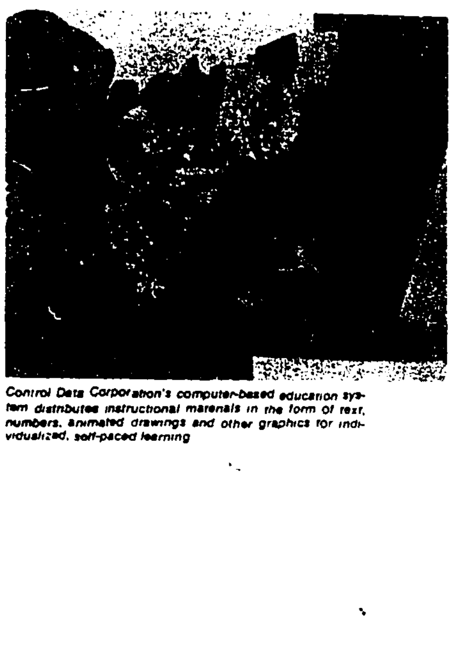
The PLATO display consists of a grid of fine wires, 512 across and 512 down, sandwiched between two plates of glass so that the wires form a grid of more than 250,000 tiny cubicles, each containing neon gas. When a cubicle is addressed by the computer keyboard, a surge of current causes the gas to ionize and glow. The display is free of flicker; unlike a cathode-ray tube, it need not be "refreshed." Because it is transparent slide pictures can be superimposed on the display. However, the plasma display panel accounts for about 35% of a terminal's cost of about $6000 at present.

Critics of the centralized approach point out that phone tariffs are on the rise and microcircuitry costs are coming down, making it economically feasible to put more and more computer power and memory into stand-alone minicomputer systems. The leading manufacturer of minicomputers, Digital Equipment Corp., has already sold over $12 million worth of minis to colleges and universities.

Several colleges and universities are now employing time-sharing services of a computer consortium, such as the Dartmouth Regional Consortium and the Oregon State Regional Computer Center. Basically, such consortia require only the installation of terminals and telephone communications lines.

TICCIT (Time-sharing Interactive Computer-Controlled Information Television) was developed under a National Science Foundation contract by the MITRE Corp. of Boston and Washington, a nonprofit systems-engineering company. Courses were developed by the Institute for Computer Uses in Education at Brigham Young University (BYU). TICCIT was originally intended for use in community colleges, according to C. V. Bunderson, director of the BYU Computer Institute.[30] However, among its first users are U. S. Navy training programs in California and Florida.

Formal field tests of TICCIT have been conducted at Maricopa Community College in Phoenix and at Alexandrias campus of Northern Virginia Community College.



Control Data Corporation's computer-based education system distributes instructional materials in the form of text, numbers, animated drawings and other graphics for individualized, self-paced learning

The Future

The author and many of his colleagues feel that technology and media can and will make significant contributions to the future of higher education.[13] [We] have witnessed many examples over the past decade in which the computer enhanced the individualization of instruction and enabled the professor to adapt instruction to the personal needs of students. Computer use to help manage the process looks promising, and as the costs of both central processing hardware and of terminals decrease, this approach will be applied more extensively. A corresponding development of technology is expected to carry education outside the school and university center to the home and community, and to business and industrial centers.

With future uses of cable systems, it will be possible to put the most disadvantaged students into contact with the most advantaged resources. Much of one's education already takes place outside the classroom. In the future it should be increasingly possible to guide that learning by the use of technology.

A recent article in the *Wall Street Journal*[31] reassesses educational trends as follows: (1) increasing demand for continuing education, (2) more flexibility in the content and structure of education, (3) more uses of computers in education, (4) use of videodisks, (5) more use of communications and multimedia, (6) training and education approaching 12% of the gross national product, (7) productivity increases, (8) more use of low-cost open structures, (9) growth of learning centers, (10) weekend colleges patterned after Mid-America University, (11) Federal support of education increasing to 30%, (12) more emphasis on the development of values, (13) more use of video-packaged education, (14) increased use of testing and a trend toward criterion-referenced testing based on specific objectives, (15) increasing student expertise in computers and personal portable calculators, and (16) the price of minicomputers dropping from $10,000 to $1,000 over the next several decades. The only "negative" in this futurecast indicates that the percentage of our high-school graduates who go on to formal higher education will not rise above 50% (compared to the present 47%).

How soon these trends may be realized has been the subject of speculation by Silberman[32] and by the author.[13] Boulding has pointed out that the schooling industry is supported mainly through one-way grants rather than by the sale of services in an open market, and consequently has little incentive to increase its productivity. He writes about alternative techniques for solving the problem, such as a voucher plan that would reward schools that achieve greater productivity, and educational banks that would lend students the full costs of their education — with the loans to be paid by an income-tax surcharge. He argues that if education is converted to a market economy, it might be easier to establish a market to support private technological developments.

In the next decade, we shall experience an ever-increasing number of changes that will transform our lives and the world of education. New mathematical development, new science, new social science, and new technology will be upon us with accelerating speed and intensity.

The new technology will include microcomputerization, laser applications, more abundant power sources, more sophisticated biomedics, extensive use of satellite telecommunications, and the beginnings of a "science of leadership." In the future each student will receive instruction according to his or her individual needs. Students will learn at their own paces, using materials and presentational systems that fit the cycle of development. Computer systems will help teachers in teaching students and diagnostic testing, but instruction will still remain under teacher control. Students will learn to take greater responsibility and make independent decisions. Critical, analytic thinking will be stressed, and students will have more freedom and use it to increase their problem-solving abilities. They will work as individuals and in small groups directly with their teachers. Teachers will not be required to write lesson plans since learning objectives and guides will have been fashioned for all subjects. Instead, teachers will spend time developing special interdisciplinary objectives and activities for a particular student or situation. Besides traditional homework, more time will be spent doing interactive lessons, with one's parents and members of the family.

Illich has proposed that we devote more energy to making it possible for people to learn in informal settings of their normal daily activities without mediation by schools or professional educators.[33] He argues that since the cost of education is rising faster than the productivity of the entire economy, it would be cheaper to give people more personal responsibility for what they learn and teach without the aid of professionals. His first step toward opening the access to skills would be to provide incentives for skilled individuals to share their knowledge. He suggests computerized matchmakers to match peers, form tutor/student combinations, and create learning webs.

An important Delphi technique[34] Study of Factors That Have Inhibited a More Widespread Use of Computers in the Instructional Process, was done by EDUCOM (the Interuniversity Communications Council) in 1972. It contained fifteen recommended action plans as suggested directions for breaking the status-quo cycle.

Clearly, education will be increasingly broadened through vocational and technical training.[37] We have witnessed these trends already at the community college level. As Lester Brown has put it, "We may be on the verge of one of the great discontinuities in human history. Those who think the final quarter of this century will be merely an extrapolation of the third will be seriously disillusioned."[38]

Our children will spend more than half their lives in the 21st Century! In 1984 there will be a population of about one hundred million Americans aged 3 to 24. The occupation for most of them will be "student." Extrapolations of present trends indicates that expenditures for education and training may then reach $100 billion a year in 1976 dollars.

The resources for a considerable transformation of higher education will be therefore available over the next 25 years. Many are looking forward to participating in the implementation of those exciting new discoveries.[39]

References

1. Eric Ashley, R. M. Besse, et al., *The Fourth Revolution* (Carnegie Commission on Higher Education). New York: McGraw-Hill, 1972.
2. *Ibid.*, p. 13.
3. R. F. Levien, *The Emerging Technology: The Instructional Uses of the Computer in Higher Education*. New York: McGraw-Hill, 1972.
4. J. W. Thornton Jr. and J. W. Brown, *New Media in Higher Education*. Washington, D.C.: National Education Association, 1967.
5. Thomas Hope, *The Hope Reports Perspective* (Rochester, N.Y.) (No. #) 2-7 March 1976.
6. W. H. Allen and D. H. Coombs, *Trends in Instructional Technology*. Stanford, Calif.: ERIC-Stanford Planning Report, 1970.
7. S. C. Tickton, Ed., *To Improve Learning: An Evaluation of Instructional Technology*. New York: Rowker, 1970-1971, 2 vols.
8. R. O. Forsythe, *Instructional Radio*. Stanford, Calif.: ERIC-Stanford, 1970, p. 3.
9. Carnegie Commission on Educational Television, *Public Television: A Program for Action*. New York, 1967.
10. Norman MacKenzie, Richmont Postgate, and John Scupham, *Open Learning: Systems and Problems in Post-Secondary Education*. Paris: UNESCO, 1975.
11. C. O. Houle, *The External Degree*. San Francisco: Jossey-Haas, 1973.
12. K. P. Cross, Personal conversation with Joseph Lipson, 1976.
13. C. E. Covert, Ed., *Proc. First Annual National Conf. on Open Learning in Higher Education*. Lincoln, Neb.: University of Mid-America, 1974, p. 619.
14. *Ibid.*, p. 113.
15. *Ibid.*, p. 131.
16. R. Martin and E. J. McCartney, "The Future Revised," *Wall Street J.*, 8 April 1976, pp. 1, 27.
17. J. L. Lipson, "The present state and evolution of nontraditional postsecondary education," paper presented at Interciencia Conference, Brasilia, 13 July 1976.
18. Department of Audiovisual Instruction, *A Survey of Instructional Closed-circuit Television*. Washington, D.C.: National Education Association, 1967.
19. P. Kramer and K. Compaan, "On printing motion," *Eduology Magazine*, 1 April 1973 (Reprinted, *Phillips Technical J.*).
20. E. W. Schneider, *Educational Technology*. Englewood Cliffs, N.J.: Prentice-Hall, 1976.
21. "The new television," *Forbes Magazine*, 1 June 1976, pp. 24-29.
22. A. G. Oettinger and Selma Marks, *Run, Computer, Run*. Cambridge, Mass.: Harvard University Press, 1969.
23. Jeremy Berstein, *The Analytical Engine*. New York: Random House, 1969.
24. M. B. Solomon, "Some computer economics in education," *Educational Technology* (No. 5) 47-49, 1971.
25. E. N. Adams, *Project ARISTOTLE Report*. Washington, D.C.: NSIA, 1968.
26. H. J. Brudner, "Computer-managed instruction," *Science* 162: 970-976, 1968.
27. G. A. Comstock, "The computer and higher education in California," in Ref. 3.
28. D. L. Bitzer and D. Skaperdas, *The Design of an Economically Viable Large-scale, Computer-based Education System*, Urbana, Ill.: University of Illinois, 1969., also see Science 192, 334 (1976).
29. "More teaching by computer," Business Week, 26 April 1976, pp. 66-B-68-B.
30. T. Magarrell, The Chronicle of Higher Education, 26 April 1976, Vol. XII, No. 9, p. 1.
31. Ref. 16.
32. Harry Silberman, "The Educational potential of technology," speech presented at UCLA Faculty Lecture series, 1973.
33. H. J. Brudner, "Education — 1984," *Technical Horizons in Education* 14-15, September, 1975, Vol. 2, No. 5.
34. K. E. Boulding, "The School industry as a possible pathological section of the American economy," *Rev. Educ. Res.* 41: 1, 11, 129-143, 1971.
35. Ivan Illich, *Deschooling Society*. New York: Harper and Row, 1971.
36. E. J. Anastasio and J. S. Morgan, *A Study of Factors That Have Inhibited a More Widespread Use of Computers in the Instructional Process*. ETS Grant NSF G57 1827 Interuniversity Communications Council, 1972; pp. 36-49.
37. K. B. Hoyt, "Broadening education through vocational and technical training," *Implications for Measurement* (Proc. 1971 Invitational Conf. on Testing Problems), p. 113.
38. L. R. Brown, *U.S. News and World Report*, 3 March 1975; p. 32.
39. Ref. 33.

Mr. BRUDNER. Thank you, sir.

Jumping to some of the very significant work that has been developing only recently, I would like to point out that despite the introduction of many kinds of instructional computer support programs over the last two decades, there has not been comprehensive statistical summary data relating to the following:

One. Extent of usage.

Two. Regional distribution.

Three. Numbers of students and grades.

Four. Academic subject areas.

Five. Categories of instructional use.

Six. Types and numbers of terminals.

Seven. And other significant areas, as documentation of gifted and disadvantaged subgroups involved.

This lack of correlated data is complicated further by disagreement and misunderstandings as to how the computer should best be used, that is, computer-managed instruction, computer-assisted instruction, computer-based administrative applications, et cetera.

It is difficult to assess intelligently the potential and needed changes in Government policy and funding, without the above information.

Using our own funds, HJB Enterprises has embarked upon a correlation and assessment study which attempts to provide a preliminary roadmap for government, industry and academe in developing and realigning plans and policies. For example, I will introduce into the record fourteen (14) appended tables concerning the ratio of users to enrollment by high school levels, number of users and geographic regions, and other significant relationships.

[Tables follow:]

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333.

RATIO OF USERS TO ENROLLMENT BY SCHOOL LEVELS

INSTRUCTIONAL COMPUTERS STUDY TABLE ONE

	TOTAL	High Schools	Junior Colleges	Colleges	Colleges+Jr. Colleges
GREATER THAN 50%	30%	43%	11%	20%	19%
20% TO 50%	31%	25%	33%	36%	36%
UNDER 20%	40%	32%	56%	44%	46%
TOTAL Schools Surveyed	367	167	36	164	200

631

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333.

