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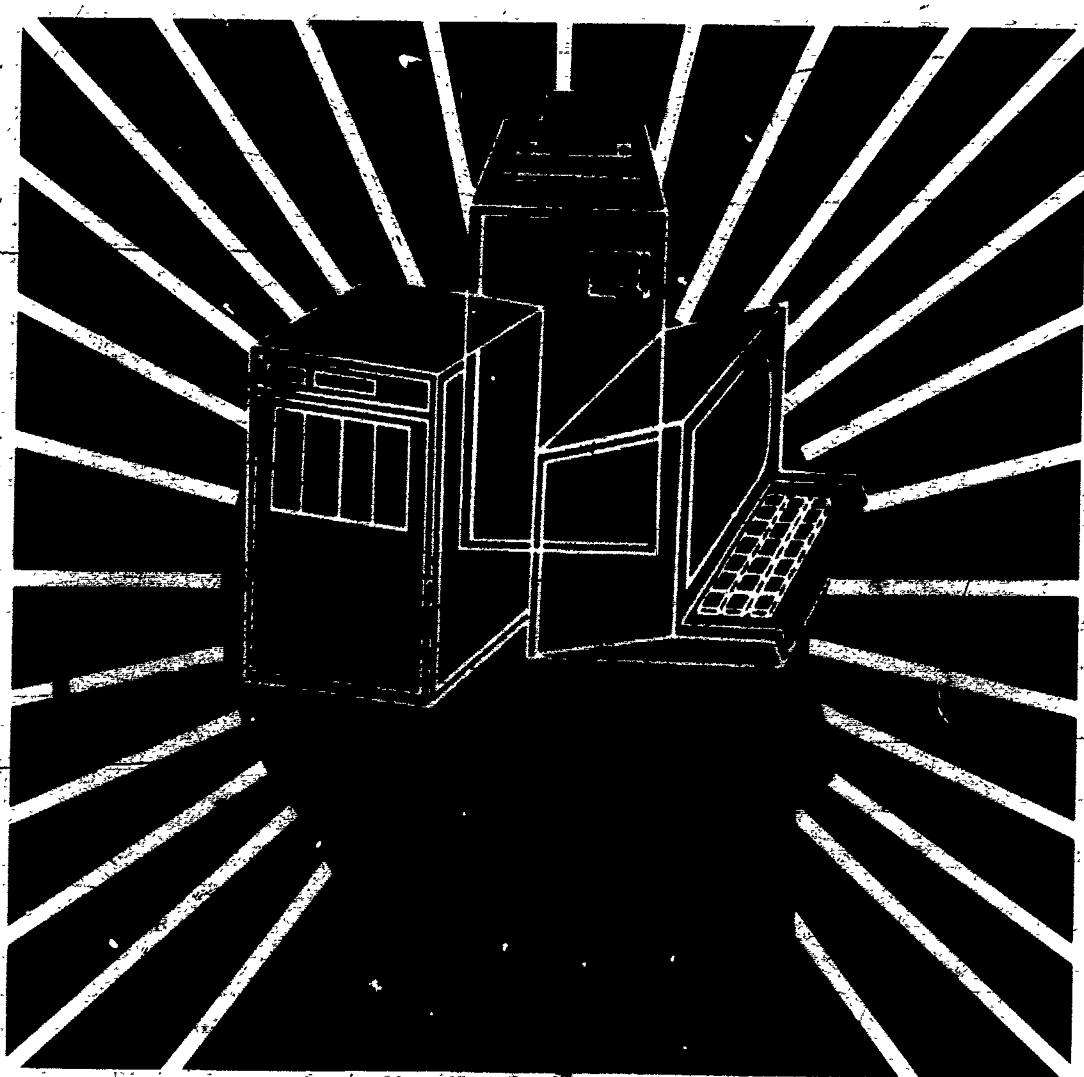
ABSTRACT

Twenty-two speakers attending the University of Oregon College of Education's Third Annual Summer Conference, entitled "The Computer: Extension of the Human Mind," in July, 1982, submitted their papers for publication in this volume of conference proceedings. Papers of a wide-ranging speculative or theoretical nature were presented in general interest sessions. Authors of these papers and their topics were Moursund on computer literacy, Bork on educational change related to computers, Zamora on off-campus computer education, Billings on learner control, Kling on the relationships between educational or social philosophy and approaches to computer instruction, Olds on the hidden curriculum of computer-assisted instruction, and Kinne on the development of the microcomputer and its market. Special interest sessions were addressed by speakers discussing specific applications of computers in the following areas: special education, educational program evaluation, elementary and secondary mathematics and science instruction, literature searches, computer programming instruction, career information systems, and home computer-based learning systems. Other special interest sessions dealt with professional associations for computer educators, resource materials regarding development of small college computer science programs, and applications of computer-assisted instruction. (PGD)



THE COMPUTER: EXTENSION OF THE HUMAN MIND

Conference Proceedings
July 21-23, 1982
College of Education
University of Oregon

PROCEEDINGS

THE COMPUTER: EXTENSION OF THE HUMAN MIND

Third Annual Summer Conference
College of Education
University of Oregon
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FOREWORD

The Third Annual College of Education Summer Conference has been designed to provide a broad perspective on the computer revolution and its implications for educators in the next few years. "The Computer: Extension of the Human Mind" will bring together leaders in the computer field to explore current issues and trends in educational uses of computers.

This is really the fourth or fifth generation of computers in the second "computer revolution" for the world. However, it is the first computer revolution for schools. Actual use of computers in schools has lagged far behind predicted use. In the past two decades, adoption of these flexible new tools has been slow due to high costs and a confusing, rapidly changing technology. Now, with microcomputers and software development it is likely that computers will have a long-predicted major impact on all aspects of education.

The effects of the microcomputer revolution are already all around us: in small businesses, the professions--particularly law, medicine, and architecture--and the arts. Video game arcades using the latest software seem to have grown overnight in every shopping center and mall in America. Personal computer costs are dropping to an affordable level; soon, minicomputers in our homes may be just as common as telephones and televisions.

Let us hope we can "extend our minds" through this exciting new technology, and learn better how to prepare our students in the schools for their new computerized world.

Robert D. Gilberts, Dean
College of Education

INTRODUCTION

The ERIC Clearinghouse on Educational Management is pleased to serve as publisher of the Proceedings of the 1982 summer conference sponsored by the College of Education at the University of Oregon. As one of sixteen clearinghouses in the federally funded Educational Resources Information Center network, the Clearinghouse on Educational Management collects, processes, and disseminates information on the structure, governance, and administration of elementary and secondary schools. The Clearinghouse views the publication of these Proceedings as not only a convenient service to conference participants, but a means of sharing the valuable materials generated by the conference with school practitioners and other interested people across the country.

Appreciation is due the conference presenters for their promptness in meeting deadlines so that the Proceedings might become a reality. With few exceptions, the presenters submitted their papers in time to be included in the pages that follow. Grouped according to general and special interest sessions, the papers are listed within each session in the order in which they were presented.

For readers' ease of reference, the presenters were asked to follow a uniform style for organization and layout of their papers. Without exception, the papers are printed exactly as they were received.

Additional copies of the Proceedings may be obtained by sending $10 (prepaid or purchase order) to Editor, ERIC Clearinghouse on Educational Management, University of Oregon, Eugene, Oregon 97403.

Philip K. Piele
Professor and Director
ERIC Clearinghouse on Educational Management
(Chairman, Conference Planning Committee)

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General Sessions

THE COMPUTER-LITERATE STUDENT

David Moursund
University of Oregon

The computer can be viewed as an extension of the human mind, much as the saw, hammer, and spear can be viewed as extensions of the human body. The computer is a tool which incorporates ideas from reading, writing, arithmetic, telecommunications, and automation.

Computers have the potential to substantially change the content and process of formal, industrial, and informal education at all levels. Computers are already changing what many millions of people do in their jobs and what they do for entertainment. Out of these observations has emerged the idea that all students should become computer literate. Unfortunately, there is no universally accepted definition of computer literacy.

This paper examines the concept of computer literacy from a student perspective. The definition of computer literacy that emerges is a functional-tool level of knowledge, relevant to the tasks and purposes of being a student. This definition can help in teacher education, curriculum design, and educational materials development as computers become increasingly important in education.

Mind Tools

One of the distinguishing characteristics of human beings is that they create and use a wide variety of tools. In early history these tools were mainly aids to survival, such as spears, clubs, and knives. Eventually, however, agriculture and its related tools emerged. At this level of civilization reading, writing, and arithmetic became useful to increasing numbers of people.

Reading, writing, and arithmetic may be viewed as mind tools. They are an aid to a human brain, supplementing and extending its capabilities. A person who can read has access to tremendous amounts of accumulated information, such as one finds in the Library of Congress or a local newspaper. Writing is a supplement to human memory, as well as an aid to communication. Almost all students can develop paper-and-pencil assisted arithmetic skills that far exceed their mental arithmetic skills.

It takes considerable effort for a child to learn to read well enough so that reading gives access to library resource materials. And each discipline has its own special vocabulary. Thus, reading instruction is both an explicit course in its own right and is also woven into all levels and courses of formal education. With increasing reading skills comes increasing and more penetrating access to the accumulated written knowledge of the human race. It is for this reason that reading is one of the basics of education.

Similarly, writing has emerged as one of the basics of education

Writing is useful in communication over time and distance. It is useful in organizing one's thoughts and one's attack on hard problems. It is an aid to the human memory.

Arithmetic (or mathematics) shares characteristics of reading and writing, but adds a new dimension. The development of our current notational system, with a zero, decimal point, and positional notation, was very difficult. The best mathematical minds of their times struggled with these tasks.

But now a grade school student can learn our notational system and can use it to solve arithmetic problems. Moreover, over the years we have developed algorithms for such difficult problems as addition, subtraction, multiplication, and division. A student can memorize these algorithms; with practice a student can develop considerable speed and accuracy at performing these algorithms. Today's eighth grader can solve computational problems that were beyond the capabilities of all but the most brilliant mathematicians of two thousand years ago.

Reading, writing, and arithmetic are wonderful aids to human intellectual endeavor. Over the years technology has enhanced their usefulness and ease of use. The abacus, invented about 5000 years ago, was so useful it is still used today in some parts of the world. The printing press, movable type, and modern high speed presses have contributed to our current high levels of reading literacy. The typewriter, now being supplemented by electronic word processing systems, is a marvelous aid to writing. Electronic calculators are now a common household item. All of these are examples of machines that enhance the tools of reading, writing, and arithmetic.

Computers

Originally computers were designed strictly as aids to arithmetic computation. The goal was to develop an automated, high-speed calculator. Certainly that goal has been realized. A medium priced computer can perform about 10 million computations in a single second. Such a machine can continue at this speed hour after hour without making a mistake.

Using pencil and paper you may be able to multiply together two multi-digit numbers in about a minute. To do 10 million such problems would take you 57 years if you worked eight hours per day, seven days per week. The medium priced computer accomplishes the same task in a second, at a cost of about a nickel, and with no errors!

Computers began to be mass produced in the 1950s. By the early 1960s computers were reliable and reasonably priced relative to their applications. That is, it was cost effective to use computers in a variety of scientific, business, and government applications.

But the use of computers was not restricted to science, business, and government. Computers could work with letters as well as digits--with words as well as numbers. Computers could be used for information storage and retrieval and for word processing. Computers could be used in art and music and in the social sciences.

The computers of the early 1960's were transistorized, using many thousands of individual transistors. At that time technology produced the integrated circuit, a collection of transistors and other electronic components manufactured as a single unit. It was cheaper and more reliable than the individual components it replaced. This resulted in a major decrease in the cost of a given amount of computer capability. Computers became physically smaller and more rugged.

The integrated circuit gave way to the large scale integrated circuit; that in turn is giving way to very large scale integrated circuits (VLSI). Now a circuit the size of one's fingernail may contain the equivalent of hundreds of thousands of transistors and other electronic components. When mass produced such VLSIs cost a few tens of dollars or less apiece. The cost per individual active element is a small fraction of a cent.

This inexpensive electronic circuitry makes possible cheap pocket calculators, electronic digital watches, and talking machines such as Texas Instrument's Speak and Spell. It makes possible personal computers, hand-held computers, electronic games for home use, and electronic arcade games.

Cheap computers are the prime reason for this conference. It is only because computers are so cheap and readily available that they are a major educational issue.

Progress in developing VLSIs with even more components is continuing at a rapid pace. It could well be that inexpensive toys of the year 2000 will contain computer power rivaling the hundred thousand dollar computer system of today.

Hardware is only one part of the computer picture. Very dramatic progress is occurring in software. A good example is provided by LOGO, a graphics-oriented language especially suited to the needs of young children. Several speakers in this conference will discuss LOGO and its potential for helping to revolutionize education.

More generally, a field called software engineering has emerged as computer scientists have learned more about the design and implementation of sophisticated software. The development of high quality software is both an art and a science, but is becoming more of a science.

The development of high quality software is difficult. It is a significant bottleneck to the increased application of computers. The difficulty can be divided into two major parts. First, we have general purpose languages such as ADA, BASIC, COBOL, LOGO, and PASCAL. The design of a new language is a difficult task. But once designed and adequately tested, such languages can be implemented on a variety of computers. Thus, in a sense, they are mass produced and mass distributed, much like hardware.

But to use such languages requires substantial learning on the part of the user. One must know a great deal about programming to develop PASCAL programs to solve the variety of computer-solvable problems one might encounter in high school or college.

An alternative is to have more specific applications-oriented, menu-driven programs. In menu-driven software the user is given a menu of options and makes a choice at each major stage of solving a particular type of problem. One must have a special menu-driven program for each general category of problem to be solved. But there are many tens of thousands of different categroies of problems that are of general interest. The task of preparing menu-driven software to solve the variety of problems that humans know can be solved by computer is akin to writing all of the books in a very large research library. Thus, while rapid progress is occurring, we will have a very long way to go. Twenty years from now people will still be complaining about the lack of adequate software.

A current major area of complaint is software that can take over a substantial part of the teaching process. We know that computers can help people learn certain types of subject matter. So, why don't we have computer assisted learning materials that cover the entire curriculum at all grade levels? The answer is obvious. The task is larger than that of developing all currently available textbooks.

The Intelligent Machine

Computers are relatively cheap, reliable, and increasingly readily available. They are a general purpose aid to problem solving, somewhat akin to reading, writing, and arithmetic. But they are also different.

We can see this difference even in a simple calculator. A primary grade student can understand the concept of division and can do simple divisions mentally. But hundreds of hours of training and practice are needed to master paper and pencil long division of multidigit numbers. Alternatively, a student can learn to use a calculator by a few minutes of training and practice.

A calculator is a simple example of an intelligent machine. It isn't very intelligent, and it is certainly limited in the scope of its intelligence. Indeed, one can get bogged down in a philosophical discussion as to the nature and scope of a calculator's intelligence.

But this misses the major educational issue. Since calculators are cheap, reliable, and readily available, most adults use them. The math education time students spend mastering paper and pencil multidigit long division might instead be spent studying problem solving, a foreign language, or oral and written communication skills.

The calculators and grade school arithmetic issue is just the tip of the iceberg. There are thousands of types of problems where a part of the problem can be solved either "by hand" or by use of a computer. A computer can draw a graph or a weather map, solve equations or perform a statistical calculation, print out text or set type for a printing press. A computer can help an artist, musician, or poet. In light of current and increasing computer capabilities we must ask about their impact upon the content of education. What should people learn to do mentally? What should they learn to do assisted by paper, pencil, and books? What should they learn to do assisted by computers?

And what about the process of education--teaching, evaluation, record keeping, and so on? It is evident that all of these are intellectual tasks, requiring considerable skill upon the part of a teacher. But computers can help in all these tasks. If computers are used as an aid to instruction, how will this affect students and teachers?

Computers and Students

How can computers affect students? We are all aware of one answer--the arcade games. Students in the U.S. now spend more money on arcade games than they do on music records and tapes, or on movies. For many students the home and professional arcade games rival or exceed television as a form of entertainment. The potential negative effect upon these students' education is large.

However, let's focus upon potentially more positive effects. How computers affect a student's education will depend upon the quality and quantity of computer facilities available, the computer-oriented knowledge of the teacher, and how much the student learns about computers. We will look at four levels of computer application to education, based upon levels of student knowledge required.

Novice Level

With just a few minutes of instruction a student can learn to turn on a computer system, load and execute a program, and interact with the program as it runs. Interaction may be via touch panel, paddle or joystick, keyboard, light pen, digitizing tablet, voice, and so on. Software and hardware can be developed to fit the needs of non-readers, physically and mentally handicapped students, and other students at all educational levels.

Innumerable studies have been done on computer assisted learning. Many studies report no significant difference, while some report negative or positive effects. The general conclusion that has emerged is that with good quality computer assisted learning materials students learn as well as with conventional aids, and students learn faster.

From the student point of view, then, computer assisted learning is a definite contribution to education. Computers can provide an individualization of instruction, feedback, record keeping, and overall sense of direction that can help many students to learn faster than they otherwise do. The explanation for this may be quite simple. For most students, interactive use of a computer is high quality time-on-task. Increased quality and quantity of time-on-task results in increased learning during that time.

Intermediate Level

There are many educationally-oriented computer applications that take a significant amount of learning on the part of a student. The use of a word processing system provides a good example. Even grade school students can learn to use a word processing system. But if the student has no typing skills the overall computer usage tends to be painfully slow.

Word processing in the elementary school is especially interesting from an educational point of view. Computer assisted learning materials exist that can be used to help a person learn touch typing. Should grade school students learn touch typing? Spelling checking programs exist. Should children be allowed to use them? If students are learning to type, will they develop acceptable hand writing skills? Some students are compulsively neat; will work processors encourage them to write more, correct errors more often, rewrite more frequently?

Another intermediate level application is computerized information storage and retrieval. There are now thousands of data banks containing educationally relevant materials. The French government is in the process of replacing paper telephone directories by computer terminals in people's homes. In some ways learning to use such a system is like learning to use a research library. A few minutes of instruction allows one to learn to browse and to experiment. Many weeks of instruction and practice are needed to learn to make full use of such systems.

Right now most educationally-oriented information retrieval systems are sufficiently expensive that only trained professionals use them. Graduate students and researchers have searches run for them, or perhaps learn to run searches for themselves. But this is gradually changing. Eventually computerized libraries will be accessible to all people, both in school and at home.

As a final intermediate level example, consider libraries of programs designed to help solve specific categories of problems. The problem might be graphing or statistical analysis of social science data. It might be writing and editing of music. It might be architectural or engineering design or structural analysis. It might be a mathematics problem, from physics, economics, or weather forecasting.

All cases require two types of knowledge. One is the specific subject matter of the application, while the other is how to use the computer system. This suggests strongly that instruction on use of a computer as an aid to problem solving be integrated into all academic disciplines at all levels. If a computer is a useful tool in helping to solve a particular category of problem then students should learn the computer tool as they study the academic problem area. The parallel with reading and writing seems evident.

Advanced Level

Writing is an important part of the reading-writing duality. Computer programming is an important part of the computers-in-education field.

You are, of course, aware that a grade school student can learn to w[illegible] simple BASIC programs to print out words or to do arithmetic cal[illegible]ations. Using LOGO a student can learn to draw geometric patterns. In both cases students can learn to program well enough to gain satisfaction in their skills and to encounter programming tasks that stretch or exceed their skills.