RATIO OF USERS TO ENROLLMENT BY NUMBER OF USERS

INSTRUCTIONAL COMPUTERS STUDY TABLE TWO

	100 to 999	1000 to 2999	OVER 3,000
GREATER THAN 50%	2%	9%	42%
20% TO 50%	14%	20%	42%
UNDER 20%	83%	71%	16%
TOTAL Schools Surveyed	42	111	201

632

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

RATIO OF USERS TO ENROLLMENT BY REGION

INSTRUCTIONAL COMPUTERS STUDY

TABLE THREE

	North East	North Central	South	Far West
GREATER THAN 50%	19%	31%	35%	35%
20% TO 50%	31%	25%	30%	38%
UNDER 20%	49%	44%	35%	27%
TOTAL Schools Surveyed	93	114	89	71

633

North East	North Central	South	Far West
Maine	Ohio	Delaware	California
New Hampshire	Michigan	Maryland	Washington
Vermont	Indiana	Wash., D.C.	Oregon
Massachusetts	Wisconsin	W. Virginia	Nevada
Connecticut	Illinois	Kentucky	New Mexico
Rhode Island	Iowa	N. Carolina	Wyoming
New York	Minnesota	S. Carolina	Montana
New Jersey	Missouri	Georgia	Colorado
Pennsylvania	Kansas	Florida	Arizona
	Nebraska	Tennessee	Idaho
	S. Dakota	Mississippi	Utah
	N. Dakota	Alabama	Alaska
		Arkansas	Hawaii
		Oklahoma	
		Texas	
		Louisiana	
		Virginia	

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

TYPE OF USE BY SCHOOL LEVELS — INSTRUCTIONAL COMPUTERS STUDY — TABLE FOUR

	TOTAL	High Schools	Jr. Colleges	Colleges	Colleges+Jr. Col.
CAI TUTORIAL	18%	11%	19%	24%	24%
CAI DRILL & PRACTICE	75%	75%	81%	73%	74%
SIMULATIONS	33%	31%	28%	36%	35%
OTHER USE	30%	27%	28%	34%	33%
CMI	10%	16%	6%	6%	6%
RATIO OF CMI/CAI	13%	21%	7%	8%	8%
TOTAL	367	167	36	164	200

634

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

INSTRUCTIONAL COMPUTERS STUDY — TABLE FIVE

TYPE OF USE BY NUMBER OF USERS	100 to 999	1000 to 2999	OVER 3,000
CAI TUTORIAL	10%	11%	23%
CAI DRILL & PRACTICE	83%	86%	68%
SIMULATIONS	29%	40%	30%
OTHER USE	26%	36%	38%
CMI	7%	3%	14%
RATIO OF CMI/CAI	8%	4%	20%
TOTAL	42	111	201

635

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

INSTRUCTIONAL COMPUTERS STUDY TABLE SIX

TYPE OF USE BY REGION	North East	North Central	South	Far West
CAI TUTORIAL	18%	20%	12%	20%
CAI DRILL & PRACTICE	76%	72%	79%	72%
SIMULATIONS	30%	38%	30%	32%
OTHER USE	28%	35%	28%	27%
CMI	10%	13%	8%	10%
RATIO OF CMI/CAI	13%	18%	10%	14%
TOTAL	93	114	89	71

636

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

INSTRUCTIONAL COMPUTERS STUDY   TABLE SEVEN

COURSES INVOLVED

	TOTAL	High Schools	Jr. Colleges	Universities+ Colleges	Universities+ Colleges+Jr. Colleges
Science & Math	94	93	92	95	95
Mathematics	55	69	56	40	43
Statistics	5	2	-	9	8
Statistics or Math	57	70	56	45	47
General Science	22	29	22	15	16
Biology	8	8	8	9	9
Chemistry	14	9	8	20	18
Physics	16	11	25	20	21
Any Science	44	42	53	45	47
Medical	4	-	17	4	7
Engineering	12	-	36	20	23
Other Technical	28	34	39	20	23
Any Non-Science Field	74	70	75	78	78
Business	22	16	42	23	27
Social Science	28	23	14	35	32
History or Humanities	2	1	3	4	4
English or Reading	20	25	31	12	15
Foreign Language	5	4	3	6	6
Guidance	15	28	8	2	4
Other	5	3	3	7	7
Multiple Use (over 5)	7	-	-	16	13
TOTAL Schools Surveyed	367	167	36	164	200

637

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

INSTRUCTIONAL COMPUTERS STUDY — TABLE EIGHT

NUMBER OF USERS FOR COURSES INVOLVED	100 to 999	1000 to 2999	OVER 3,000
Science & Math	88	95	96
Mathematics	57	57	54
Statistics	5	8	3
Statistics or Math	60	59	57
General Science	21	23	22
Biology	7	12	7
Chemistry	7	18	13
Physics	12	23	13
Any Science	36	52	43
Medical	5	2	4
Engineering	-	5	18
Other Technical	33	28	29
Any Non-Science Field	67	63	82
Business	17	14	26
Social Science	24	33	27
History or Humanities	-	3	3
English or Reading	24	11	23
Foreign Language	2	6	5
Guidance	10	19	14
Other	5	3	6
Multiple Use (over 5)	-	3	10
TOTAL Schools Surveyed	42	111	201

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

INSTRUCTIONAL COMPUTER STUDY — TABLE NINE

COURSES INVOLVED BY REGION	North East	North Central	South	Far West
Science & Math	98	91	93	94
Mathematics	53	55	57	55
Statistics	10	4	3	1
Statistics or Math	57	58	60	55
General Science	18	20	20	31
Biology	5	12	10	3
Chemistry	16	13	13	11
Physics	17	16	15	17
Any Science	42	45	43	49
Medical	6	1	3	4
Engineering	11	11	16	13
Other Technical	32	25	28	27
Any Non-Science Field	68	84	70	72
Business	20	21	26	18
Social Science	25	39	21	23
History or Humanities	2	3	3	1
English or Reading	11	25	18	25
Foreign Language	3	4	2	11
Guidance	17	20	8	11
Other	4	6	4	4
Multiple Use (over 5)	8	7	7	7
Total Schools Surveyed	93	114	89	71

639

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 0890
(201) 828-9333

INSTRUCTIONAL COMPUTER STUDY   TABLE TEN

NUMBER OF TERMINALS BY SCHOOL LEVELS	TOTAL	High Schools	Junior Colleges	Universities +Colleges	Universities+ Colleges+Jr. Colleges
5 or less	29%	46%	17%	16%	16%
6 to 10	13%	15%	11%	10%	11%
11 to 50	39%	27%	53%	49%	50%
Over 50	19%	13%	19%	26%	24
TOTAL Schools Surveyed	367	167	36	164	200

640

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

INSTRUCTIONAL COMPUTER STUDY — TABLE ELEVEN

NUMBER OF TERMINALS BY NUMBER OF USERS	100 to 999	1000 to 2999	OVER 3,000
5 or less	67%	47%	12%
6 to 10	10%	19%	9%
11 to 50	19%	30%	50%
Over 50	5%	5%	29%
TOTAL Schools Surveyed	42	111	201

641

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

INSTRUCTIONAL COMPUTER STUDY

TABLE TWELVE

NUMBER OF TERMINALS BY REGIONS	North East	North Central	South	Far West
5 or less	30%	30%	29%	28%
6 to 10	12%	16%	10%	11%
11 to 50	44%	45%	34%	31%
Over 50	14%	10%	27%	30%
TOTAL Schools Surveyed	93	114	89	71

642

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

INSTRUCTIONAL COMPUTER STUDY TABLE THIRTEEN

HIGH SCHOOL APPLICATIONS BY STATES (& REGION)

North East	North Central	South	Far West
New Hampshire-2	Ohio - 7	Maryland - 3	California - 17
Massachusetts-19	Michigan- 5	North Carolina -6	Oregon - 6
Connecticut- 2	Wisconsin-2	Florida -3	Utah - 2
New York - 18	Illinois- 8	Texas -8	
New Jersey - 9	Minnesota-18	Virginia -6	
Pennsylvania- 3	Iowa - 2		
	Kansas - 3		

643

All others in Region: 1 or 0

HJB ENTERPRISES
333 Montgomery Street
Highland Park, New Jersey 08904
(201) 828-9333

INSTRUCTIONAL COMPUTER STUDY TABLE FOURTEEN

Jr. College+
COLLEGES+
UNIVERSITY
APPLICATIONS BY
STATES (& REGION)

North East	North Central	South	Far West
New Hampshire-1	Ohio -9	Maryland -5	California -3
Massachusetts-9	Michigan -7	N. Carolina -7	Oregon - 2
Connecticut - 2	Wisconsin-4	Florida -6	
New York -12	Illinois-10	Texas -12	
New Jersey - 9	Minnesota-8	Virginia-3	
Pennsylvania -10	Kansas -1		

All Others in Region: 0 or 1

644

Indicative of the need for this study are the following examples drawn from preliminary analysis:

(1) The States which currently have the highest support levels for traditional educational techniques are, for the most part, the ones which are also in the forefront of instructional computer usage.

Mr. SCHEUER. Which States are they?

Mr. BRUDNER. For example, Minnesota, which has at least 26 instructional computer facilities at high school and college levels, ranks fifth in the United States in its appropriations per capita.

Mr. SCHEUER. Which are the first four?

Mr. BRUDNER. The first four States are Alaska, Hawaii, Wyoming, and Washington which have skewed data because of the high fixed costs for limited populations. So really if you eliminate some of those early States you find many of the States that I will get to in a moment are even higher in rank than the study indicates.

One of the things that can be done in this period of rising educational costs and rising demands on the system is to make more cost effective use of educational technology.

I think the first major point I am making is that there has been very little money spent on studies of studies. In other words, it seems as if every decade, Mr. Chairman, we begin this field as if all the work that had gone on in the previous decade has not contributed anything to the body of information that forms a valid base.

Mr. SCHEUER. You are saying there is a need to synthesize.

Mr. BRUDNER. There's a need to analyze existing data immediately to see what has happened as a result of many, many millions of dollars that have already been spent.

Mr. SCHEUER. Is this what you have done?

Mr. BRUDNER. I have started to do this.

Mr. SCHEUER. Why don't you tell us in your own words what you have found out from your beginning synthesis of the existing information.

Mr. BRUDNER. One of the dramatic results that is corollary to what I am developing now is that many of the States that would benefit most from this technology are the furthest behind.

Mr. SCHEUER. Which States are they?

Mr. BRUDNER. As some of the remarks you made off the record would indicate, the tables are skewed in an interesting way. We find, for example, the Far West is predominantly in a leadership position in this field. We find, for example, the second greatest activity occurs in the South.

Mr. SCHEUER. When you say the Far West, is California—

Mr. BRUDNER. California, Washington, Oregon, Nevada, New Mexico, Wyoming, Montana, Colorado, Arizona, Idaho, Utah, Alaska and Hawaii are strongly, preliminary analysis indicates, in a leadership position.

The next group of States in a leadership position are the Southern States. Coming in at a medium level are the North Central States, and the Northeast, at this time, seems to be the weakest region of the country in the particular areas reviewed, even though many of the worst urban situations lie in the Northeast.

Mr. SCHEUER. Why is this so?

Mr. BRUDNER. I'm not trying to analyze all of the reasons, or interpret the reasons. I have my own opinions. But right now I'm trying to present the data as clearly as possible.

Mr. SCHEUER. But I'm asking you why do you think that's so? Why should New York, which is probably the largest center of academic excellence in the world, with the possible exception of Boston and perhaps California, why should New York fall so far in the rear with all of the excellence of education and research. After all, it is the brain center of the communications center.

Mr. BRUDNER. Within the cluster of the Northeast, New York is in a leadership position with respect to other Northeastern States. However, it still lags, overall.

Mr. SCHEUER. But it is still forth ranking.

Mr. BRUDNER. New York State, according to the same October 1977 issue of the Chronicle of Higher Education, has now fallen all the way to position No. 27 in the United States in support for higher education.

Mr. SCHEUER. Per capita?

Mr. BRUDNER. Yes. Part of the problem relates to the overall financial situation. I believe another part of the problem—this is again my personal opinion—relates to the fact that many of the States which originally were in a leadership position, have taken their own position for granted, and have become more status quo oriented. Many areas of the South and the Far West have reached out, and tried to become more innovative, and have allowed for greater accelerated movement in the area of educational technology.

Mr. SCHEUER. And here they are not as financially hardpressed as some of the older urban cores of the Northeast.

Mr. BRUDNER. That's true. We find that many of the innovations, such as the computer-managed instruction systems that have been referended by others, people have tended to be cost effective implementations of the computer, and yet adoption of such methodology has moved along haltingly.

Early analysis also suggests that there is a heavy utilization of some of the most sophisticated equipment, for lower level drill and practice applications as opposed to additional advantageous uses that could be made involving simulations and individualized tutorials with gifted students and the populations that have been discusses.

Mr. SCHEUER. In other words, they have the computer there, but they're not using it in its most creative form and are not exploiting its potential.

Mr. BRUDNER. That appears to occur in a greater number of cases than one would like.

Mr. SCHEUER. What does that mean? Does it mean we need to educate educational administrators, or we need to educate the teachers themselves to the use of the computer, or we need to design more course materials?

Mr. BRUDNER. All three of those conclusions are appropriate.

Mr. SCHEUER. What else?

Mr. BRUDNER. I think we need more leadership. We need demonstration centers of the type that have been referenced earlier where models of excellence can be pointed to.

Additional areas where instructional computers could have major significant impact are also the areas of continuing education, job corps-related applications, and industrial training. Again, the surveys recently made have indicated that none of these sectors have been adequately developed in this regard.