As students progress into secondary school and into higher education they gain more and more knowledge of the tools and problems of various academic disciplines. The computer programming skills needed to help attack these problems grow accordingly.

We can look at this problem at any educational level. Suppose we have a college freshman who has never used a computer. How many college level courses are needed [illegible] the student can program at a level compatible with the student's [illegible]all level of education and problem solving skills? The student is taking courses in the humanities, social sciences, and sciences. In one of these areas the student encounters a problem that is well suited to computer-assisted solution. Is one year of computer science/computer programming coursework enough? How about two years?

We know that such levels of skill can be learned by many students at the precollege level. This can be accomplished by a combination of formal instruction in computer science and the continued use of the student's computer-related skills in a variety of other courses. Once again, the parallel with reading and writing is evident.

Professional Level

We all understand there is a difference between a "functional literacy" level of reading, writing, and arithmetic, and a professional level of knowledge and skill. So it is also with computers.

Some secondary schools have vocationally-oriented courses in data entry, data processing, or machine maintenance and repair. More frequently these and other job-entry-level courses are offered in two-year colleges or private data processing training institutes. The data processing field is very large and still rapidly growing, so that many people find employment based upon such levels of education.

The demand for computer and information science bachelors, masters, and Ph.D. graduates far exceeds the supply. In recent years there has been an explosive growth in students seeking a bachelor's degree in computer and information science. The production of Ph.D.s is totally inadequate to staff the degree programs these students wish to pursue.

Computer Literacy

We can now see the difficulty in settling upon a single and simple definition of computer literacy. Every student can easily master the Novice Level of computer knowledge. If appropriate hardware and software are available this can make a significant contribution to the student's education.

With appropriate instruction, every student can acquire a functional Intermediate Level of knowledge in several major application areas such as word processing and information retrieval. Again, this is quite useful to the student.

Every student can develop rudimentary programming skills, but with the languages and computer systems currently available it is not evident that all students can acquire an Advanced Level of computer knowledge and skills. For many the effort required may be too high relative to the potential rewards.

The parallel with reading and writing breaks down here. One can be a very effective user of computers without knowing how to write programs. An Intermediate Level of skill and knowledge may suffice for many students.

Computer literacy, then, depends upon the individual students. A college bound high school senior, intending to major in engineering, needs a different definition of computer literacy than does the tenth grade drop out. Computer literacy for a college graduate in physics is different than computer literacy for a college graduate in art or music.

In any event, one thing is clear. Our school systems are not producing very many computer literate students. We have a very long way to go before we can claim a high percentage level of success in producing computer literate students. This is especially true at the pre-college level of education.

Ethical and Social Concerns

This discussion and definition of computer literacy has focused upon a functional, useful-tool level of knowledge. There is another dimension which is quite important. It has to do with the ethical and social issues surrounding computers and their applications.

We are all aware of how tools affect their users. Our society is highly dependent upon the technology of automobiles, electricity, and telephones. Increasingly we are dependent upon computers.

And there is the issue of misuse or abuse of computer capabilities. We have increasing numbers of very large computerized data banks. The year 1984 is nearly upon us, and computers are a major facilitator to "Big Brother is watching you."

Other social and ethical issues center around the "haves" versus the "have nots." Some people have computers in their homes. Their children may have a distinct educational advantage. Some schools use computers mainly for routine drill and practice in the basics of education. More affluent school systems tend to use computers to help develop higher level problem solving skills.

The social and ethical aspects of computers can be woven into our educational system at a variety of levels. Special attention may be given to them in secondary school social studies courses and in similar parts of a student's computer literacy education.

Computer Literacy for Teachers

The model for computer literacy discussed in this paper requires that students at all academic levels and in all academic disciplines be given computer-related support and instruction. Hardware, software, curriculum materials, and knowledgeable teachers are required.

Hardware can be mass produced. We can be assured that for many years to come we will continue to have a rapidly decreasing price-to-performance ratio for hardware. Eventually computers will be commonplace in homes and schools.

The software problem is difficult and is less amenable to mass production techniques. But good progress is occurring, so increasing amounts of suitable software are becoming available. While the software problem will never be completely solved, it will gradually become smaller.

We do not yet have curriculum materials suitable for integrating computer usage throughout our educational system. Even if we did, we do not have sufficient computer literate teachers to handle this integration. While computer literacy for students is the ultimate goal, it is computer literacy for teachers that stands as the major barrier. If we want students to become computer literate then we must put considerable resources into preservice and inservice teacher education program.

This conference constitutes a useful step in attacking the problem of computer literacy for teachers. It represents a commitment on the part of the University of Oregon's College of Education to helping both preservice and inservice teachers learn more about computers. I am very pleased to be a participant in this conference.

THE FOURTH REVOLUTION - COMPUTERS AND LEARNING

Alfred Bork

> "Of all human inventions since the beginning of mankind, the microprocessor is unique. It is destined to play a part in all areas of life, without exception--to increase our capacities, to facilitate or eliminate tasks, to replace physical effort, to increase the possibilities and areas of mental effort, to turn every human being into a creator, whose every idea can be applied, dissected, put together again, transmitted, changed."[1]

The theme of this paper is that we are on the verge of a major change in the way people learn. This change, driven by the personal computer, will affect all levels of education from earliest childhood through adult education. It will affect most subject areas and most learners. It will affect both education and training. It will be one of the few major historical changes in the way people learn. The impact of the computer in education will not produce an incremental change, a minor aberration on the current ways of learning, but will lead to entirely different learning systems.

This massive change in education will occur over the next twenty years. Schools, if they exist at all, will be very different at the end of that period. There will be fewer teachers, and the role of the teacher will be different from the role of teacher in our current educational delivery system. I use "schools" throughout this paper in the general sense to include any formal schooling activity, whether it be the third grade or the university, or any other level; for emphasis I sometimes mention particular types of schools.

I hasten to say that this change will not necessarily be a desirable change. Any powerful technology carries within in it the seeds of good and evil, and that applies to an educational technology. One of my major goals in making presentations of this kind is to nudge us toward a more desirable educational future rather than a less desirable educational future. Our efforts in the next few years are particularly critical for education.

The full, long-range implications of the computer in our world of learning are seldom discussed. Indeed, people are often overwhelmed by the technology, delighted with each new toy which they receive. Yet these implications must be considered if we are to move toward an improvement in our entire educational system.

The strategy of this paper will be to first look at the "why," then to look at the "how," and then to return to present action. Many of the issues are discussed in more detail in my recent book, <u>Learning with Computers</u>.[2]

WHY WILL THE COMPUTER BECOME THE DOMINANT EDUCATIONAL DELIVERY SYSTEM?

In making a brief case as to why the change I am suggesting will take place, I first look briefly at educational factors in modern society. Then I will consider aspects directly related to the computer.

Current Status of Education

First, it does not take any great effort to see that our educational system is currently in trouble. We are being told this constantly from all sides. The daily newspapers, the popular magazines, and recent books are full of descriptions of the problems of our current educational systems. One can even measure these to some extent by declining SAT scores, declining steadily until last year, and similar results from the National Assessment tests.

Independent of statistics, however, the most interesting and critical information is the decline in faith in education in the United States. We can see this very heavily reflected among politicians at all levels. At one time for a politician to speak out against education was suicidal. Now we find that it is often politically effective. Indeed, our current president campaigned on the notion that we didn't need a Department of Education, although so far he hasn't abolished it. But he did abolish the entire science education division within the National Science Foundation, simply by cutting its budget effectively to zero. The politicians know that education has little support in American society and that, indeed, it is politically expedient to cut educational funds. Education has few defenders and many detractors.

I do not wish to imply that these problems with education are simply a matter of public relations. Indeed education has very real problems in this country and elsewhere. In the whole history of the American educational system there has seldom been a time when there was greater turmoil and where the status of teaching, in both the public schools and universities, has been lower than it is now.

All indicationr point to the fact that this decline in popular support of our educational system will continue. Few positive factors other than interest in the computer can be pointed to.

Coupled with this declining appreciation of education, perhaps even a consequence, is a factor which affects education even more directly, the factor of increasing financial constraints. The schools do not raise enough money to run an adequate educational system in this country today. Any adequate science or mathematics teacher can make far more money outside of the schools and universities than that individual can make within the schools. A few teachers will be dedicated enough to stay with the schools or to go to schools in spite of this. But many competent people will not, and many people who are not competent to do anything else will teach. These are harsh statements, ones that are not pleasant to hear, but I think they must be made.

Financial constraints also show up in other important ways in education beside teacher salaries. We have had no new major curriculum development at any level in the United States for over ten years. I am referring to sizable curriculum development projects, the type which could lead to improvement in our educational system. Indeed, since the development of the MACOS course in the early 1970's, federal funding in curriculum development stopped almost entirely. Ironically, we were just becoming skillful in such development when the funds vanished. What we learned is now being used in large-scale curriculum development in other countries.

Another dismal factor in American education is the current classroom environment. Even young children frequently show little interest in education, reflecting widespread parental attitudes. High school classes often seem more like battle fields than educational institutions. This is in stark contrast to what one finds in many other countries at the present time.

Hence, American education, and to a lesser extent education everywhere, is in trouble at the moment. It needs new approaches and new ways of doing things. Much of the pressure on education is from the outside, and this is the type of pressure which can lead to real change.

> "The teaching profession is caught in a vicious cycle, spiraling downward. Rewards are few, morale is low, the best teachers are bailing out and the supply of good recruits is drying up."[3]

Computers

When we move from this dismal picture of what is happening in education today to look at the computer situation, the picture is entirely different. The computer, the dominant technology of our age and still rapidly developing, shows great promise as a learning mode. It has been said that the computer is a gift of fire.

First, a few hardware comments. Personal computers will be dominant in education. But it is a mistake to believe that computers currently around are the ones I am talking about. We are only at the beginning stage of computer development, particularly with regard to the personal computer. Today's Apples and even today's IBM Personal Computers, a good bit more sophisticated than the Apple, are hardly a shadow of the types of machines that will dominate learning. Central processing units are becoming cheaper and more sophisticated, and memory of all types is rapidly dropping in price.

The integrated circuit technology is only at its beginning, and we can expect a long steady decline in prices, increase in capabilities, and decrease in size. Going along with this will be increased educational capabilities, such as sound (both in and out), much better graphics, alternate media, such as those provided by the videodisc, and a host of other rapid developments. In planning for computers in education we must give full attention to this dynamic situation rather than focusing on today's hardware.

Technology is not learning. We can be too carried away with the technology and become interested in it to the exclusion of learning! So we should not give primary attention in education to the new hardware developments. The real interest in the computer in learning lies not in its decreasing price and increasing capabilities, obvious to all, but rather to its effectiveness as a learning device.

How does one demonstrate this effectiveness? In education the traditional mode of experiment has seldom proved to be satisfactory. Neither the financial resources nor the number of subjects are adequate in most existing educational research. The difficulties have to do with the many variables which cannot be controlled, so different from the experimental situations that were typical of the physical sciences. Few large-scale experiments have proceeded with the computer, and these were often flawed. Further, our skills in developing materials have advanced, and many of the studies are based on minimal early material. We can find lists of research projects that supposedly do or don't demonstrate that the computer is good in learning, but I am singularly unimpressed with most of these studies when I examine them closely.

So the use of adequate comparison studies in demonstrating that computers are useful in education is seldom practical. All is not lost, however, in demonstrating effectiveness for users. One important way to do this, very convincing in many situations, is to look at some examples of what is possible and to point out the features of those examples which lead to the computer becoming generally very effective in learning. It is this approach we will follow here. Another approach is through peer evaluation, the examination of materials by pedagogical experts in the area involved.

<u>Educational Technology Center Projects</u>

I will describe in this section three projects in computer based learning from the Educational Technology Center. The first used a timesharing system; the others, more recent, were developed directly on personal comptuers.

The first project is a beginning quarter of a college based physics course for science-engineering majors. The key computer materials are the on-line tests, taken at a computer display. Other computer learning materials are also available. The tests have in them a large amount of learning material. As soon as a student is in difficulty, he or she is given aid which is specifically related to the difficulty. Each test is unique. Passing is at the competency level; students either demonstrate that they know the material or are asked to study further and then take another variant of the test. In 10 weeks we give about 15,000 individual tests to 400 students. The computer keeps the full class records.[4] The National Science Foundation provided support.

The second project is concerned with scientific literacy. It hopes to acquaint students with some fundamental notions about science: What is a scientific theory or model? How is such a theory discovered? How do we use it to make predictions? What determines if it is a good theory or a bad theory? The material, currently six two-hour units, is designed for a general audience, with initial testing done extensively in the public library. The materials have also been tested in junior high schools, high schools, community colleges, and universities. Support was from the Fund for the Improvement of Postsecondary Education.[5]

The third project aims at helping students become formal operational in the Piaget sense. The primary level is junior high school. The format for these units is similar to that for the science literacy materials. The project is supported by the National Science Foundation.[6]

Computer Advantages

Given a brief view of several activities involving the computer in learning, we can now say why the computer is such a powerful learning device. At least two factors are critical in considering the effectiveness of the computer in aiding learning, the interactive nature of computer based learning and the ability to individualize the learning experience to the needs of each student.

One of the major problems in education, particularly education which must deal with very large numbers of students, is the fact that we have lost one of the most valuable components in earlier education, the possibility of having learners who are always playing an active role in the learning process. In classical Greece, with the Socratic approach to learning, two or three students worked closely with Socrates, answering Socrates' questions and therefore behaving as active learners.

The process was highly labor intensive. As we had more and more people to educate it became less and less possible to behave in this way. We cannot afford or produce enough master teachers to base our educational system on the Socratic approach. But we can develop good computer based learning material in which the student is always active. The computer may enable us to get back to a much more humanistic, a much more friendly, educational system by making all of our learners participants rather than the spectators they frequently are in our present book- and lecture-learning environments.

The second advantage offered by the computer is individualization of the process of learning. Everyone says that students are different, that each student is unique, that each student learns in different ways. But most of our standard learning procedures, such as the lecture, are very weak in allowing for these individual differences. They typically treat most students in the same way. For example, if a student in a particular point in a course lecture is lacking some important background information, that student is swept along in our traditional courses with everyone else in the class. The missing information is hard to acquire under those circumstances. The rational procedure would be to allow the student needing special help to stop the major flow of learning at that point and to go back and pick up the background information. But most of our present structures for learning have no adequate provisions for such a possibility. The actual needs vary between what can be learned in a few minutes and what can be learned in a whole course.

With the computer the situation is entirely different. Each student can move at a pace best for that student. Each student will be responding frequently to questions. (We have found in our recent programs that a student responds about every fifteen seconds). So the computer, with curriculum material prepared by excellent teachers, can determine what the student understands or does not understand at a given point. Remedial aid can be given where appropriate, simply as part of the flow of the material with no break from the student point of view. Indeed, the student, using well-prepared computer based learning material, does not have the impression that any "special" treatment is taking place, so no psychological stigma is attached to such aid. With the individualization possible with computers, one can hope to achieve the goal of mastery learning, where everyone learns all material essentially perfectly.

So much for "why" computers are going to become the dominant educational delivery system. The two factors mentioned, the unpleasant situation in education today and the usefulness of the computer as a way of learning particularly in dealing with large numbers of students, suggest to me that the computer will move rapidly forward in education. But we still must look at the other side of the question, the "how" of the development. That is, how do we move from our present situation, where computers are little used in learning, to a situation in which they are the dominant delivery system? This is the subject of the next section.

HOW WILL WE MOVE TO MUCH GREATER COMPUTER USE?

Let me first recapitulate earlier information. The period ahead in education, for at least ten years and probably longer, is likely to be one of tremendous turmoil and strife. We are just beginning to see the outlines of that strife at the present time. The strife will be increased greatly in education as we begin to move toward such ideas as voucher systems and more detailed accountability. The traditional methods of preserving the status quo in education, or allowing only small incremental changes to take place, such as the power of the administrators and the unions, will have relatively little effect; much of the turmoil in schools will be imposed from the general community. Often changes will be generated by financial decisions which lead to less money to the schools. The challenge will be the most serious one that has been seen in a very long time in the educational system.

The following comment by Peter Drucker gives a view of the situation from outside academia:

> "In the next ten or fifteen years we will almost certainly see strong pressures to make schools responsible for thinking through what kind of learning methods are appropriate for each child. We will almost certainly see tremendous pressure, from parents and students alike, for result-focused education and for accountability in meeting objectives set for individual students. The continuing professional education of highly educated mid-career adults will become a third tier in addition to undergraduate and professional or graduate work. Above all, attention will shift back to schools and education as the central capital investment and infrastructure of a 'knowledge society'."[7]

Thus, we will have a society more and more unhappy with the current educational system, a society groping for new ways to handle education. Few "solutions" to the problem will be apparent.

Home Computers

During the same period of time computers, particularly personal computers, will be decreasing in cost, increasing in capabilities, or (more likely) some mixture of these two trends. The changes will often be drastic. While the term one hears in the computer industry, zero cost hardware, is intentionally something of an exaggeration, it does reflect what is happening in many areas of computer technology.

One aspect of the rapid development of personal computers that will be extremely important for the future of education will be the increasing presence of the computer in homes. Homes will represent the largest possible market for personal computers, since in no other situation can one speak of millions of units. There are approximately eighty million American homes; so the number of computers which can be sold for home use, provided the ordinary person can be convinced that the computer is valuable to own, is enormous. The home will be the driving force for education too, since the commercial pressures for home sales will be very great.

In a sense, education is never "first" with computers. For many years we piggybacked on essentially a business or scientific technology in computers with education only a poor follower. The new situation will be similar, but with the home market the dominant one.

To sell computers for the home, it will be necessary that they do something. The average home owner is not going to buy a computer on the grounds that they are currently being sold to homes, primarily for hobbyists. The home user of equipment buys an appliance, a device such as a refrigerator or stove that accomplishes some task or tasks. They don't buy a gadget that they can put together in various ways to accomplish different types of tasks! The size of the home market will depend on the skill of vendors in convincing people that the computer in the home will be useful to the average person. Some estimates have suggested sixty million computers in homes in ten years.

I do not wish to imply that a single appliance-like use of the computer will drive the home market. On the contrary, a variety of such uses are likely to be important. Home word processing, for example, will be an extremely important use. Home financial systems, complete enough to keep all the financial records and write the income tax when asked to, and to aid in home financial decisions, will also be of importance. Personal record keeping systems, including class notes, lists, and similar uses, are also likely to be of major use in the home. Finally, educational material will be one of the types of material that without question will drive the home market. The size of this market will depend on the quality and quantity of such appliance-like programs.

Thus, we will find learning material based on the computer being developed for home computers, in some cases almost independently of whether it will also be usable in elementary and secondary schools, university, or other learning environments. Schools will use the material developed primarily for education in the home even though it may not be ideally suited. It may be that this material will often have more careful thought put into it than some of the earlier products developed particularly for the school environment, simply because the potential market is so much larger and users more discriminating. Schools are already desperately searching for computer based learning material and are finding that little good material is available.

The people who are using the new learning materials in the home will be coming to our schools and universities. They will already have become accustomed to interactive learning, and more and more they will demand it in educational institutions. If the educational institutions wish to survive, they will provide it.

I am taking what may seem to many of you, given the nature of the audience, to be a very market-oriented point of view. But we must be realistic in trying to plot the future. We must understand that the most fundamental issues that will determine the future are these marketing issues, not the academic issues which may be at the forefront of our own minds.