There are an increasing number of success stories being documented each year. The technology is advancing. Evidence presented at these hearings has revealed a significant potential for the improvement in learning, not only on the part of the disadvantaged and the gifted, but a major segment of our Nation's population. I think one of the personal positions I would take is that we are not talking about 1 or 2 percent of our population in these hearings.

Indeed, when we talk about the group of special education people involved, the group who have learning needs apart from the norm, we are talking about a major portion of the population of the United States. And these same programs which can have such dramatically positive impacts on the disadvantaged and gifted, will also benefit the majority of the population.

The realization of this potential will depend not only upon increased financial support, but it will depend also on a full analysis of past and present programs, and accurate and relatively complete assessments and evaluations. I think we have been delinquent in that area.

Mr. SCHEUER. How do you think that should be done? Who should do it? Who should fund it?

Mr. BRUDNER. One part of the charter of the National Institute of Education is in this area. The National Science Foundation should increase its activity. I think there should be greater support and greater commitment to these kinds of research programs that need to be done to turn up the areas that can be accelerated most rapidly. There also should be greater interagency coordination.

If we look at the great advances that have been made in many fields, if we look around the room and see the dramatic technologies that enable us to put men on the Moon and we examine how our understanding of the basic laws of physics came about, we find out that many of these understandings developed not from people working in isolated areas or theoretically constructing cases, but from observing what has been taking place in experiments and demonstrations made under carefully controlled conditions.

I believe that a great deal of learning research can be expedited by identifying and analyzing the billions of dollars worth of activity over the last 20 years that has taken place in programs sponsored by the U.S. Office of Education, its former Bureau of Research, and many other agencies, such as the National Science Foundation, and other Federal and State kinds of studies. I wish to reference here the New York State systems study which I directed in 1969. I am offering the executive summary for the record.

[The study follows:]

EXECUTIVE SUMMARY

by

Harvey J. Brudner

SYSTEMS STUDY OF PRIMARY AND SECONDARY EDUCATION WITH EMPHASIS ON URBAN CORE AREAS IN NEW YORK STATE

PREPARED FOR

Dr. T. N. Hurd, Director
Division of the Budget

October 1969

by

WESTINGHOUSE LEARNING CORPORATION
100 Park Avenue, New York, New York

I. SUMMARY AND RECOMMENDATIONS

A. EXECUTIVE SUMMARY

1. PREFACE. These volumes summarize the results of the first phase of a Systems Analysis Study of Primary and Secondary Education in New York State with Emphasis on the Urban Core Areas. The Westinghouse Learning Corporation was awarded a contract to conduct the Phase I study, and prepare a proposal for Phase II, after the Business Advisory Committee on Management Improvement, and the Interdepartmental Management Improvement Council recommended that scientific management techniques be applied to some of New York State's difficult problem areas. The New York State Education Department strongly urged the selection of urban core education as the subject area of the first study in its field.

This study was conducted by the Westinghouse Learning Corporation under the guidance of the New York State Division of the Budget in conjunction with the Education Department. A special Interdepartmental Steering Committee was created to assure that the State could bring all necessary resources to bear, and to act as an advisory group to the researchers with respect to priorities and areas of emphasis. The Steering Committee was composed of high-level representatives from the Education Department, the Division of the Budget, the Division of Human Rights, the State University, and the Office of Urban Education.

The commitment to provide all citizens with an equal opportunity for productive participation in community life can only be met by providing every citizen with a quality education. The problems associated with fulfilling this commitment are immensely complex, and the development of solutions involves working simultaneously with large numbers of factors and interrelated variables. To date traditional efforts dealing with a few isolated variables have, for the most part, failed in spite of relatively large amounts of funding. Unfortunately, this failure is most pronounced in the urban core areas.

This study represents a unique attempt to explore the feasibility of applying interdisciplinary systems analysis and operations research techniques to the complex social system of education. The Phase I preliminary analysis has been conducted to define the many problems within the New York State educational system that impair its performance, as well as identifying effective educational approaches. The study creates a unified framework within which some internal and external factors which influence educational performance can be analyzed rationally in order to point out ways to overcome problems. It attempts also to create cost-effectiveness indicators to measure the impact of programs against their financial demands. Studies to expand and delineate these approaches are proposed for the second phase of the program.

2. INTRODUCTION. The Westinghouse Learning Corporation's Phase I study has led to several significant new findings, and the

reconfirmation of some significant trends. We have found:

a. In spite of major efforts on the part of all related New York State Departments, Divisions, Agencies, and associated units, the educational goal of offering each individual of the State an equal opportunity to acquire the knowledge, skills, and attitudes required for productive participation in community life remains unfulfilled throughout the State in general, and especially in urban core areas.

Little of the New York State educational system at any level seems verifiable in theory, practice, or results. It is safe only to conclude that costs are going up, as are the demands of many concerned groups for justification of these increased expenditures.

But the major issue is much more than money and facilities. Even where these appear to be adequate, students and community residents are still discontented and dissatisfied. They want to have a greater voice in decision-making, curriculum development, and, in some cases, the hiring and firing of teachers.

During the past decade, legislation has been enacted to provide for greater equality of educational opportunity. Several hundred millions of dollars have been spent. To date, it can be said that the objective has not been realized. In the present educational system, inequality has been found to manifest itself in two basic ways: (1) the child who resides in an urban core community typically attends a segregated school, and (2) scores lower than his non-ghetto peers on standardized tests. Again, however, it was found that the problem of validity -- test items, norms, and quantitative interpretations of the scores -- is in serious debate.

Many of these ghetto students are among the group generally referred to as the "disadvantaged." Some researchers, however, have indicated that students generally classified as disadvantaged actually demonstrate superior performance in some areas, though these areas are often not specific objectives of the current educational system. Then, to some extent, "disadvantagement" might also be regarded as a function of the objectives to be achieved.

Thus, the basic inequality seems to reside in the failure to make education and educational opportunity relevant to the needs of the urban core child.

b. The situation is not self-correcting, and the recurring series of riots, boycotts, strikes, and disturbances indicate that well-planned, concentrated, new approaches and efforts are needed without delay.

c. The limited and cumbersome approaches of highly centralized metropolitan educational agencies have been too remote, too irrelevant, and too haphazard to be responsive to community and neighborhood needs.

d. Special problems have developed as our urban core areas become increasingly populated by minority groups with cultural and language barriers.

e. Underachievement is the norm in these areas, and it increases in proportion to the time spent in the educational system. A typical six-year old urban core child is already about 10 months behind his middle-class counterpart; by the twelfth grade he is 42 months behind.

f. The heavy demands on the city and State tax money are reaching plateau levels; only new and more cost-effective approaches can return the urban educational systems to a healthy state, and avoid violence and disintegration.

g. The contributory problems associated with the present failure of urban core schools are widely spread throughout the school system itself (teachers, administrators, parents, curricula, students, facilities, services), and throughout the related extra-school agencies (government, community, political and pressure groups, communications media, labor groups, related educational institutions, business, religious, and service agencies).

h. The failure in extra-school areas is almost as contributory to educational breakdown as is the failure in the schools themselves.

i. Systems analysis, scientific methodology, technology, and modern management techniques hold great promise, and may be the only realistic solution to improvement of the quality and effectiveness in urban core areas.

j. A comprehensive network of demonstration programs

23-082 O - 74 - 42

based on proven successful projects is required to optimize the design of an improvement program in relation to expenditures.

k. Systems which overcome the environmental handicaps of the disadvantaged are also highly beneficial to the "advantaged" and the State in general.

l. Cost-effectiveness studies of educational approaches are becoming increasingly practical and of great significance to educational improvement planning and distribution of corrective efforts and resources.

m. Many proven educational "success stories" can serve as hypothesized models for demonstration programs; however, added findings from research and development can still further increase the cost-effectiveness of any future state-wide implementation programs.

n. The same principles and approaches can and should be applied in different ways in educational districts of varying makeup.

o. A strong program of controls, evaluation, and testing must be developed so as to better relate program costs to output quality and quantity.

3. SYSTEMS ANALYSIS IN EDUCATION. A total systems study of a state-wide public educational system involves a complex body of numerous variables within and without the system, all of which are interrelated in again as many ways. Nevertheless, it is this type of complex arrangement of variables to which the systems analysis approach addresses itself.

This scientific approach was used to set out guidelines for a methodological study through a definite sequence of research activities. The necessary first sequence of events was the development of a framework broad enough to encompass the entire spectrum of variables in the educational system. This framework was divided initially into a number of logical categories (components of subsystems) into which variables known or discovered were placed. At the first level, these were necessarily broad.

The first-level model had the following special characteristics:

> Inter-component communicability. Information gained in one component improved knowledge in the others.
>
> Communicability retention. The state of inter-component communicability was retained as each component was reduced to the next detail level of subcomponents.

When these constraints were met in the model. the analysts had a method of classifying and controlling the information extracted from the educational system; the approach provided a consistent frame of reference for going into the system and questioning it for information. As the analysts were extremely critical of each datum extracted, as well as of their categorizations, orderliness began to be imposed on the complexity of variables.

The five elements of the first-level model developed in this way during Phase I were:

a. An educational objectives specification model.

b. An evaluation and assessment matrix, correlated to designated objectives.

c. An expenditure-effectiveness model.

d. Extra-system variables correlation matrices.

e. An evaluation flowchart for related programs.

4. EVALUATION OF OBJECTIVES. Of primary importance to the systems analysis is the discovery and clarification of the goals or aims toward which the New York State educational system ostensibly operates. These must be known so that the system components and processes have meaning.

The analysis began by attempting to ascertain the goals of the system. We reviewed the literature of education and questioned the educators, students, and general citizenry whom the system ostensibly serves. We found a diverse range of objectives at every level -- some objectives existed to serve others. We also found little precision or agreement as to what each objective meant in actual fact, and even less agreement as to how they rated in relative priority.

Given this situation, a six-character matrix was developed in the same manner the first-level system components were derived:

Social
Attitudinal
Intellectual and Academic
Physical and Emotional Health
Vocational and Professional
Evaluation and Assessment

An attempt was made to translate statements from the literature (educational and popular) regarding objectives into this frame. Further, a small (not statistically pure) sample of core and non-core school and community respondents were asked to rank these factors.

Generalizations were made about which categories of objectives each emphasized as important. Gross comparisons were made among our selected subgrouping of the population. Interesting congruities and incongruities were obtained.

Based on the results from qualitative analyses of the preliminary data and attempts to interpret the data, a reexamination of the categories was made and a revised list developed according to guidelines set out in a developed taxonomy of objectives:

TABLE OF
EDUCATIONAL OBJECTIVES-STUDENT DEVELOPMENT

A. COGNITIVE

1. GENERAL SUBJECT MATTER
   Reading/Writing/Speech
   Mathematics
   Humanities
   Social Sciences
   Natural Sciences

2. AESTHETIC
   Recognition of
   Applied-Creative, Participation

3. SPECIALITY
   Vocational
   Professional

4. COGNITIVE PROCESSES
   a) METHODS & TECHNIQUES

B. AFFECTIVE

1. SOCIAL
   a) INTERPERSONAL RELATIONS
      Adults
      Parents
      Peers
      Groups
      Social, Cultural, and Ethnic Groups
   b) SELF-CONCEPT
      Understanding of
      Himself
      Member of Society

2. ATTITUDINAL
   a) LEARNING BEHAVIOR

(Table continues)

Knowledge
Comprehension
Application
Analysis
Synthesis
Integration
Evaluation
Curiosity
General Positive Attitude

b) INDIVIDUAL ROLE
as Student
Member of Community
Member of Society
Worker

c) INITIATING BEHAVIOR/ MOTIVATION
Search/Experience
Initiative
Persistence

d) PERSONAL MANAGEMENT
Task
Time

Receiving
Responding
Valuing
Organizing
Extending
Conflict Resolution
Frustration Tolerance

C. PSYCHOMOTOR DEVELOPMENT
Bodily Mastery
Health/Personal

An important outcome of feedback from the field work was a set of criteria necessary for future classification schemes of educational objectives; namely:

The number of categories is limited.

The majority of stated behavioral objectives can be logically placed in one of the categories.

Category subjects are amenable to curriculum designers.

The categories can be subjected to modification by dynamic feedback upon implementation.

An evaluation program can be developed.

> The effect of implemented programs on attaining them can be consistently determined.
>
> Subst-ntive generalizations can be made concerning programs, objective intent, and implementation.

By adhering to a reasonable scientific methodology in describing the objectives categories above, a workable model for future research has also been generated. The absolute necessity for evaluating and assessing research programs in education against a predetermined set of explicit objec ives cannot be overestimated. Such evaluation is always taking place in education, but usually on the basis of implicit objectives. These are sometimes undesirable and, even where they are not, lack of explicitness makes quantitative determination of effectiveness impossible.

Evaluation of achievement of objectives by the student or by the system is no' a thoroughly developed component of the educational system, the study concluded. There exists a growing number of standardized achievement and general knowledge tests that have useful validity and reliability. As one moves into the affective domain, however, the tests become sparse and weak, or heavily dependent upon highly-qualified professional interpretation. This is true, despite the growing support to increase the educational efforts in affective areas.

Teacher evaluations leave much to be desired as do materials evaluations, administrator evaluations, etc.

The study group developed a matrix of evaluation types that correspond to the objectives categories.