Companies

When we look at the school market, we see interesting commercial pressures. The dominant sellers of educational materials to schools today are the commercial textbook publishers. Yet commercial textbook publishing is a static domain at almost all levels of publishing. That is, it is difficult for a company to make much progress there, in the sense of increasing profits. Education itself is getting declining amounts of money. There will be declining numbers of students for many years. The competition between companies is fierce. To end up with a much larger share of that market at the present time, considered purely as a textbook market, is extremely difficult.

So it is not surprising that many of the most influential textbook publishers are now beginning to devote sizable amounts of effort, attention, and money to computer based learning. They see this as a new market, where it is not at all clear at present who will become dominant. Thus, a minor textbook publisher could see the possibility of becoming a major computer based learning publisher, or a major publisher could see that computer based materials would very much increase revenues. Or a new company could see this as a particular opportunity for advancement, allowing them to leap over the established companies. All these situations are happening now.

The list of textbook publishers putting sizable resources into computer based learning is a distinguished one. It includes such names as John Wiley, Harper & Row, Scott Foresman, Science Research Associates, McGraw-Hill, Random House, Encyclopedia Brittanica, and many others. The type of involvement is different in different companies--this is, after all, a new market, one that is poorly understood by everyone. The degree of involvement also differs from company to company and is likely to differ in time.

In addition to these established companies, new companies, often particularly devoted to either educational software or to personal computer software more generally, are coming into existence. Sizable amounts of venture capital are available for such companies. These companies, old and new, will be selling their wares, and so more and more school districts and universities will be able to easily acquire computer based learning materials.

Both old and new companies will have people actively soliciting school business. The older textbook companies may want to tie in the computer material with their existing textbooks, but the newer companies will have no need for this, and so may be open to more adventuresome activities. Some of the companies will be selling to a combination of the home and school market. In general the materials developed for the home market will be available in the school market too.

Schools

Given the turmoil and financial restraints in the schools, the commercial pressures, the pressures created by the home market, and the increasing effectiveness of the computer as a learning device, more and more schools will turn to computers for delivery of learning material. Indeed, we can already spot this happening, although in a minor way.

One interesting sign is the fact that many schools, particularly small schools, no longer have adequately prepared teachers to teach many of the important courses in the curriculum. Thus if we look at high school courses such as trigonometry, advanced mathematics, and science courses, rural schools in the United States presently are often not providing these capabilities, at least not in a way that is competitive with the better large urban schools. Computers will be a mechanism for equalizing opportunity for students by providing computer based learning courses in these declining areas, courses that otherwise would not be available. Hopefully, these courses will be developed by the best individuals from all over the country.

We may see a decreased role of the formal school and the formal university in our educational system. Much education will be able to take place in the home in a flexible fashion. At the university level we already see one outstanding example of a development of this kind, The Open University in the United Kingdom, but still with relatively little use of computers. The Open University has demonstrated that good curriculum material in home environments can be effective as a learning mode and economical as compared with the standard cost of education. Voucher systems, if they are enacted, will make home learning much more likely.

I do not wish to imply that all education will move to the home. Indeed, a view of the educational system such as that shown in George Leonard's book, Education and Ecstasy, suggests that the sociological components, the factors associated with living with other people and living with oneself, will still probably best take place in small group environments within schools. But many of the knowledge-based components of learning may move to the home.

Types of Usage

We have discussed very little about the way computers will be used within the school system. Something needs to be said about this, if only to counteract some of the current propaganda.

I wish to go on record as stating that the computer will be used in a very wide variety of ways within our educational system. The notion that some "right" way exists to use the computer, and that other modes of computer usage are somehow wrong, is one that has been promulgated, I am afraid, by a number of individuals and groups in recent years. Indeed, often staged debates at meetings comparing types of usage have been held, with the implication that there are right and wrong ways to use the computer in education. Books have been organized in such a way that it sounds as though there were a competition for different types of computer usage.

These debates, often on philosophical grounds, have made a tacit assumption that a right way to use the computer exists, if only that way could be discovered. Mostly the authors have had a naive belief in their "right" way, and then set out to try to establish a case for their beliefs. The principal problem with this type of reasoning is that it often does not proceed from instructional bases, nor does it proceed from empirical bases, experimental studies. That is, the issues that dominate are often technological issues, the nature of the computer hardware and what can be done with the computer hardware. These writers are trying to carve some unique niche for the computer among other learning media.

These technologically-based and media-based arguments for a single type of computer usage are, I believe, entirely misleading. The decisions as to how to use computers--the modes of computer usage, ~~the areas~~--should be made entirely on pedagogical grounds, the questions of what aids learners rather than on these philosophical, media, or technological grounds. Whenever decisions are made on pedagogical grounds, it will be found that a wide variety of computer uses will be employed, uses which are often adapted to the individual situation being considered. There is no single "right" way to use computers, but rather a great variety of ways.

I will give a brief classification of the various ways the computer can be used. This list is not exhaustive nor does it show fine detail. But it may be useful to at least consider the range.

Computer Literacy. Computer literacy is ill-defined and so much debated. It is recognized that at all levels of education, starting perhaps as early as eight or nine years old and continuing through the school system, university, and adult education, that individuals in our society need to understand the various ways the computer is going to be used in that society; they need to understand the positive and negative consequences of those ways. Few full-scale computer literacy courses exist. Indeed, what often passes as computer literacy is vague history or learning to program in a simplified way, to be discussed in a moment. So this is still very much an open area for computer uses. Specialized courses are needed for each group addressed; thus, computer literacy for teachers is a pressing national issue.

All these courses need to consider such important future uses as word processing, personal financial and record keeping systems, and eductional material.

Learning to Program. Learning to program is already a rapidly increasing activity in our universities and schools. It represents in grade six through twelve the most common usage of computers at the present time. Unfortunately, where it happens at this level it is often a disaster, harming more than helping the student.

The major problem is the way programming is taught. A whole group of people is being taught a set of techniques which are no longer adequate to the programming art today. These techniques were common in the early days of computing, but they are inadequate according to today's standards. Many of the people learning to program in junior high school and high school cannot overcome the initial bad habits which have often been instilled in them when they come to the universities. Many universities are now reporting this phenomenon.

The main culprit is BASIC. It is not that BASIC has to be taught in a way that is antithetical to everything we know about programming today. But it almost inevitably is taught in such a fashion. BASIC is the junk food of modern programming. Indeed, the analogy is close in that junk food tends to destroy the body's desire for better types of food. But the analogy is weak in one regard: BASIC is the initial language of the vast majority of these people. It is as if you started feeding junk food to babies one day old and didn't give them anything else until they were six! If I could leave you with one message, perhaps ~~the most~~ pressing message, it is to STOP TEACHING BASIC. It is becoming clear that students who learn BASIC as their first computer language will in almost all cases acquire a set of bad programming habits. These habits are very difficult to overcome, so BASIC programmers have difficulty writing readable and maintainable code.

The following recent comment by a distinguished computer scientist, Edsger Dijkstra, is relevant:

> "It is practically impossible to teach good programming to students that have a prior exposure to BASIC: as potential programmers they are mentally mutilated beyond hope of regeneration."[8]

What programming languages should we teach? There are a number of possibilities for junior high and high schools. Logo is certainly one interesting possibility, although I must confess that some features of Logo are different from those recommended in the best modern programming practices. Logo, however, is introduced in a problem solving environment, and that is very much to its advantage. Often its main intent is presented not to teach programming but to teach more general problem solving capabilities or some specific area of mathematics. But its general problem solving effectiveness has yet to be demonstrated in our mass school environments with ordinary teachers.

Another good possibility is Pascal or a Pascal-like language. The material developed at the University of Tennessee and sold by McGraw-Hill under the name of "Computer Power" is an excellent example of an approach of this kind. If one looks for print material that is usable at the high school and perhaps even at the junior high school level at the present moment, the "Computer Power" material looks to me to be easily one of the best possibilities.

Another approach is to develop some interesting capability based on a structured programming language. For example, the recent Karel, The Robot from Wiley follows such an approach. Turtle geometry, in Logo, is the best known example.

Learning Within Subject Areas. Undoubtedly the largest use of the computer in schools at all levels will eventually be not the categories just discussed but rather the use of the computer as an aid in learning mathematics, in learning to read, in learning to write, in learning calculus, and in all the other tasks associated with the learning process.

One person may work alone at a display or several may work together. When one looks at these learning tasks in detail, again one finds a great variety of computer use, ranging from tutorial material, to intuition building, to testing, to aids in management of the class for the student (feedback on what is needed and how to go about getting it), and the teacher. The three projects presented earlier show something of the range of possibilities.

Unfortunately, much of the material now available of this type is very primitive. We are, however, rapidly learning to develop better material to aid learning.

PRODUCTION PROCESS

If we are to move to meet this new future, where the computer will be the dominant educational delivery system, a critical aspect will be the generation of effective learning material. We need new courses and entire new curricula, spanning the entire educational system. Hence, the development we are talking about is a nontrivial process. It is the degree of success of the development process that will tell whether we will improve or hurt education. We must convince the likely distributors that it is important to develop quality materials, not the junk typically available today.

The development of curriculum material in any field and with any medium and at any level is a difficult process. It cannot be done by amateurs who are doing it simply as a spare time activity. Many new observers in this field, looking at the problems quickly, tend to underrate these problems of developing effective learning material. Hence, some of the solutions which have been proposed are solutions which are simply not adequate to the problems. Some of these solutions assume only small incremental changes in the curriculum structure and do not understand the magnitude of the development necesary.

We cannot discuss fully in this paper all the aspects of the production process. The Educational Technology Center has extensive literature available concerning these issues for those interested.