5. URBAN CORE SCHOOLS. A first-level assessment of urban core schools was performed by the systems study group on the basis of the objectives categories. For the sake of study, urban core schools were described in the following traditional eight areas: (1) Learning Methods and Materials, (2) Teachers, (3) Administration, (4) Program and Curriculum, (5) Services, (6) Facilities, (7) Parents, and (8) Related Extra-System Influences. An attempt was made to look for each area of the objective matrix throughout the school. Information was gathered from the literature and field work.

Urban core schools shared the problems noted earlier as to objectives and evaluations. There appeared to be minimal use of the educa- onal technology so prominent in the literature.

Urban c schools generally have serious problems in almost all of the ove eas regardless of how they are classified. In non-core eas, any of the behaviors that are vital to a successful education pro- n are ac in the home. The non-core student's entering behaviors are often sufficient to compensate for (or adapt to) any deficiencies in the system. The urban core student usually enters the system with considerably fewer of the repertoire of behaviors required to succeed in the system. Furthermore, the system fails to take advantage of many of the behaviors which are peculiarly his. To a large extent these findings confirm the conclusions of the Coleman study -- which suggests that improvement can come about through efforts in the "extra system" (home and community).

The school seems unable to mitigate or to adjust to deficiencies. Many innovative programs were found to exist; however, we lack the reliable testing instruments to measure their effectiveness. Where special programs exist outside of the school, evaluation of results is often equally unreliable, but seemed to be consistently more satisfying. Our cost-effectiveness analysis further supported this conclusion.

6. RELATED PROGRAMS. A large number of educational programs operating outside of the regular school was reviewed. These ranged from pre-school to adult vocational programs; some were highly materials-oriented, others were not.

The consensus seemed to be that these programs tended to get better results than programs operating in regular schools. Further, it was felt that the regular schools have no conscious plans to translate successes in program developments from the related to the regular.

A first-level evaluation model was developed for related programs which it is hoped will aid in discovering ways to replicate successes from outside programs into the facilities serving more students.

7. NON-EDUCATIONAL FACTORS. The analysis of extra-system problems focused on nine major sectors:

Housing
Health
Employment
Welfare
Law and Administration of Justice
Local Government Structure
Organization

Media and Communications
Group Interactions and Individual ... tions

The data space for each of the nine major sec... ... a oartitioned where relevant in terms of:

Demog... Data
Econom... ... ctors
Social Fac... s
Political Facto...
General Envir... ... ntal Factors

This breakdown led to a definition of problems in each sector and an identification of the major ... system variables via a series of correlation matrices; the research ... laid the foundation for a detailed analysis of the functional relationships between extra-system variables and intra-system learning variables.

8. COST-EFFECTIVENESS. A major problem of educational decision-makers is the allocation of funds. Such decisions cannot be based on a comparison of per-dollar cost alone, but must take into account the effectiveness of alternative programs toward reaching given educational goa' . Cost-effectiveness analysis is directed toward presenting the decision-maker with a way of comparing alternative programs or courses of action into a fairly systematic way.

A major outcome of the Phase I effort was ... e development of such a cost-effectiveness measure: the Expenditure for Effectiveness Indicator (EEI).

EEI is intended to be used in the comparison of "programs," defined as "activities designed to achieve a stated objective, and having identifiable costs and measures of effect." EEI is a synthesis and refinement of past cost-effectiveness measures in that it allows the input data to be specified as a range of values rather than a single number. This allows the degree of uncertainty associated with any of the input estimates to be indicated in the final measure.

EEI is computed from:

- the average cost/student;
- the effectiveness of a program or program area; and
- a weighting of the importance of a program according to the needs of a particular school.

The effectiveness of a program is rated along a scale from 10 percent (no significant increase in effectiveness) to 100 percent (maximum increased effectiveness). The weighting is accomplished through an Importance Mean Weight (IMW), computed along a scale from 100 (for programs of negligible importance) to 1000 (for programs essential to a school).

These three input variables are related as follows:

$$EEI = \frac{\text{Average Cost/Student}}{(\text{Effectiveness}) \times (\text{Importance Mean Weight})}$$

A sample calculation, comparing two reading programs, and incorporating the degree of uncertainty in arriving at the input information, is shown below:

Program Area	Avg. $/Student ÷ [Effectiveness	X Importance Mean Weight]	= Expenditure Effectiveness Indicator (EE
(1) Conventional	$200 ± 50	.25 ± .05	900 ± 90	$0.89 ± .30
(2) Special	$500 ± 50	.70 ± .07	900 ± 90	$0.79 ± .13

The analysis in this hypothetical example reveals that the seemingly more expensive special reading program is more expenditures-effective. These results would serve as indicators to the decision-maker, not as final answers to his problems. While "area effectiveness" and "importance" factors selected from an accompanying scale are estimates, both of these areas would become more explicit as the objectives and evaluation components of our model were further developed.

After analyzing hundreds of programs and studies of programs for educational effectiveness, Westinghouse Learning Corporation's New York State Systems Study staff applied its EEI methodology to 22 educationally successful programs. It is important to underscore that all of the 16 elementary and secondary programs, and six pre-school programs have shown measurable cognitive student gains, and employed what are felt to be reliable methodologies and professional practices. The Table which follows presents their EEI determinations, and estimates of uncertainty in these values.

On the basis of the results of the Table, it is suggested that 17 of these programs be further "production-engineered" and evaluated as part of the proposed Phase II program.

Further development of the EEI methodology is also suggested during Phase II.

A PRELIMINARY COST-EFFECTIVE ANALYSIS OF SUCCESSFUL EDUCATIONAL PROGRAMS

	$/Student	Effectiveness (Gain)	Weight	EEI($)
ELEMENTARY AND SECONDARY PROGRAMS				
1. The School and Home Program of Flint, Michigan	2.50	[illegible]	500	.01 ± .05
2. The College Bound Program of New York City	48.00		900	.05 ± .02
3. Junior High Summer Institutes of New York City	50.00	[illegible]	900	.06 ± .02
4. Programmed Tutorial Reading Project of Indianapolis, Indiana	40.00	.50	800	.10 + .20 − .05
5. Teacher Expectation Project in South San Francisco, California	20.00	.80	400	.10 ± .05
6. After-School Study Centers of New York City	70.00	.80	700	.12 ± .05
7. Self-Directive Dramatization Project of Joliet, Illinois	73.00	.70	500	.22 ± .09
8. Homework Helper Program of New York City	237.00	.95	800	.31 ± .10
9. Elementary Reading Centers of Milwaukee, Wisconsin	150.00	.50	800	.38 ± .12
10. Intensive Reading Instructional Teams of Hartford, Connecticut	330.00	.95	800	.43 ± .14
11. Speech and Language Development Project of Milwaukee, Wisconsin	200.00	.80	500	.50 ± .22
12. Communication Skills Center Project of Detroit, Michigan	264.80	.80	600	.55 ± .20
13. WLC Jamaica Educational-Cultural Advancement Center, Jamaica, New York	500.00	.95	900	.57 ± .05
14. Project R-3 of San Jose, California	300.00	.80	600	.60 ± .20
15. More Effective School of New York City	920.00	.50	900	2.05 ± .85
16. Project Concern - Bussing Program of Hartford, Connecticut	1473.00	.50	900	3.20 ± 1.60
PRE-SCHOOL PROGRAMS				
1. Pre-School Program of Fresno, California	640.00	.95	1000	.67 ± .25
2. Diagnostically-Based Curriculum, Bloomington, Indiana	500.00	.85	800	.75 ± .25
3. Academic Pre-School Program of Champaign, Illinois	800.00	.95	950	.85 ± .23
4. Perry Pre-School Project of Ypsilanti, Michigan	1075.00	.80	800	1.50 ± .50
5. Infant Education Research Project of Washington, D. C.	1800.00	.90	1000	2.00 ± .65
6. Early Childhood Project of Institute for Development Studies (New York City)	1800.00	.80	1000	2.25 ± 1.20

9. CONTINUING R & D. Educational progress, in general, has been hampered by limited research, development, and evaluation. In most states educational R & D is less than one percent of the overall educational budget. Our study indicates that New York State is no exception.

The basic plan proposed by the Westinghouse Learning Corporation is to maintain and expand the research which has been started in Phase I, and create special separate demonstration and evaluation projects which will verify the educational and cost-effectiveness of major programs which our Phase I study to date indicates are successful.

As Michael Faraday wrote,

> "There seems to be a natural law that regulates the advance of science. Where only observation can be made, the growth of knowledge creeps. But where . . . experiments can be carried on, knowledge leaps forward."

B. CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS. The following can be concluded from the Phase I efforts of the Westinghouse Learning Corporation:

The understandable confusion that exists in connection with New York State's educational systems' goals, methods, evaluation approaches, and dollar funding can be ameliorated by careful development of systems and models similar to those which have evolved during this Phase I study.

The growing urban demands for immediate change and improvements in education cannot go ignored; at the same time, they should not be allowed to generate massive, haphazard programs at the expense of long-range, careful analysis, research, and development.

Our initial systems efforts revealed the need for discovering and making more explicit the aims of New York State's educational system. This information must come from educators, community members, and the students themselves. Alienated groups at both ends of the economic ladder are demanding, among other things, a greater voice in this formulation. In this case, the continued expansion of the "objectives" component of the research model is not incompatible with the demands for immediacy.

Another important set of findings in our Phase I study was the identification of some 25 major success factors, and about 50 supplementary success factors, common to effective educational projects. Many of these factors are being hypothesized for further study and evaluation in the recommended Phase II program.

Further, our Phase I work has enabled us to hypothesize a cost-effectiveness model, a related-programs evaluation scheme, and an extra-system variables identification model. The proposed Phase II set of projects can serve to further refine these component approaches to allow for greater specificity and higher reliability.

Our Phase I study has further underscored the need for greater personalization of the educational process. This shows up in the demands for making education relevant to the present and future needs of the individual student, as they relate to his capabilities, those of his local community, and those of society in general. It is apparent that greater use of educational technology can allow for this transformation in a cost-effective way.

2. RECOMMENDATIONS. Westinghouse Learning Corporation has proposed a matrix of 48 projects, each compatible with one or more of our information needs. While there are 12 called "research and development projects," and 36 called "demonstration projects," they are all active programs operating in the laboratory of the real world. The 12 R & D projects are called so only because they are relatively untested; they do, however, show great promise. The 36 demonstration projects are largely replications, in New York State settings, of efforts that have appeared to be educationally successful and cost-effective elsewhere.

The following lists the 12 major areas to be studied, advanced, cross-correlated, and cost-effectiveness evaluated. Each area has four accompanying projects ranging from relatively simple to highly innovative.

In each area, three of the four proposed efforts are demonstration projects, and the last an R & D effort.

a. Accelerated Remediation

b. Administrative Information Systems

c. Cultural and Community Factors

d. Early Learning

e. Home and Learning Climate

f. Individualized Instruction

g. Multi Media

h. Non-Educational Factors

i. Psychological Factors

j. Teacher Training

k. Temporal Factors

l. Work-Study Factors

	C	R
1	Northside Center Concentrated Re-Sources	Accelerated Remediation Study at Fieldston
	Total Socio-logical Learning Data Bank	Multi-Variate Analysis
	Project Unique, Rochester, NY	New Science in the Inner-City Columbia Universi
	Cortland State University of New York	EJucational Testing Research Program
	The Perry Pre-School Project in Ypsilanti, Michigan	Demographic and Family Factors Albert Einstein Medical Center
11	Plan-Jamaica Demonstration Local District #28	Individualized Instructional Research
	Project R-3 San Jose, California	Computer Assisted Instruction--Picture Phone Project

Index	A	B	C	R
8	Westinghouse Urban Systems Development Corporation	Harlem Health and Welfare Program	Applied Research Division	Center Urban E
9	Diagnostically Based Curriculum, Bloomington, Indiana	Communication Skills Center Project, Detroit, Michigan	Cooperative Project with a Special New York School	Affecti Variabl
10	Sensitivity and Nova Teacher Training Package--Teacher Expectation	Individualized Instruction American Institutes for Research Package	Total MS Degree Program	Researc Teacher Materia
11	College Bound Program of New York City	After School Study Center	Intensive Reading Instructional Teams of Hartford, Connecticut	Learnin and Man
12	Vocational Education Program	Combination Program of Greece, New York	On-The-Job Education Program	Manpowe Develop Educati

ls are coded by the numeric number shown under "Index" (1-12) followed by the alphabetic ame level as "Index," (A,B,C,R), e.g., 1A,1B,1C, etc.

Concurrently, there is a need for assessing present eva ments and procedures. This approach is required to develop pirical methodology for evaluating the relative effectiveness c research and demonstration projects in attaining the desired : objectives. In order to provide for cross-correlation, the ev cedure proposed by Westinghouse Learning Corporation will b like set of evaluation techniques to be applied across all progı mixes of correlated tests to account for areas in which prescı interfere with experimental design, and/or where such tests : mentary or unreliable on their own.

Overall, the comprehensive R & D demonstration progr areas is intended not only to further develop project methodol point towards optimization of the way to effect urban educatioı for New York State within the next decade.

ucation in New York State too
provide an equal opportunity
The apparently poor results
:annot merit the public's favo
large extent present efforts
a non-synergistic atmospher
of the need to adjust traditio
:n, scientific approaches for

Learning Corporation's Phase
tent scientific methodology fo
ban education. Some of the r
istics of the proposed second

Irban Education
and Assessment Program
Expenditure-Effectiveness

litional and Innovative

nterorganizational

Analysis Techniques

Intensification of Feedback Channels

Intergovernment Involvement, Planning, and Coordination

To carry out this effort, Westinghouse Learning Corporation proposes to enlist the aid of many of the most capable people, organizations, and governmental units throughout the State. The goals of the proposed three-year Phase II program are ambitious and significant. Anything less would be to deprive an important segment of New York's citizenry of a major opportunity for advancement.

points I wanted to make, s

Brudner, I would just rai
rsity of Wisconsin brough
nent ago yourself about lea
ily fragmented downtown
erred to as a very severe
risdiction over this whole
here this morning, one o
irce person, but he testifi
r the subcommittee the m
Dr. Vanderheiden had me
g of all of the executive br
l VA, and so forth, to find c
nding is a major problem;
ny cooks in the broth and t
is the head honcho on this
ey were, HEW.
e is confusion downtown,

eve that hearings such as t
he professionals that I ha
red before this committee,
nlightened policy in this ar
f the committee and the
complishments, one must b
a careful and full suppo
s.
Thank you very much. We
we are grateful to you for

) p.m., the subcommittee v

APPENDIX

RVEY RESULTS AND RESPONSES

mation on the topics covered i
sent to the witnesses and a lis
nded were:
aker, Dr. Donald L. Bitzer, Dr.
. Glenn L. Bryan, Dr. C. Victor
Crandall, Mr. Gerald L. Freeborn
n, Mr. William C. Norris, Dr.
Rutherford, Dr. Dorothy Sisk,
n, and Dr. John Volk.
ho responded were:
sity of Illinois, Dr. Karen Blo
k, University of California, I
Dr. Joseph R. Denk, New Jersey
liam S. Dorn, University of Den
South Carolina, Dr. Thomas
B. Edwards, Dr. Beatrice F
Lab; and, L. H. Nawrocki.
Xerox Palo Alto Research C
ation, Dr. Duncan Hansen, Sci
ntelek, Inc., Mr. James Johns
artmouth College, Dr. Harvey

sir.

ise a point that Mr.
it out when he was
adership. It appears
i in the executive
problem downtown
field.
of the last witnesses
ed last week and I
inutes from a meet-
entioned.
ranch and organiza-
out what to do about
who funds what? It
there doesn't appear
s? I put that to Mr.

how can Congress

this and getting the
ve heard; and other
certainly represents
rea. I strongly sup-
recognition that in
begin with a careful
rt of high-potential

are very impressed
your patience. The

was adjourned.)

n the hearings, a ques-
t of experts in the field.

John Seely Brown, Dr.
Bunderson, Dr. Sylvia
ne, Mr. Dustin Heuston,
H. F. O'Neil, Mr. Vito
Dr. Thomas G. Sticht.

ek, University of Pitts-
Dr. Alan Collins, Bolt,
Educational Computer
ver, Dr. Karen Duncan,
Dwyer, University of
rr, ARI Organizations

Center, Mr. Keith Hall,
ence Applications, Inc.,
on, CONDUIT Central,
Long, IBM, Dr. Harold

iversity, Dr. Kent Morton, Dartmouth College, ntario Institute for Studies in Education, Dr. niversity, Mr. John Powers, The Authorship ney, University of Southern California, Dr. f Pennsylvania, Dr. Robert Seidell, HUMRRO, of Iowa, and Dr. Charles Warlich, University

ages are the only data provided. Selected com- l.

: (efficient) then they could be. Computer tech-

ency Distribution

ercent	Efficient:	Percent
52	Strongly agree	48
37	Agree	30
7	Neutral	13
2	Disagree	4
2	Strongly disagree	2

COMMENTS

teacher to do all that is required.

y will not necessarily lead to improvement.

ing with education of the handicapped, due to planning and too many architectural barriers.

ds of the gifted's insatiable learning needs.

have been routinely accepted by most schools.

purchasing, decisionmaking and instructional nificantly improve the efficiency of most schools.

ng, proper use of technology can provide more

it computers can assist in increasing the effec- as well as increasing administrative efficiency.

ze of the school district, the greater the need stems.

been—less effective than they could be. So are are today asked to do far more than they ever elp, but it is not the magic elixir.

courseware package is used at a large number

elp the problem--provide motivation and inter- cher time. But computers will not replace tra- I suspect more teachers will be needed with the ns."

lways undermine advances due to technology. nology with cost-effectiveness (directly) misses

Scores—No effective consistent criteria for suc- ndividualization—Good individualized instruc- ime.

ion somewhat.

r training programs. Witness the "New Math" of lack of teacher preparation (in part).

forward. However, new concepts of education are needed.

ive and efficient, but the educational demands elp.

e both less effective and less efficient than they ow drastically computer technology can change ability but without more widespread computer rded as nothing more than an expensive status

Research findi
of CBE on learn
Computer is nc
Computers do
My intuition i
on literacy.
My own child'
for large segmer
not use of studen
To be effective
cept of the indi
efforts in order t
The problems
edge explosion.
mately bound u
rent age. To ex
during the deca
books increased
Book Trade Inf
also been shown
creased over 20(
tions of compute
March 1973). Re
related job indu
leled the knowl
the jobs facing
Consequently, a
existing educatic
It used to be
work. Today we
the curriculum
move the curric
overwhelmed wi
tional logistics.
Note that I fo
tion of whether
schools, not on v
The problems
technology can
pulsory educatio
ing activities of
institutions mig
activities. This,
Computer techno
with local resou
delivering instru
in the education
Given the cu
purposes, little
far, the new me
sents a new devi
curriculum cont
information shou
to do or to prog
them the ability
can mold to thei
be used to teach
information, the
is available on th
Computers co
instruction.
2. Computer
in practice.

:onsistently show the power and impact

n very well.
as great as the printing press has been

e need for "individualized" instruction
ion. By efficient. I assume cost/benefit

hnology must be harnessed to the con-
on. We must decrease mass education

least partially a result of the knowl-
itself is both a reflection of, and inti-
idity of change characterizing our cur-
xplosion phenomenon is the fact that
seventies, the number of titles of new
le the Bowker Annual of Library and
. The rapid growth in computers has
ion explosion in that decade. It has in-
and over 1200% for dedicated applica-
iod of time (e.g., EDP Industry Report.
xplosion is the fact that the computer-
ges in jobs in general have also paral-
on. Estimates are that some 80% of
y schools today probably do not exist.
ig literacy is an essential part of any

the classroom where he could do the
he child with his age group and bring
much easier to move children than to
ach child. The teacher is swamped and
is a great aid to the teacher in instruc-

ously stated. I answered it as a ques-
e the effectiveness or efficacy of the
e effective or efficient.
m from deep social unrest. Computer
tially, unless a major revision in com-
ew technology can play a role in return-
k environments; separately designated
al management and special interest
custodial nature of public schools.
dable for general home use, combined
encourage changes in the structure of
ental resistance to direct participation
liscourage any such changes.
ch using computers for instructional
nt of instruction can be predicted. So
a new delivery system. Often it repre-
l. To "drastically" affect schools, new
ccess, control, etc., of vast ranges of
omputer) students today are learning
not being taught skills that will give
make the computer a media that they
example, the computer technology can
needed to research and to synthesize
schools more effective. Little evidence

e delivery but the very content of

stems have proved effective (efficient)

Frequency Distribution

	Percent	Efficient:
--------	26	Strongly ag
--------	35	Agree -----
--------	28	Neutral ---
--------	4	Disagree --
--------	4	Strongly di

COMMENTS

entered management, but do not
o provide information as opposed
en quite helpful to educators.
educators are faced with large nu
ds and a desire to offer a wide
ed effective when used in conju
m (IMS).
nstruction has resulted in more
school districts have been mor
efficiency vs. improving instruct
ttle work has been done on using
nagement.
ve. when used well. Sometimes a
rained persons use properly desi
ort this.
e than CAI.
nplete misunderstanding of the

e as effective as instruction bei
ction far beyond potential of ma
to complexity of human factors
otentially.
CMI can help make the overall e

have sufficient learning skills to v
rners without such skills will ne
tive instruction.
ut most effective uses of instruc
ated to what to do with data wh
of CMI.
ogy and software developed to da

erience with computer manage
agement of business have clearly
erations of a business. There are
to do with social changes brough
y's paper flow. But for instructio
f closed instructional packages
ouble is, education should not b

Instruction Systems have prove

Frequency distribution

	Percent	Efficient:
-----------	41	Strongly a
-----------	30	Agree ----
-----------	15	Neutral --
-----------	7	Disagree -
-----------	2	Strongly d

COMMENTS

urement has been produced.
oved effective only in limited sit
and circumstances.

In carefully selected environments, e.g., C
I know of no good data supporting CAI, b
story—it's tremendously effective.
Effective—When application is properly r
properly designed and developed. Efficient–
ning factors are attended to.
Especially in the military.
Not proven to be—but some forms (depe
simulations could be revolutionary.
CAI is still not a proven approach.
CAI . . . suffers from being seen as a magic
Most available CAI material would be just
does not make full use of the instructional p
was happy just getting anything written.)
But the full impact has not been realize
If used as a supplement to "traditional" in
The only thing we really do know about
is that it is effective in training students, ge
and in a shorter amount of time than non
has been compared. This says nothing, of c
ness in all parts of the school curriculum,
the question. I believe we should accept wi
schools that show CAI as the sole reason fo
scores (in reading and mathematics); oft
tion of the increased attention placed on
emphasize the teachers here) who are using
instructional systems themselves. I am, of c
lyst to encourage an interest in learning;
taining, fine, but we should be reminded th
that lets us measure all the reasons for t
Man and machine need to work in concert.
Best example is Suppes' math which is ef
approaches are more costly.
The facts are in and the data are convi
efficient and effective medium of instructio
skills.
Tremendous variation on both counts.
CAI is effective when operated by properly
Very difficult to really assess.
CAI stimulates creative learning and teac
Research on the cost-effectiveness of CA
level. CAI is apparently effective as a sup
ticularly for disadvantaged students. At the
CAI is as effective as traditional instructio
and can also result in substantial savings o
in instructional computing has been largel
effectiveness but on the basis of the value-a
ment in instruction.
Effectiveness has been proven; efficiency
Problem is mostly because people expect
4. What human/organizational factors a
mentation of either CMI or CAI? Technica
crucial?

COMMENTS

Authorship support, capitalization, key pe
cation of facilities. (All equally critical)
Education is labor-intensive, and will beco
should supplement, not replace, teachers.
Teacher and institutional understanding a
and organizational.
Making it easy for teachers to use, plus
be integrated. Well designed materials th
knowledge of how to "adopt and manage." F
Re-training teachers necessary to change
orchestrator of instruction (vs. deliverer).

t to tell top management the truth about costs, uncertainties, lifficulties of implementing CMI or CAI. It takes a real commit-ich yet-to-be-known about human cognitive processes.
e critical. The role that teachers must play is quite different. ed new habits.
a knowledgeable focal point. (b) Where and when should ogy be applied. (c) The management problem implied in (a). ectively you must be very clear at the outset what you expect or to be (or how you want it changed).
fficult get authors to write really good lessons—because if they talent, why not write a textbook which gets wider distribution

achers and other educational personnel is vital.
istration awareness, training. Inexpensive computers and

staff: The availability of high quality materials; The develop-ter-culture among students and faculty; Easy accessibility to ent workshops.
zational: Managerial capability, creativity, understanding. fic: Critical Mass, good software, good communications and face, high reliability. Both factors are equally important!
volved in the educational process must be included in the CAI s, teachers, parents, administration). System flexibility to pro-ll these above.
school personnel, understanding by the community, affordable tware.
ould be flexible to meet the needs of users.
appropriate instructional material, computer hardware too

visory leadership by educators who assume responsibility for nstruction.
to help the teacher solve his or her work problem, not just talk tered materials. Ultimately, the cost and power of hardware timate potential. But in order to make it work, a high minimum s required for a number of years. Although almost everyone man factors are most important, in truth when technology is it inevitably transcends human concerns, as in the development

eachers—unwillingness of college administrators to look ob-

teachers. Competent local coordinator of CAI activities.
d act as an addition to or elaboration of current educational replacements for. Successful applications have been in this de-ccess, I think, is dependent on it.
/organizational factors are related to the lack of success in of either CMI or CAI? Technical scientific factors? Which are

COMMENTS

n undermine the success of CAI: (1) Implementing a program ers understanding its role, (2) attempting to start a program minals. Unless a teacher has enough terminals where she can of the class at a time, the teacher feels that kids are constantly to CAI and she never has the whole class at one time. This n to be a hindrance as well as an aid.
sion that some efforts have been handicapped because of inade-ck of control, lack of support, amateurism, and underestima-s and resources required. From a technical standpoint, we are ve to know a great deal more if we are ever going to get to the n really engineer the instruction from a process control

major technical problem but is fading. Disinterest and hostil-hers centered control of class and students is not in tune with successful use of computers. 'Computer literacy' is hard to come

users and public. Many educational decisionmakers are unaware of computer technology. Gap between existent technology and knowledge of the means to apply this technology. Instructors may have information about CAI/CMI but often have no idea of how to use it. Equally important.

Lack of clearly defined objectives.

Failure to involve all concerned early in the planning steps makes implementation difficult. Lack of adequate personnel training contributes to lack of success. Initial costs of equipment and lack of adequate courseware for many subjects limits desirability of CAI in many cases.

Teachers are fearful of using CAI and administrators see CAI as expensive. Few educators can do programming. (Factors are equal.)

(a) Insufficient resources or time to develop an operating system (usually up-to-five years); (b) Lack of technical training; (c) Lack of curricular materials.