Several critical points concerning products should be made to give the reader a reasonable overall viewpoint. The production system is a complex system, one that should involve many types of people with many different skills. If one looks at the production of <u>any</u> educational material, one sees that that is the case. We can learn much by examining effective curriculum production systems, such as that currently in use in The Open University, that used in producing the major curriculum efforts in the United States more than ten years ago, and that involved in such areas as the development of textbooks.

What we need to resist is the notion that one person, perhaps a teacher in his or her spare time, will do it all. I do not believe that any sizable amount of good curriculum material will be produced by this method. Furthermore, I do not believe that the devices which are being urged for these teachers, such as simple-minded authoring systems based on toy languages (Pilot) will be effective. Nor do I think that languages such as Tutor will be effective, because they do not meet the reasonable criteria associated with modern programming languages. Most of these languages are old in their design, and few of them understand the nature of structured programming. A serious professional approach is needed if we are to maintain the quality of the computer based learning materials produced.

We can see a number of stages needed in such a professional approach, listed below.

a) Preplanning
b) Establishing goals, objectives, and rough outlines
c) Specifying the materials pedagogically
d) Reviewing and revising this specification
e) Designing the spatial and temporal appearance of the material
f) Designing the code
g) Coding
h) Testing in-house
i) Revising
j) Field testing
k) Revising

The last two stages may be repeated twice.

In the entire process the educational issues, as opposed to the technical issues, should be dominant. The best teachers and instructional designers should be involved in stages c and d to assure the quality of the product.

PRESENT STEPS

This paper has presented an overview of some of the problems associated with reforming an entire educational system during the next twenty years. Many details are either not mentioned or treated very hastily. But I hope I have given enough details to convince you of the main directions that need to be taken.

As teachers, most of you are undoubtedly interested in what you should do now to work toward a more effective future for education. First, you must decide whether you would like to be involved in the type of curriculum development I suggested will be necessary. If you do want to be involved, you must take a long-range view of how to prepare for this activity.

I would not advise you to buy an Apple and start to use it! Nor, as you might suspect, would I advise you to take courses in BASIC. But it would be desirable to take a variety of courses, if they are accessible to you or to study on your own, in certain areas.

Here are some suggestions. The first three refer to areas of learning, either through formal courses or through informal methods.

1. Learning theory. Good curriculum development cannot be developed without some appreciation of how people learn, even though there is no single coherent theory there. Courses in learning theory may help, based on the research literature concerning learning.

2. Curriculum development. The question of how to develop good curriculum material is one that deserves serious study. Some universities provide such courses. Some textbooks exist. Many of the issues are independent of computers, referring to developing with any learning media.

3. Modern programming languages. You might want to become acquainted with modern programming languages, such as Pascal and Ada. Again, you must be careful here. It is possible to meet these languages either in an old fashioned environment or in one that stresses structured programming. You want the second possibility. Look at the textbook. If it doesn't introduce procedures until a third of the way or even further along, don't take the course. This isn't the only factor, but it is a good way of distinguishing reasonable from unreasonable courses.

Avoid the "CAI" languages--they are inadequate, not suitable for serious material. Look at the authoring approaches based on modern structured languages.

4. Listen to students. In your own teaching, begin to move away from the lecture mode presentation into a more Socratic mode. A critical factor is listening to what students say and watching what they do. This means that when you ask questions, you have to wait for answers! It also means working more individually with students in groups of two to four. It is only by this procedure that you will begin to build up the insights you need for how students actually behave when they are learning.

People whose primary mode of interaction with students is through the lecture mode or through textbooks are seldom the best choices for preparing computer based learning material. The development of computer based learning material will need vast numbers of experienced teachers, teachers who have been listening to their students and who understand student learning problems.

5. Personal computers. Begin to use a variety of personal computers, with particular emphasis on the new generation of 16 bit machines. Read the journals that tell you about new equipment. Watch for voice input, better graphics, and full multimedia capabilities.

6. Critical attitude. Look at a good bit of computer based learning material, trying to develop a critical attitude toward it. Don't be overwhelmed simply because it is interactive or because the computer is involved. Keep your mind on the learning issues and learn to develop some sensitivity as to what existing material helps learning and what doesn't.

Most existing material is poor. Find out why. Read the journals that specialize in critical reviews.

7. Work with others. The development of good computer based learning material is best done in a group. Work with others in discussing goals, strategy, and the details of design.

8. Future orientation. Concentrate on the long-range situation, not today or tomorrow. Decisions which are "good" from a short-range point of view may be undesirable in the long range to both you and to the future of our entire educational system. So keep the long-range point of view strongly in mind.

9. Visions. Begin to think about what type of future educational system would be both desirable and possible. If you want to influence the future, you must have visions.

> "Developing quality computer-assisted instruction demands forethought; those of you who are unfortunately caught up in expedient movements in education need to take a closer, more courageous look at the nature of the hope on Pandora's chip. You're dealing with as powerful a tool as the gods have ever given us."[9]

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ComputerTown
A Do-It-Yourself Community Computer Project

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As the number of microcomputers increases, so do the number of alternative learning environments. Education, in many forms and on many subjects, is being carried "to the streets" and into the community. Some of the emerging enterprises are the "storefront" learning centers, museums and theme parks, and community-based ComputerTown sites.

Storefront Learning Centers

The idea of a storefront learning center is not new. Before computers were readily available, there were alternative classroom experiments in many areas of the U.S. that focused on the delivery of traditional learning materials. When computers arrived, a handful of eager pioneers explored computer-centered learning situations. In the early 1970's, Liza Loop founded the LO*OP Center, and People's Computer Company established the Community Computer Center in California.

These early ventures pointed the way toward the future but appeared too early in the cycle. Recent advances in low cost, portable technologies has spawned a new generation of alternative education enthusiasts. In the late 1970's, Annie and David Fox created the Marin Computer Center in San Rafael, California. Their successful and innovative project represents the latest precursor to the host of other learning places being generated.

In Rolling Hills, California, Blair Sullivan founded Math City, a place to learn after school. In half-hour sessions, Math City uses computers and software to provide drill and concept formulation opportunities for children of the nearby community.

The Learning Circuit in nearby Los Angeles, California, also helps people make connections with computers. Gary Ward, the operation's director, offers courses and hands-on experience in programming, use of a computer, financial applications, word processing, data base program usage, and microcomputer-based management systems.

Computer Capers operates inside a shopping mall in Mountain View, California. People can "rent" time on a computer by the hour or half hour. Computer Capers provides access to a variety of common microcomputers, offers classes on programming and applications, and lets you "preview" software in your rental sessions.

Jerry Brong in Washington state has started a chain of storefront centers targeted for rural communities. He plans to offer hands-on computer classes, assistance to school districts in the areas of word processing training, and a number of other services. Interestingly enough, his company's name is Community Computer Center, Inc. The wheel turns full circle.

Museums and Theme Parks

One of the earliest museum-based public access computer facilities, and currently one of the largest projects, is the Lawrence Hall of Science in Berkeley, CA. This science museum, perched amid the Berkeley foothills, houses both interactive scien[illegible] exhibits and a multitude of microcomputers and computer terminals. In [illegible]n, the museum has a computer van that travels to local schools.

With the influx of micro-technology, several new and innovative "hands-on" museums and theme parks have appeared. All of these places provide the public with the opportunity to actually use and learn about computers, along with numerous science and technology exhibits.

The Capital Children's Museum (CCM) in Washington, DC is a prime example. Ann Lewin, the dynamic director and founder of CCM, advocates "learning through doing." All of the exhibits, and the large computer room called the Future Center, encourage exploration and play. At the CCM, kids and adults find that they can rarely resist putting their hands into or onto some part of the participatory environments.

Sesame Place, a joint venture of the Children's Television Workshop and the Busch Entertainment Company, sits in a bucolic community in Lower Bucks County, PA. As you would expect from the people that brought you and your children Sesame Street, they combined their skills and the talents of Joyce Hakansson, a former staff person at the Lawrence Hall of Science, to produce a unique Computer Gallery. They built special keyboards, and encapsulated over 50 Apple computers in brightly decorated boxes.

The magic of these places have inspired others to try their hands at mixing people, computers, and exhibits. Some notable projects are: the Pacific Science Center in Seattle, WA; Boston Children's Museum, Boston, MA; Franklin Institute, Philidelphia, PA; and the traveling Chevron Creativity Exhibit. New ventures appear monthly. Look for microcomputers to appear in zoos, aquaria, and your local theme parks. This summer, the San Francisco Exploratorium, a renowned museum of science and human perception, is offering computer graphics courses for kids 6-years-old and up.

ComputerTowns

Bob Albrecht and I began the community experiment, called ComputerTown, USA!, in the Spring of 1979. Late in 1980, the National Science Foundation awarded a grant to the project through People's Computer Company to develop a detailed and transportable model of the project. We were to use the grant money to encourage others to begin ComputerTowns in their own communities and to develop an implementation package to assist with that process.

From the beginning, ComputerTown consisted of three elements: an idea, things we did within our local community, and a set of locations or sites where ComputerTown events and activities took place. All three of these elements are addressed in the introductory sections of the project's implementation package. Here are a few excerpts from that material answering the most frequently asked questions about ComputerTown. The implementation package will be available for public dissemination late in 1982. The title of the package is ComputerTown: A Do-It-Yourself Community Computer Project. authored by L. Loop, J. Anton, and R. Zamora.

What is a ComputerTown?

A ComputerTown is any public access computer literacy project. It is a group of individuals, adults and children, helping each other become informed citizens of toady's information society.

A ComputerTown's goal is to offer an informal educational opportunity for everyone in the community to become "computer literate."

Who Benefits From a ComputerTown?

Anyone who would not otherwise have access to a computer or computer know-how benefits from a ComputerTown.