Human/Organizational: Poor training, teacher, insecurity, mismanagement. Technical-Scientific: High cost of software and systems: slow response times; Complexity; Poor reliability. More failure stories related to the Human/Organizational areas, especially underfunded, overambitious programs, and poor management.

Lack of flexibility . . . exclusion of teachers from an active role.

High cost, resistance by educators, lack of Federal support, non-recognition by industry of education or as a potential lucrative market, lack of audio capability, graphics, etc., at a cheap enough cost.

Too often, CMI systems are inflexible, and require users to adapt or change behaviors to accommodate the system.

Tendency in education to accept gimmickry for dealing with difficult problems.

Lack of enough high-quality courseware.

Insufficient development support, undercapitalization, authorship external to production environment, poor software and data base development, lack of institutional support (in order of cruciality).

Ignorance and lack of interest. Overstatement by developers of the systems capability. Cost is too high.

(1) A curriculum, or teacher, that cannot be adapted, enabling the computer resource to 'fit' and function well: (2) Technical scientific—no one knows, really, what a successful implementation is, given the high cost of a computer resource. Both."

Without teacher training, the program will fail. Technical Scientific factors—we've been thinking too 'big' about CMI/CAI. Very small, inexpensive applications can show more cost-effectiveness, and can be delivered without complex systems and supra-systems. Both are crucial.

Authoring of individualized instructional material.

I would add that no existing implementation comes even close to utilizing what is known about the teaching-learning process.

Match of application to need. Use of interdisciplinary teams vs. Cottage-Industry-Renaissance-man approach. Adequate funding. Adequate political support. Adequate planning. Adequate Management. All are crucial. Instructor roles changed to Instructional Evaluator/Manager/Problem Solver. Economic accommodation would be made in that Instructor/Student ratio must be increased gradually to recover costs as system matures.

The factor I would like to emphasize is that the "end users" must be part of the design process, specifying their needs as well as learning the new possibilities. In the case of CAI and CMI, I refer to both the teachers and the students. Teachers' attitudes are quickly picked up by their students. CAI or CMI can only be successful if the teachers (who might be parents) approve of their application and, therefore, cooperate in their optimal use. Ultimately, the systems must be designed to allow student control, not necessarily of the choice of the central instructional material, but of the choice of "spin-off" applications, such as providing new data or wiring programs that make new use of the given data.

The lock-step nature of the courseware has positive value for some users, notably community college students, young adults who appreciate the advanced specification of course objectives and the precise knowledge of how to obtain successful course completion. But I believe that the technology is more successful when its use is not constrained by the programming, when the teacher and/or student can modify the system to fit their particular needs. (As we have no long term experience in a general education program, I was compelled to qualify the preceding statement with the term "believe".) We can liken this situation to providing the teacher/learner with a textbook that must be presented exactly as

selected for study. From this I suggest tl
puter will be as a media for the stora
information; once retrieved, the inform
analyzed in numerous ways by available
organized, the information can be stor
directed retrieval by the user. Technicall
provide such computer systems for educa
availability of the systems will mean.
systems alone, without well-devised curri

Obvious technical problems exist at all
and software, appropriateness of coursew
on the learners by attempts to present n
denying the learner access to the ability t
ple, programming).

Schools generally resist CAI/CMI. At
CAI CMI are too high.

H/O: No one knows. Cultural rigidity
known seem to be big barriers, in additio
answer. New educational concepts are ne
tionize education when we don't know
Technically, more and better person/mach

Lack of willingness of faculty and sch

Failure to understand or apply basic i
the student population.

Decisions in public education are decent
tion time (12–15 years) is needed for a
as part of the normal way of conducting

The CAI ideas are not very inspiring.

Our school systems need to evolve av
which assumes that everyone learns at th
away from a system heavily dependent on
are conservative organizations, so this evol

Computers suggest measurement. The t
themselves as threatening. Faculty ince
parent education about computer applica
today should not be equated to that of 1

Poor task orientation. Lack of compute

Lack of success to date is simply becau
yet advanced enough. School systems ma
fear of technology or inertia against inno
been warranted.

Lack of equipment and lack of allocated

CMI or CAI appended to conventiona
opportunity for success because of the thre

6. Computers, especially after gains ma
sent a situation as revolutionary for our
printing press.

Frequency distribution:

Strongly agree
Agree
Neutral
Disagree
Strongly disagree

COMME

I expect microelectronics technology wil

But remember, the printing press didn't
of our lives.

But remember, the printing press didn't
able correspondence courses haven't solve
problems.

It is only an extension of the printing pre

Only when coupled with videodisc that
and motion plus book potential through th

uggest that the most promising use of the com-
he storage and retrieval of large amounts of
information can be put together, displayed,
vailable tools or new programming; once (re)-
be stored in new ways for more personally
echnically, we do not as yet understand how to
or educational use nor what the results of the
mean. We should assume, however, that the
ed curriculum, will not be effective.
st at all levels of use: reliability of hardware
courseware, and artificial constraints imposed
resent materials on inappropriate media or by
ability to extend his studies (through for exam-

CMI. At the present time, the total costs of

rigidity and unwillingness to explore the un-
addition to money. But more money is not the
are needed. How can microprocessors revolu-
know how to design educational software?
on/machine interfaces are needed.
and school to support the implementation.
basic instructional techniques appropriate to

e decentralized and therefore more demonstra-
d for all of the decision makers to see CBE
ducting education.
spiring. That's what is holding things back.
volve away from an organizational structure
ns at the same rate and in the same way, and
ndent on the lecture. Universities, particularly,
this evolution will not be easy.
t. The teacher of today views measurement of
lty incentives are important, as is faculty/
applications in instruction. Note, the CAI of
hat of 1965.
omputer science expertise.
ly because the technology and software is not
ems may turn out to be a problem because of
ast innovation, but to date their resistance has

llocated funds for educational technology.
ventional instruction formats has very little
the threats posed to personnel.
ains made in micro electronic technology, pre-
for our society as that of the invention of the

	Percent
	70
	26
	2
	2
	0

COMMENTS

logy will drastically impact nearly all aspects
s didn't give us great literature and the avail-

ss didn't give us great literature and the avail-
't solved many of our training and education

iting press.
se that allows movie (T.V.) format with sound
rough the insertion of hundreds of still frames

Not that drastic, but a sine-quo-non condition for survival.
Almost as revolutionary as the printing press.
If thoughtfully used.
Potentially this is true.
There is no way to anticipate the full impact of this technology on our society. Where quantitative projections have been made (i.e., number of computers in use in 5 years, etc.), they have almost universally been seriously underestimated.
More so when society is better able to accept and use the technology.
This is particularly true in the case of general purpose microcomputers. These are beginning to show up in cars and household appliances and have the potential for massive impact on type and degree of training required for operation of industrial and service equipment.
Will become commonplace.
The interactive learning possible with computers will change all our educational institutions.
They deal with intellect and communication.
Computers have the potential of being as important as the printing press. The micro electronic technology developments have placed powerful computers within the economic reach of the average student and citizen. However, the significant innovations and applications needed to create an educational revolution still lie ahead of us.
My response reflects my previous emphasis on the use of the technology for access to (1) previously unattainable kinds and amounts of information and (2) methods for viewing and manipulating that information. The printing press represented a major change in the distribution of information; small computers owned by individuals but linked over networks to public or private data bases (libraries) represent not only new and revolutionary methods for the distribution of information, but also for the use of that information.
7. Non traditional education though home-owned computer based education is inevitable.

Frequency distribution:

	Percent
Strongly agree	44
Agree	33
Neutral	15
Disagree	2
Strongly disagree	4

COMMENTS

Limited to a subset of areas; often prohibitively expensive.
Though only as a supplement to public education. One quetsion: accreditution!
Entertainment is inevitable and, thereby, some education.
Potentially (Recall, however, that T.V. had the same potential.)
Home centered use of all types of information utilities, services, and capabilities is inevitable.
The potential is there, but it will require the appropriate social milieu.
Only problem remaining seems to be courseware.
But not necessarily as the result of systems acquired specifically for education (the effect of T.V. is comparable—T.V. was probably acquired for entertainment in the typical home but has inevitably led to learning that is not always of a desirable type—e.g. violence, passivity). The ubiquity of interactive computer systems (including games attached to T.V. sets and home computer systems) is going to have a similar effect whether planned or not.
No curriculum is presently available for widespread home use.
But only as supplemental approaches to education.
It probably will be T.V.-based, too.
May depend on commercial success.
Adult, perhaps; elementary/secondary, no (education requires baby-sitting).
It is a matter of time, really.
Systems will have to be almost foolproof to be successful.
This fact is becoming clearer and clearer—just witness the Christmas adds this season.
But, it remains to be seen to what extent such education can support or supplant formal public education.
People need social interaction as a part of their education.

It's just a matter of time.

It will happen, but there is no guarantee it will be good education.

It depends on what is meant by inevitable. Traditional education will be around for quite a while.

If used as homework, fine! If seen as substitute for school-based education, bad.

Especially in the area of games. Also, in order to use computers to increase our laziness we will often have to learn new skills in order to use them.

The advent of computer-based education in the home will be largely due to factors outside education. The energy crisis may lead us to substitute telecommunications for travel and consequently we may return to the home as the center of education. Home use may be inevitable for special groups such as the elderly or the handicapped or for special purposes such as teacher training.

I must repeat that delivering instructional materials via home-based computer systems means a return to the home. Education in ones home is not non-traditional, just non-contemporary. It is not clear that the ultimate home media will be the computer, but the computer does seem to be serving as a catalyst, getting educators to rethink the institutionalization of learning. Its value lies in providing materials and teaching methods to less-advantaged homes, countering the possibility of locking children into the educational level of their parents.

To some extent. Our experience has shown, however, that school children learn better in groups, even when they are learning on the terminals. Although the instruction is individual, the child needs the support of the group and wants to share his success with his peers. Often these successes are very subtlely communicated, as the child appears to be whispering to no one in particular, "All right! Hey. I got it! Wow, a hundred percent correct!, etc." Where we have put children on terminals isolated from other children of elementary school age, their enthusiasm noticeably diminishes.

8. Home-owned computer based education requires some type of governmental action to make it worthwhile/or most optimal.

Frequency distribution:

	Percent
Strongly agree	28
Agree	20
Neutral	28
Disagree	7
Strongly disagree	15

COMMENTS

I'd rather deal with a reliable business; government is not guaranteed (on basis of my experience) to produce either worthwhile or optimal products.

Otherwise, it will be haphazard—at best. After all, quality education is difficult and expensive to construct and the immediate payoffs (seen by industry) are dwarfed in comparison.

Probably in the form of compulsory standards and "truth in advertising". Incentives should also be considered.

Private industry wil introduce games and entertainment—not instruction.

It would probably take government interaction to make it worthwhile but it requires careful monitoring.

I believe that government action is needed to more quickly move the technology into formal schooling, and to stimulate the constant development of more adequate courseware.

To particularly bring the cost down.

The commercial market mechanisms will probably have a greater influence on home-owned computer based education than any governmental action.

Support of research as well as regulation for dissemination.

Some efforts should be expended in this area—but not at the expense of other programs—and not a massive shift.

Quality control cannot be achieved otherwise.

Home computers will develop very nicely if the Federal Government will just stay out of the way.

Put the money into good instructional software development.

It probably would benefit, but may not require it.

Yes, provided it must be very open-minded about what can be done—history shows government "action" is not very good at this, unfortunately.

This is a "mixed bag".

Direction and support during early stages would be helpful and influential. Restriction of options and over regulation would be harmful.

It would depend on the action. I would suggest support for development. Industry does not yet see a profitable market to reimburse these costs.

Support for micro-computer courseware development to permit distribution at low cost—say $15–25 for three semester hour course or for one year elementary mathematics.

Government should just concern itself with public education, but not just in computing.

The momentum is already building.

Probably only insofar as insuring that enough basic research in instruction using the medium is performed to insure that a high standard of quality is established.

Federal action is required to stimulate availability of curriculum materials and to create the mass market which would put equipment in the price range for individuals.

Perhaps in need for standards.

Otherwise it will benefit primarily the affluent members of society.

Investment by the government could speed up the process by decades.

If "governmental action" means competency-based granting of academic credit.

Federal governmental action is required to change the compulsory attendance laws and approve new methods for certification; copyright specifications are needed for computer courseware; extension of state methods for the approval of instructional materials for computers as well as conventional media are desirable, as well as state guidelines for management of home-based programs. This probably opens a need for parental as well as certified-teacher training programs, and the need for central resource centers for student-teacher interactions and group activities. To give access to all school-aged students, such centers would necessarily have to be publicly administered.

9. Computer literacy is a desirable national goal.

Frequency distribution:	Percent
Strongly agree	72
Agree	15
Neutral	4
Disagree	7
Strongly disagree	2

COMMENTS

It will probably be more important than classical, mathematical literacy!

Just as paper/pencil literacy has led to discoveries unimaginable, it seems likely that computer literacy will become a powerful tool for thought. People not able to utilize this technology will be the functional illiterates of terminals.

Necessity.

Computers are here to stay and we must all learn to use and live with them. Too much ignorance exists. It should begin in the schools, preferably with students 12-14 years old.

Certainly less important than energy or transportation literacy!

Schools specialize in teaching languages (English, Spanish, Math, Physics, etc.), and the computer language is one of the most powerful for a student to know in tomorrow's society.

"Literacy" means knowing how to use and program a computer—not just awareness of computers.

Not anymore necessary—in fact, less necessary than everyone having to learn to garden, cook or drive.

For most of the population (60–70%).

But there are several levels of computer literacy, which itself has not been adequately defined.

To agree here would be like proposing automobile literacy or electronics as a national goal (because people use them in their daily lives).

The degree of computer literacy in the coming years will be an intellectual and economic "amplifier". That is, an advantage in computer literacy and facility will accrue proportionally larger benefits as time goes on.

Especially for "traditional" education.

This may occur almost automatically as microcomputers become more a part of the environment but could be helped by minimal supplementation of math and general science courses in elementary and secondary schools. It is not necessary to make everyone a FORTRAN or BASIC programmer.

Can be best achieved by self initiative when equipment is available to the mass market—CB radio and audio-cassett recording are examples of this concept.

We are a computer-oriented society!

All types of literacy are to be desired.

It will soon be as basic a skill as arithmetic and it will continue to have increasing influence on everyday life.

Dealing with computers is a part of life now, and so courses in programming are as necessary as English or math.

It is not possible to disagree with the notion that computer literacy is desirable. The printing press made books and other reading materials generally available; paper and pencil, cheap and portable communications media, made the ability to write generally available. The pervasiveness of the applications of a medium demands literacy about its applications. Note, I said the "applications" of the medium, not necessarily the medium itself. For example, it is not a national goal that each person understand how carbon is formed into pencil lead. but it is a goal that each person know how to write legibly with that pencil lead. Similarly, it is not a desirable goal that each person understand the electronics of a computer. but, given the growing use of computers in businesses, schools, and home entertainment and appliance centers, it is desirable that each person understand how to use computers, how to control them. To protect users of any medium, it is also desirable that the user understand the limitations imposed by the particular medium (for example, programming constraints can be imposed by size of computer memory not by the definition of "computer").

With half of our Gross National Product (GNP) involved with information and nearly half of our labor force holding informational jobs, it is clear that ignorance of computers and information processing may cripple an individual occupationally and as a consumer. Universal literacy makes it possible for nations to introduce new innovations and technology which can improve national well-being and productivity. Without it, innovation becomes much more difficult and takes much longer to achieve. Moreover, an informed populace can more intelligently exercise the control and use of computers in an information society.

10. We need a national commission to look into these and other issues involving computers and their role in the learning process.

Frequency distribution:	Percent
Strongly agree	30
Agree	26
Neutral	26
Disagree	4
Strongly disagree	13

COMMENTS

May be useful. but I think national commissions are overrated and overdone.

Could be a two edge sword. If the commission comprises men of vision, then yes, but few people grasp new paradigms that easily.

We have already had many commissions; their recommendations have not been acted on.

A commission is not the appropriate vehicle to investigate these issues.

Need to include someone from the gifted field.

The changes of the last decade have been rapid and have affected all levels of education. If we are to achieve the goals of quality education and equal opportunity we must assess these uneven and rapid changes and provide for a more equitable distribution of resources and a more cost-effective product.

The sooner, the better.

National support may be preferable.

It might be a good first step.

National level important--You get the best people, and the scientific issues here are complex.

Commissions tend to codify or put an imprimatur on what is already known.

Commissions are a waste of time—look for creative individuals.

Better results might be obtained by commissioning several groups, each coming at the problem from a different perspective: computers/hardware, course content, instructional science.

We need to know what is going on and to disseminate information to aid progress in the field. Commercial economic incentives need to be encouraged to fuel growth and development outside the government sector, as well.

Since I do not see how a national commission can help or hinder the development of these issues, with the exception of temporarily misplacing financial and intellectual energies, I strongly disagreed with the statement.

It could be worthwhile if the right experts were involved.

Would be helpful, yes.

I don't see the benefit.

National commissions seem to do little more than restate the obvious (at great cost to the taxpayers).

Federal government needs to provide the stimulus which will encourage participation of business and industry through market incentives.

This group must be carefully organized so that it is not unduely influenced by a single element.

Not clear a commission would help anything.

Can't hurt, although many blue-ribbon panels have been ignored in the past.

11. We need increased funding/coordination at the federal level to solve the above problems. (Specify type and level).

Frequency distribution:	*Percent*
Strongly agree	54
Agree	26
Neutral	11
Disagree	4
Strongly disagree	2

COMMENT

Funding and coordination at late elementary/early secondary level may well be desirable and effective in promoting literacy, but I'm not convinced it would be either helpful or appropriate in developing the home market.

Greater need for R. & D. funding across all federal agencies—approximately $500 million.

Yes, however we should also recognize that most of the current funding agencies have shown little understanding of the dramatic potential and problems in using and shaping technology for education.

Standards for software, hardware could be coordinated.

Funding/coordination is needed at the HEW level.

With funding available, many exciting education projects for gifted could be implemented.

The amount of discretionary resources for education at the Federal level is greatly limited. If new efforts are to be initiated, additional funds will be required.

Categorical funds—Elementary/Secondary Level—Continuous Funding.

Because of additional costs associated with developing and implementing CMI, and the need for more R. & D. on how computers can best support instructional management, the Federal government should increase funding to states and local school districts to develop effective CMI systems. State governments working with local schools are in the best position to develop comprehensive, coordinated systems.

(1) Unless a high minimum of mass of capital is available for many years at a time, no technological project can be successful. (2) 2-3 million dollar per project per year.

Schools should provide computer literacy as a part of their regular educational program. Local school agencies do not have funds to pay for the computers needed for such courses. The Federal government should provide these one-time start-up funds to the schools.

Agree we need increase because potential is increasing. First needed is an information/research coordination and resource center which acts as a search/resource center. New areas like this are plagued with duplicated effort and lack of information.

Type: Larger centralized projects. Level: Uncertain.

Not sure about best ways. What is clear is that development times are longer than the 3–5 years afforded projects in the past. Patience is needed with respect to efforts like PLATO and MITRE.

Federal government has funded PLATO, but no one can get to it, so why spend more money?

Need both funding and coordination.

The track record so far (e.g. NSF) has not been spectacular. Although ONR did an excellent job in support of early research (in the middle 60's).

The need is to support creative and responsible groups, and not be afraid to list "ideas" as the product being produced.

At the present time, funding should be aimed at improving understanding of the teaching-learning process, the development of improved methods of instructional design, and the development of advanced prototypes. Once the "bugs" have been worked out, the entrepreneurs will take care of the dissemination.

Funding give support. Coordination helps apply it to the "right" places. Obviously there is a cautionary implication here.

I think the national functional literacy problem is a disgrace. We need intra-educational and extra-educational system actions.

Basic study into how people learn; fund pilot projects of great diversity (TICCIT and PLATO answered many questions unasked, even, when they were begun. Too bad they aren't being evaluated properly) to fund effective roles for computers in education. Imagination is needed.

Not needed.

I hate to see tax money thrown at general problem areas in hopes that some of it will stick long enough to do some good. The only areas that would seem to benefit (and them only with hardnosed administration of funds/coordination) are those in which start-up costs are too great for individual users (or commercial ventures) to justify exploration but which have promise of ultimately providing improvements which would benefit large portions of the population. Much of the NSF support of early CAI systems fits into this category.

Details would have to evolve from goals and objectives established by federal commission.

Need standards for design, development, evaluation and transport of materials.

You can always use more money, but first one needs to determine what needs to be done.

More prototype projects, particularly with newer equipment (intelligent videodiscs, for example) are needed to enable us to fully see this powerful new teaching medium. Unfortunately, funding has *dropped* recently, at a critical time.

Money to provide faculty incentives.

Federal money in education is now directed at programs and research that will have less impact in the future.

It must be properly channeled and combined with user education and courseware development.

We need initially a heavy emphasis on research and development in order to surmount application problems in the future.

We need to divert funding from present sources in education that appear to be largely unproductive of their original goals. Teacher aides do not appear to help raise achievement scores. Smaller classes do not appear to raise achievement scores. I believe we are spending the money in the wrong areas.

Coordination of funding is always desirable, at any level: increasing funding without providing better technical direction is simply not good business practice. The problem is that dollars-and-cents numbers do not generate the instructional theory needed to guide new educational uses of computer technology. Incentives on the federal level are traditional methods for stimulating nationally needed activity (I am, of course, thinking of tax incentives for business investments). But the markets for computer hardware have expanded without governmental intervention: these markets have encouraged industry to invest research money in hardware development. Our knowledge of software (e.g., programming language) design and implementation lags considerably behind hardware design and fabrication. As the market expands to less technically knowledgeable users, as it is now doing, the demand is increasing for more congenial interface methods (input/output devices as well as programming languages). Industrial and academic researchers are turning to these issues right now.

The question is, firstly, how much federal government intervention is needed to guarantee that this kind of research is carried out and at acceptable speeds: and, secondly, whether the results of federally-funded research centers get sufficiently distributed, with or without industrial interest, to be worth the expenditure of funds? Federal funding should open the door to a broader range of studies; initially, the kinds of instructional materials made available should be greater by providing increased resources for a greater variety of researchers. But bettter federal coordination is needed to guarantee the accessibility of these materials to the average user of a home computer; here, I do not mean by finding profit-seeking publishers to disseminate the material, but by providing free library access and by supporting the initial teaching efforts (the initial idea is public libraries for public school personnel, teachers and students). Lack of broad use of nationally-funded curricula in the past, possibly due to their ultimate market costs, should emphasize this point.

We are no longer patient consumers of school programs, willing to wait for the "one best way" to evolve. But we are conservative in our willingness to change abruptly: a great deal of new ideas and testing of those ideas to determine their viability is always in order. For example, I believe that the caution with which schools are incorporating calculators is appropriate; I do not believe, however, that the schools can afford to dismiss calculators or computers (no more than schools could afford to ignore the use of typewriters). Federal funding is desirable to help in broad-based evaluations; centers to provide experienced research teams for these purposes are significant aids to getting the job done. Prior government emphasis on development programs requires too much money over too long a period without producing resources that can be made more generally available. Stronger emphasis is needed on researching applications for available technology, and, perhaps through industrial cooperations, keeping pace with the products that are developed, but not as yet marketed.

If what we need is more ideas about applications of computer technology and better evaluations of those applications, then funding a limited number of research centers seems counterproductive. I fear that putting the researchers all in one place means that they will all start doing the same thing, producing fewer ideas that must be positively evaluated for their work to continue. The overwhelming "sameness" of research examples in the computer science area of "artificial intelligence" seems to support this fear. But this statement, in itself, is counterproductive since good research needs good resources; a critical mass of people to carry out the very large tasks. This seems to imply that a significant number of research projects must be funded to generate several, good competitive ideas with sufficient funds to carry out evaluations of the ideas. As stated before, their research priorities are to find new instructional applications of computer technology that make use of the medium's unique capabilities to access and edit information (rather than using the medium as a new delivery system for current instructional content), to carry out national programs of evaluation, and to provide public access to the resulting products.

12. We need a center (or centers) of excellence to complete research on these issues.

Frequency distribution:

	Percent
Strongly agree	59
Agree	22
Neutral	4
Disagree	9
Strongly disagree	7

COMMENTS

These centers have been the most effective resource.

Private industry has always outstripped the grantees in innovations that can be applied to education.

That would be great!

May simply want to strengthen existing centers (e.g. LRDC/University of Pittsburgh).

Government interpretation of 'centers' is university/research groups. If 'center' included actual users (e.g. selected high schools), the results would be very worthwhile, and my vote would be 'strongly agree'.

The country can get far more for its money by funding outstanding individuals and small centers. Large centers tend to be less efficient. Their main advantage lies in greater visibility in the broader community.

Yes . . . Some academic, some industrial.

It is time to consider this.

Should look at hardware, software, courseware, societal issues individually and collectively.

Not necessary.

I would hope that it is recognized that several such centers already exist de facto.

Major efforts are needed to build CBE courseware to meet national priorities and needs.

This is where the research should be conducted.

But be sure it is not just the "old boys" being supported one more time.

Additional research is badly needed.

Because of the high cost of computer research and development, centers of excellence is the best approach.

We need better hardware for learner interactive use followed by massive amounts of software development.

This is urgent—now!

Such centers must also serve as a training ground for some of tomorrow's top-notch educational researchers and educators.

There should be more than one center to avoid getting "locked into" a specific approach.

Need 3 or 4 alternate centers to develop courseware and algorithms.

It should be staffed with qualified personnel including advocates.

These centers need to be distributed throughout the United States for easy access to all.

Absolutely necessary—small amounts spread nicely will not be very effective.

Such center (centers) should serve as a resource and support for State and local efforts.

Federal centers would become too bureaucratic to stay ahead. Individual groups should be financed at.

Largely, massive funded centers are great for working on highly technical, well-defined problems. Here we have a case of existing high technology and poorly defined problems. Small or medium centers or individual researchers with teams would seem much better.

While centers of excellence would be useful, the innovative and effective use of technology requires many forms of activity. Priorities for research, training, curriculum, and courseware development are also required. No one activity or no small collection of performers are capable of bringing about widespread change. A programmatic effort is required.

Yes, but let's get it established within the educational establishment. Educational technology people are afraid of CAI because they do not understand it. We need a nationwide effort to educate or re-educate these people and get CAI/CMI accepted within the mainstream of the profession.

13. Such center (or centers) research priorities should include:

COMMENTS

Determine research gaps. Special applications (e.g. handicapped and remote sites). Mechanisms for technology transfer.

Authentication of results of these mediums and dissemination of the practices.

Reliable, versatile, and inexpensive hardware. Effective means for producing coureware with a strong level of credibility.

Yes, probably two or more. However, the charters for these centers must be carefully thought out and articulated or otherwise they will pursue the ordinary and not venture into the vast unchartered territory that must be ingeniously explored.