Children meeting microcomputers for the first time encounter a new tool for solving problems and expressing creativity. When a disadvantaged child discovers that he can program a computer, he is suddenly open to a whole new spectrum of educational and vocational possibilities. Teenagers, many of whom are already computer literate, learn social and teaching skills. A ComputerTown provides a significant learning experience which broadens and supplements what a child learns in school. This knowledge is often passed on from child to parent.

Initial adult users with little experience often exhibit anxiety and discomfort when they first encounter the technology. An introductory set of workshops, courses, and hands-on experiences address these peoples' questions and concerns. The words "Computer Comfort" categorize this stage of the user's investigations. The user looks for some way to relate to the technology, some way to get comfortable with it, and ComputerTown shows them how.

Once a sense of comfort is established, the user and his interactions with ComputerTown progress through a stage labeled "Computer Awareness." The focus at this and the previous level is not on "proficiency" (that is, on "reading and writing" in the traditional sense) but on "familiarity" with the technology. Knowledge at the experiential level, gained by hands-on activities, takes precedence over "hard" learning objectives, such as being able to program.

Once users are comfortable with the technology and aware of the computer's capabilities, they are offered preliminary courses and workshops in "Computer Tool Use." Some of these activities might include learning to program the computer, experimenting with various computer languages, or adapting software packages for use within the home or small business.

What Does a ComputerTown Do?

Each local ComputerTown determines its own activities. In its first two years, the ComputerTown in Menlo Park, CA has run many classes, workshops, playdays, special interest study groups, and lectures. Computers have traveled to the pizza parlor, the senior center, economically disadvantaged sectors of the community, and special education schools. ComputerTown, Menlo Park has also provided continuous public access to microcomputers at the public library, and its "computer validation" experiment certifies adults and kids in the rudiments of microcomputer operations. Still more projects are in the idea stages at Menlo Park: rent-a-computer (to use at home), rent-a-computerkid (to teach you how), tours of computing facilities, neighborhood computer clubs, show and tell meetings, video games contests, programmable vehicle rodeos, and a mentor program to find computer professionals who will work with those whose grasp of computers becomes advanced.

There are no specific requirements for ComputerTown activities. They grow and develop according to community need and interest.

Where is a Typical ComputerTown Located?

A ComputerTown can be most anywhere. It is an informal learning environment, with all the variation that entails.

In one community, ComputerTown may be a common interest shared by independent people and groups who decide to make computers available for public use. Another ComputerTown could be a formal organization which has officers, a well-defined program of activities, a place of business and equipment. Some ComputerTowns are located at libraries, recreation centers, or other public facilities. Others may promote computer literacy with the support of private groups, computer stores, computer hobbyist clubs, or schools and colleges.

Someone sets up a computer where people can learn through hands-on experience, and suddenly you have a ComputerTown.

Are There Any ComputerTowns Yet?

Quite a few exist already, and the list continues to grow. ComputerTown, Menlo Park, located in the public library, has been promoting computer literacy since 1979. There are now over 50 ComputerTown sites throughout the U.S., and over 30 sites in the United Kingdom. By the end of 1982, the project expects to have at least 100 designated affiliate sites within the U.S. alone.

Why Do We Need ComputerTowns?

Dave Tebbutt, who helped develop the British ComputerTown network, called ComputerTown, UK, puts it this way:

"We need a wide acceptance and familiarity with computers among the population at large. ComputerTown provides a completely non-threatening and fun way of bringing this about. In the future, our children will be thinking in ways that we can't even envision at the moment. The computer is providing them with an intellectual tool that they can drive and control to achieve mental feats which we would probably consider absurd -- if we knew what they were likely to be! Our approach to ComputerTown is intended to create an environment in which this can happen."

Summary

What is next with ComputerTown? The local Menlo Park sites include the public library, a senior citizen's center, a neighborhood youth club, and a children's museum. The project's local Teacher Corps is conducting over 20 classes and workshops during the summer season. The ComputerTown consulting staff is pursuing a number of projects within the public and private sectors. Several large community events are being scheduled for the fall and winter, including a Learning Conference and a couple of "ComputerTown Meetings." Each "meeting" will be open to about 1,000 community residents, providing them a forum to ask questions and learn about microcomputers.

The ComputerTown News Bulletin continues to be published every two months and, based on our membership drive, could be expanded in both size and frequency. A ComputerTown book series has been negotiated with a major publisher with beginner's microcomputer books forming the body of the published materials. The project's implementation package will be one of the first books to be completed.

The project will be featured on an upcoming PBS video documentary called "Don't Bother Me, I'm Learning: Part 2." Several staff members are involved in a TV pilot program for cable broadcast.

In addition, the project staff will be monitoring the progress of several test sites in the Western U.S., and evaluating potential sites on the East coast. Under the NSF grant, a set of "official" sites are being followed as they begin to use the implementation package to create their own versions of the ComputerTown project. The key site in the West, is the Community Resource Center at Wenatchee Valley College, Wenatchee, WA.

All of the activities listed above are based in Menlo Park. Across the country and around the world, the dozens of ComputerTown affiliates are initiating their own projects, consistent with the needs of the communities and their locally available resources. Each ComputerTown site is unique; each creates its own expression of providing its community with access to technology. Each site develops and grows because a small number of community-based, dedicated people decide they want a ComputerTown in their area.

ComputerTown has evolved from an idea being tried in a small California community to an international, grassroots, volunteer project of impressive scope. ComputerTown, the storefront learning centers, and the museum and theme park experiments represent new models for providing the public with information about and access to technology. They are part of the future, happening right now, in your neighborhoods.

* *

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COMPUTER-ASSISTED LEARNING: A LEARNER-DRIVEN MODEL

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In this past year, educators in every school district in the country either accidentally or purposely had to think about computer use. At one time or another, they probably ended up in at least one or more of the following situations:

* Hearing their students talk about the "best" microcomputer or the most challenging video game.
* Reading cover stories about computer use in Time, Newsweek or their own professional journal.
* Seeing hardware and software advertisements in their local newspaper or a textbook publisher's catalog.
* Attending inservice sessions about computer use or conferences with microcomputer themes.
* Going to computer stores to see what was available or to other schools to observe teachers who were using computers.
* Convincing their department heads, principals or PTA's to buy one or more microcomputers for their school.
* Reading The Computing Teacher, Electronic Learning, or Classroom Computer News for software reviews and teaching hints.
* Reviewing, purchasing and cataloging software, then showing it to other teachers.
* Trying new teaching techniques with computers, developing new computer literacy courses or writing computer curriculum guides.
* Buying their own microcomputers, learning how to program and then writing or revising software for their classes.

Many of these educators, though exhausted at the end of this past school year, are still excited about the changes they are slowly causing in their schools. The students have had a chance to interact with computers, even if for a short period of time, and to try some of the different modes of computer-assisted learning.

These modes of computer-assisted learning can be portrayed in several different computing environments. Picture a computer resource room with 15 microcomputers or computer terminals. There is one student at each work station, concentrating on drill and practice questions that appear on the computer screen. Picture the classroom next door which has two microcomputers for the 30 students. In this room most of the students are working at their desks but several groups of students are huddled around the two microcomputers, running or de-bugging some programs they have written. A half hour later, some of the groups switch places so that more of the students get a turn at the computer.

There is nothing "better" about either of these two computing environments. Each has different but worthwhile goals for today's schools. Each environment has activities with the potential to assist learners with what they need or want to know.

The difference in the two different environments is in the amount of control that the student has while at the computer. In other words, is the computer activity one that is hardware/software driven or is it learner driven?

What Are Some Learner-Driven Models?

Although computer activities rarely fit one model or the other, we can give a general description of computer-assisted learning models that are learner-driven. Generally they enable the student to use a computer as an object for thinking, problem solving or expressing ideas. The computer is not just a vehicle for delivering instruction but instead a tool for exploration. Students use the computer for assistance in building something, which can be a program they want to write, a world they want to simulate or a term paper they want to word process. What follows are some examples of computing activities that illustrate the concept of learner-driven.

Programming

Programming a computer is probably the most learner-driven of all computing activities. As the learner writes step-by-step instructions for the computer to follow he or she is in complete control of the machine.

A student can ask the computer to print a name on the screen 10 times, to generate random numbers, to play music or to make a line drawing. When the computer actually does what the student wanted it to do, it's an exciting and rewarding experience. The process is somewhat like building a model rocket and seeing it launch successfully.

Programming has been offered for many years as an elective course in the high school or as part of a mathematics course that incorporates computing. However, as hardware accessibility grows, there is a trend to provide more programming experiences to students at both elementary and secondary levels. The goal of these programming experiences in schools in not so much to train students to become programmers, but instead to teach them to communicate with a computer. Programming teachers can assume that their students will use programming tools to solve problems later on, just as mathematics teachers now assume that most of their students will not become mathematicians but instead use their mathematical skills as tools to solve problems.

The process of programming gives the student a new way to think and express ideas. It can also be hard work that requires sustained effort and an ability to withstand a great deal of frustration. But somehow that effort seems worth it to the students. Their programs become intellectual products that they can share with their classmates and friends. Students gifted in sports or music have visible, respected products in basketball shots or instrumental solo performances. The logical thinking student now has a product that his or her peers value. Whether students create an arcade-like game or a practice exercise in French, the students are creating interesting and profitable products.

Students who program experience a situation that focuses much more on the process than on the actual result. They spend more time de-bugging and enhancing the program than they ever did writing the original code. But a program that doesn't run the way they want it to is not a case of being wrong - they instead view fixing the program as a puzzle to solve.