Should be multidisciplinary, emphasizing the psychology of learning and striving to integrate advances in computer hardware, software, courseware, and the ways that knowledge can be represented, organized, stored, retrieved, etc.

(1) Development of courseware for mass distribution: (2) Development of models for human environments that will succeed—in homes, schools, offices.

Evaluations of existing systems and conduction of tests in realistic environments.

Planned studies of what kinds of covert cognitive skills are developed by computer/media technologies so that, as in the case of paper/pencil literacy, we can efficiently teach the "study skills" for computer/media technology.

Computer programming effects on teaching efficiency.

(a) The development of equipment systems for specific educational problems; (b) The development of high quality curriculum; (c) Training and workshops for teachers and instructors; (d) Technical advice to administrators and instructors; (e) Research on and the testing and evaluation of instructional systems.

Research on: Learning styles; Curriculum for individualized instruction; Cost-effectiveness processes; Educational organization, Finance, and management; Educational evaluation; Software generation; Disadvantaged and gifted; Social science.

(1) Research on new technology; (2) Courseware development; (3) Evaluation research.

Net gains, amount, kinds of technology, and mix.

(1) Integrating computer usage with socio-political realities; (2) Reducing costs of operating CMI systems; (3) Placing graphics on computer for cost-effective retrieval.

Videodiscs.

Exploration of computer language alternatives. Development of achievement tests for computer literacy. Development of courses in computer use for problem-solving.

(1) Defining what is possible; (2) Small experimental demonstration programs; (3) Much teacher (not PhD. but regular teacher) input; (4) Defining ways/languages to simplify computer use.

Creation of instructional materials.

Quality materials, systems, and transportability.

(1) Assessing state of the art in instructional/management know-how; (2) Development of sophisticated computer answer processing and management routines; (3) Redirect learning psychology to solve instructional problems.

Cost-benefit analyses. Research on learning style and computer delivery.

More emphasis on applications strategies.

Imagination should be their most important product.

A wide variety of activities, with the emphasis on basic research and advanced prototypes.

Hardware/Software testing/Enhancement/Development/Curriculum development/Demonstration activtiies.

Long-term funding, long-term access to students, long-term commitment of professionals.

Courseware development aids; teacher training materials or procedures; user requirements for software; hardware needs in education.

(1) Behavioral research; (2) Learning research; (3) Human/machine interface research—Computer should interact richly with all six senses.

Computer literacy.

A center must have the flexibility to move forward with the state-of-the-art. Hence there should be a proven hardware design capability. A center *must* have access to a wide range of real user populations and a proven capability of interacting with these populations under learning conditions that are both realistic and experimentally clear. Given this setting, there is a need: (1) to identify optimal parameters for instructional man-machine interaction (e.g. 'human factors' aspects); (2) to identify optimal structures for CAI-CMI languages; (3) to identify critical barriers to effective application of known principles of instructional design; (4) to further knowledge of techniques of individualized instruction.

Include development with research because research without development will not advance the nation. Centers focused on separate disciplines (Math, Science, etc.) would be extremely useful.

Design, evaluation, applications, transport.

Determining how the curriculum should look given the existence and availability of computers.

(1) Role of graphics; (2) Role of full multi-media capabilities; (3) Development of systems for producing CAI/CMI materials; (4) Hardware specifically oriented to educational uses.

Given solid and valid curriculum and a coordinated faculty effort what does the application of computers to education at large do.

Multi-disciplinary approach.

Development of small, powerful computers, and development of sophisticated tutorial programs and educational games.

Development of courseware in critical teaching areas.

(1) Hardware; (2) Operating systems and languages; (3) Subject matter software development."

14. There are bureaucratic bottlenecks that prevent dissemination of computer-based techniques, ideas, courseware and hardware that would improve the chances of all segments of our population to become better educated.

Frequency distribution:

	Percent
Strongly agree	35
Agree	24
Neutral	13
Disagree	15
Strongly disagree	4

COMMENTS

Number 14 is a loaded question. The two parts, (1) bottlenecks to prevent dissemination of computer-based materials and (2) bottlenecks that prevent all segments of our population to become better educated, do not necessarily belong together. The first part has been answered in the above, stating that I agree that bottlenecks exist that are mostly financial for disseminating software and courseware. But it is certainly far from guaranteed that alleviating these bottlenecks will improve the chances of all segments of our population to become better educated. Introducing another new device will not solve the problems of today's educational system because, as stated earlier, those problems are social ones, coming from the economic and ecological uncertainty with which we are all trying to live.

The bottlenecks are more technical in nature including design, authorship quality, and quality of distribution.

One in particular—the policy of no royalties on partially government-supported curriculum projects has caused delays of several years in some cases. For NSF-sponsored COMPUTE materials, the effect has been to preclude commercial publication. The government should be more flexible in allowing the use of existing commercial resources, such as publishers, even if it means that someone might (?) get rich.

Granting agencies do a poor job of protecting the public interest and assuring public access.

I think dissemination is ok, but I wonder about how easily site people have been able to use my coded programs.

Need for a national clearinghouse of computer-based techniques, ideas, courseware and hardware.

For example, CETA program precludes CAI in basic skills.

Political expediency, anti-intellectualism, middle-management types, the university research office.

Skepticism and lack of understanding on the part of school people (Note: Some of the skepticism may be warranted.).

Ignorance of this technology on the part of the administrators and teachers.

Lethargic support by administrators, in part caused by an exaggerated cost estimate. Poor support for efforts needed to package materials. CONDUIT is a help.

Yes, but these are not by any means our biggest problems.

Mostly an understandable hesitancy to expend tight funds for efforts that will not have immediate payoffs.

Lack of 'universal' standards.

The recent ending of the TIE program in NSF is a current bottleneck.

School systems may be bottlenecks.

Not bureaucratic—just lack of money, lack of a market and therefore lack of materials.

USOE, NSF, State departments of educators.

Government regulations on use and procurement of ADP services and equipment.

I feel the colleges and universities keep calling for research grants to develop avant-garde hardware and software without proper attention being paid to the financial constraints in public education. More attention should be directed at developing low-cost production technics of felt needs of the practitioners. I do not feel the need for a color picture to be superimposed on the cathode ray tube but

I would like a low cost audio system that could accompany primary reading instruction.

Lack of coordination at Federal level, even within agencies. Annual shifts in priorities can rob existing programs of effectiveness and even prevent them from being properly completed.

They are just the usual ones: budgetary. etc. . . . They assume more importance because of the need for integrated effort with freedom to consider tradeoffs across areas (e.g. hardware vs. software).

DOD regulation 18–1 and similar federal restrictions to purchase computers. OE and NSF legal hold on copyrights where federal funds have been used to develop.

The chief bottleneck is method of evaluating proposals. There is no consistency. Another is method and criteria of selecting programs.

I believe the major "bottlenecks" are not with government bureaucracy but with educators who refuse to believe that learning/teaching can be vastly different and much more efficient by using technology.

CAI is not being disseminated because of a lack of an adequate dissemination source and budget.

New technologies often require new organizational mechanisms to facilitate their adoption. Studies of how to reduce the time-lag between the identification of a problem and the implementation of a viable solution are probably merited.

Inflexibility of ESEA Title language, and State regulations that make it difficult in many cases to fund CAI/CMI programs.

Protection for authors and investors; incentives to improve and modify consumer protection . . .

Federal guidelines: purchasing procedures, student population, time frame, funding plans.

Regulations concerning purchase of ADP equipment.

Many educators fail to seek new devices to facilitate better learning.

Program offices have: (1) Lost courage to back projects themselves—Committees from outside decide everything and thus project institution from Congressional criticism. Committees are usually wrong—afraid of new, risky, or complex. (2) Too many bureaucrats to give away too few funds. Thus almost all grants take 6–8 months to process and they can have only a few thousand dollars apiece.

Regulations that present federally supported projects from recovering royalties or courseware, etc.

The tendency to fund research projects but little or no information dissemination/resource activities. When funded—large centers in global areas are set up instead of providing funds to small information centers concerned with specific areas.

Most courseware developed to date is ill designed, parochial, limited in scope and effectiveness, not worth disseminating. What is needed is a machine independent, individualized/CAI/CMI curriculum development effort in major content areas akin to the major curriculum development efforts done after sputnik in physics, biology etc. This development should be done by professionals using academicians and teachers as resources, not vice versa. This curriculum should be objective based, criterion referenced, and uniform across the country. Credit should be obtainable from all participating schools/universities, and incentives for offering such nationally accredited courses should be provided.

15. Are there any additional issues that have been overlooked in the above?

COMMENTS

What agency(ies) is most appropriate for establishing policy and disseminating funds? At present, efforts are fragmented.

I feel that 75% of the technology has already been developed and is price effective. Let us implement it now!

Yes—Involvement of industry. Incentives for private distribution networks to implement the fruits of government-sponsored R. & D. and to carry these good design standards to homes and schools.

Institutions of higher education, where teachers and educational administrators are educated, do not provide substantial training in the technologies of education. Major funding of higher education may be necessary to redirect these schools from teaching teachers about the more mundane "methods" of the past, to teaching them about the present and future use of media and technology, particularly computer/media technology.

Asimov claims computers can be creative and be programmed to learn—to reach this goal our gifted need to be cognizant of the importance of the role of computers in our lives and to work in harmony with them.

(1) Developing better mechanisms to facilitate cooperation among education, business and the government. (2) New financial mechanisms for the acquisition of capital for long-term educational investments. (3) The crisis of technical and educational obsolescence and the role of technology and the Federal government in continuing education.

There is still a need for a National Dialogue between Industry/Government/and Academe supported and encouraged on a continuing basis (e.g. Project ARISTOTLE).

Successful implementation of a complex technology into education requires very careful planning, is expensive and will require all possible management and technical skills. Underestimating the problems will lead to a disaster. Quick solutions could lock schools into systems with technological obsolescence before they are even used.

Need for education. Industry cooperation. Establishment of an all-technology school. Teacher training. More efficient distribution of funding to result in better consideration of projects.

Practically every program officer involved in technology at NIE or NSF has lost the ability to fund new and important projects with any substance or speed. This is a direct result of Congressional policy: (1) Funds have been cut back; (2) Available funds have been designated by political fiat such as UMA and the Alaskan Satellite in NIE. If Congressmen want to designate certain project funds, these should be added above standard budget, otherwise project officers have no funds left for significant projects. (3) Political attacks by politicians, followed by cries for accountability, on agencies such as NSF simply destroy program officers' ability to function. Their superiors make certain a "public" group of outsiders make the decisions. This strategy relieves the agencies of accountablity and protects the agency leadership. It also ensures mediocrity and the death of anything creative or significant. (4) Union lobbying and State lobbying for direct funds for education has made Congress shy about using funds in R & D posture. Union members and States want direct funds for salaries, not new programs or technological delivery systems. Congress has responded accordingly. (5) Congressional Staff leadership has not been very interested in this area.

Yes. What will happen if no federal action is taken to educate the public in the use of computers? The answer is that only those individuals and affluent schools which can afford to buy the new computers will derive the benefits. The economically and socially advantaged will develop new skills that further widen the gap between themselves and those less advantaged. Only a public education program can avoid this outcome.

The potential is very great for the use of computer or microprocessors to offset the handicap faced by many severely physically handicapped individuals, including: Non-speaking (physically unable), non-writing and non-manipulative, blind, and deaf.

Cooperation with private industry, for example: Computer companies and publishing houses with particular emphases and standards and distributon.

There is no mention of any new curricula demands (e.g. Computer Science) nor of hardware intercommunications.

In addition to computer literacy, more attention would be paid to the "adjunctive" use of computers—as data analyzers, vehicles for simulation models, and objects to be programmed.

Teacher training in schools of education needs to be informed. Sometimes (actually often), instructional designers that are really good using the computer medium are really hard to come by.

The role of teachers.

The questionnaire is directed primarily towards questions of implementation. There are a few systems currently that are worth implementing on a large scale: most are not. More important, we can and must develop far better systems. It would be a serious mistake for the government to fund large scale implementations when what are most needed are better understanding and advanced prototypes on which to base large scale development and implementation.

Obviously there will always be many unexplored issues in any discussion of a topic such as this one. One which is worthy of further attention is the area of government underwriting of increased basic research in which automated learning systems are both the object of, and the vehicle for the research effort.

Everyman's portable automatic tutor is a reachable dream. But it would take extraordinary wisdom, integrity, honesty, and patience to make it happen.

I feel that you are being told that if only the government would pour money into research and implementation of micro systems for everyone, then everyone would use his/her own computer and become educated. Not so! Personal computing software development is stalemated—no one knows how to turn people on to learning. With traditional media, our options were limited: with the computer, ways to learn are limitiless. Lets not use the computer to mimic the dark ages of learning: let's explore and capitalize on the richness of this new tool.

Yes. Emphasize computer literacy to overcome the reluctance of people to use computers in education whether at home or school. We must overcome fear by understanding, not bury the technology in a deluge of research and reports!

The real problem is finding out where and in what way computers can and should be used in education. There still are too many computer projects that simulate long division. Not only that, we take 5 years (if you add up all the months spent in elementary school) teaching long division. Rather than mechanizing the present curriculum, we need a new one.

We should be encouraging commercial vendors in taking a more active role in marketing course material of this kind.

The educational advantage of the new technology is that it can provide personalized attention to the students problems and misconceptions, and it provides the student with an environment where the student can try out ideas without fear of criticism or failure and can have more control over the learning process.

○