Although BASIC is still the most common computer language in the schools, newer languages, such as Logo and Pascal are becoming available to students. The recent interest in Logo, especially at the elementary grade level, gives us some indication of the kind of computing environments that will become more common in the future. Logo was developed over a ten year period under the direction of Seymour Papert in the Artificial Intelligence Laboratory at MIT. This language allows the learner to teach the computer to do new things by creating procedures for each of the parts of the task. Students use common expressions like "forward", "back" and "right turn" to direct a robot turtle around on the screen to create exciting graphic designs. To get the turtle to carry out certain tasks, some children may "play turtle" and step through the process to figure out the needed commands. Using "turtle geometry" on a computer gives an immediate and concrete output on the screen and thus concretizes the process of programming.

Teaching the computer to do a task forces the student to describe the task in a clear, concise way. However, these task descriptions can be given in very individualistic and personal ways by the student. The computing activity that allows a student to structure information in a systematic way and to creatively combine the different pieces of information is indeed a learner-driven activity.

Word Processing

The computer can be as much a writing tool as it can be a calculating tool. In fact, more and more students are discovering the tools in word processing and using them to write their stories, book reports or term papers.

With the help of a text editing program, students can enter in words, sentences and paragraphs, revise them, store them and retrieve them as needed. They must decide what words to put on the screen and how much to say. The computer doesn't do the writing for them. It simply saves them from retyping some of the words, sentences or pages during the revision stages.

Researchers such as Daiute have found that after students have become familiar with the keyboard, they find writing on the computer easier that writing by hand and that they do more of it. They also make more changes in their text and learn to make more meaningful types of revisions.

As the quantity and quality of the word processing software grows, it will become easier and easier do enter text into a computer and to revise it. The writing task, which may be painful and lonely, may be thought of differently when the task can be done much more efficiently. The computer as a flexible note pad during the composition stage enables the student's research notes, free-writing and outlines to be expanded into drafts, then revised for the final text.

There are also programs that serve as tools for revision. Automatic text analysis software searches for specific words or patterns in the student's draft. For example, it may count and average the number of words per sentence for the student who later uses the information to decide whether or not the sentences are too long. Error identification programs mark spelling and sometimes punctuation errors in a draft. For example, the computer compares each of the words in the draft to a list of words stored as a dictionary in the computer. The computer doesn't tell the student that the word "organisation" is spelled wrong. It simply highlights it and relies on the student to accept it as spelled or to change it to its correct spelling.

So although the learner will have more and more tools available in the future and may be able to create a written product more efficiently the decision about what to say, and how to say it, still rests with the learner.

Using Message Systems

Our postal and telephone systems are usually convenient models for communicating with other people. New microcomputer owners do not just use their machines to write programs, word process, do practice exercises or play video games. They quickly discover how to get their hardware to communicate with other microcomputers or to a much larger, central computer system. And so the computer, with the help of phone lines, a modem and software, becomes another communication tool for students.

The communication links available to students presently take on one of these two forms:

1) a direct link from computer to computer as in a TALK or

CHAT mode. Whatever the first student types into the computer not only shows on his or her screen or paper, but it is also displayed on the second student's computer at the same time. The first student may ask a question and the second student may respond. This electronic conversation is somewhat like the telephone system but instead of voice transmission, it is text that is sent back and forth over the wires.

2) a mail system that allows a student to send mail to another student via a central computer or phone lines. The letter is typed by one student and sent electronically to the other. When this student next works at the computer, he or she is told that there is a message waiting to be read.

Imagine a class in one state having computer pen pals in another state. Electronic message systems can help those students explore other geographic regions. Besides sharing information about each other, they can share computer programs that they have written. This cooperative sharing of information is indeed closer to what many people consider an important process in education.

Producing Artistic Work

The sound and graphics capabilities of the microcomputer make it a useful tool for artistic production. Peripherals, such as electronic keyboards and speakers, along with the appropriate software, enable a student to create new musical sounds or recreate the traditional sounds of the organ, piano or any other instrument.

The pitch, tone and volume of a musical note can be numerically represented by data that can be stored in a computer. Through a program they have written or with special software, students can access and change these numbers. When they ask the computer to play the revised sequence, they can hear their newly created sounds.

Peripherals such as graphics tablets allow students to draw a picture on the flat drawing board with a pen. This picture also shows up on the display screen of the microcomputer. After the picture has been drawn or traced onto the board, the components of the picture, such as the lines, shading or color, can then be revised, saved or later transferred to paper.

Students can also create animation effects by moving graphics characters around on the screen. Using the keyboard as input, the students can create line drawings or specially formed characters by writing a program or using software designed to do that. Once these images are created, they can be controlled by the appropriate commands from the learner.

The computer makes no judgements about the quality of the artistic work that the student produces. It simply enables the student to create the new sounds or shapes and serves as the medium for that exploration and product.

Manipulating Data Bases

Students can use the computer as a tool to create their own "data bases" or to access the larger data bases created by others. In the first instance, children can gradually store their new words in a computer file for later use. These words can become a thesaurus or dictionary for the learner, depending on how he or she decides to organize and use it. A class could also develop a file of definitions, examples, descriptions, or stories. This collective data base can be used by any of the students as material for a report or other writing project.

There are more sophisticated computer systems where larger amounts of data, such as the contents of journals or newspapers, are stored. Students who want to do research on a specific topic can use their computer to link into one of these computer systems and run a search of these data bases. They may have to give several descriptors for the topic, request certain sources and specific time frames for the search before they get a listing of all the relevant articles.

Again the learner-driven model is exemplified because the student is deciding on the topic to explore, the places to search for information, and how much of the retrieved information to actually incorporate into a report. In this case the computer helps the learner see that writing is a process of discovery, of researching, and combining information into a meaningful whole product.

Using Simulations

Computer simulations allow the learner to experience environments that are otherwise too expensive, complex, remote or dangerous to experience in reality. Simulations give students a chance to explore or create situations where they can discover the relationship among the different variables and the extent to which these variables affect the final result.

There is a popular simulation called "Oregon Trail", also called "Trail West" and a number of other titles. The student who uses this simulation tries, with the assistance of a wagon and horses, to make a trip west across the United States as in the pioneer days. The student makes decisions about the amount of money to be spent on various items, and basically tries to stay alive during the course of the travel. In experimenting with different amounts of money, the student soon sees relationships between the amount of money spent on food and the possibility of starving or between the ability to hunt and the amount of money needed for food.

Students become actively involved in the process because their decisions are producing immediate and viable results. If they are told in the end of the "Oregon Trail" that they have starved to death before arriving in Oregon because there wasn't enough food, most students will want to try again and see if they can't make their destination alive.

When students actually control the process, whether it be a trip to Oregon, a chemistry experiment or pollution of a lake, they may understand the process better. The ability to speed up the process may allow for more examples and assist the learner in forming generalizations. Slowing down a process may enable the learner to understand a specific instance of the process. Some things in real life happen too quickly for the student to be able to see the process. Simulations provide the students with opportunity to see.

Playing Computer Games

There are many strategy games that enable students to use problem solving techniques or their logical thinking skills. Students may opt to play games like "Mastermind" or "Bagels", either competing against the computer or a classmate.

While computer games may range from those that teach traditional content to those that are for pure entertainment, there are aspects of the popular ones that make them exciting to learners. Malone's study of the intrinsic motivation of computer games helps us delineate what those intriguing characteristics are for students. He found that there needs to be 1) a challenging but personally meaningful goal, 2) a fantasy environment where players use their skills to get involved in a real life (baseball) game or not so real life (space war) process and 3) and a curiosity about an environment where the players can do increasingly complex but possible tasks.

Adventure games can be intriguing for learners. They can imagine that they are exploring an enchanted land or uncovering the secrets of an ancient civilization. In adventure games, the student encounters a number of decision points. At each of these points the computer indicates to the student where he or she is located, the visible items, and the directions in which he or she can move. The student responds with something like a two-word sentence, which is typically an action verb followed by a noun or direction such as North or South. As the student carries on a conversation with the computer, he or she moves around in the environment exploring the setting. In order to do that, the student may draw physical or mental maps of the environment, or enlist the cooperation of classmates who are also playing the same game.

How Are Learner-Driven Models Developed?

The learner-driven models just described are taking place in many schools because several groups of people have assisted in making it happen. First, someone developed the idea for a simulation, adventure game, communication system or a new language. Then others wrote code and documentation to get the language or software into a format suitable for users. After the ideas or the actual software was produced, educators figured out a way to make use of them in their classroom.

Implementers

The educators must be the implementers of the learner-driven models. They have to actually help create the computing environment that they want, both philosophically and physically. They need to select the appropriate hardware, languages and software. Then they need to develop or select the computing activities for the learners, factoring in their own instructional styles, their students' learning needs, the capacities of the computing equipment, as well as funding and time restrictions.

Problems Involved

Educators need assistance in building learner-driven models, as well as developing other computing environments. There has been a lack of available resources for teachers to use. Only a very few schools of education in the country have created well-designed programs that prepare teachers to effectively use computers. Teachers also need print resources and examples of interesting worthwhile problems for students to solve. And so they go to conferences, read computing and education magazines and share ideas with each other.

What Are the Some Effects of Using Learner-Driven Models?

Even if we wanted to, it would be difficult to quantitatively measure the effects of learner-driven models. Although people in education argue more process-oriented activities in schools, we need to accept these activities as opportunities for students and be less concerned with the traditional measures for success.

Teachers and researchers have seen some interesting changes in the schools as a result of the new computing environments. Teachers are assuming new roles in relationship to each other and to their students. Those willing to use computers in their classroom are being called "teacher technologist". Those willing to share information and ideas about computer use become computer resource teachers. For most teachers, it means moving from a comfortable instinctive mode of operating to a new unfamiliar mode of teaching.

Students who use and learn about computers in their classes ask more questions than in the traditional classroom. Teachers who are used to having students respond to their questions are now faced with not only more questions from students but more challenging ones. Student experts are emerging in the educational environments. When they can't get their questions answered by the teacher or the computer, they ask their classmates, then computer store personnel.

Conclusion

The new computing environments are exciting and challenging for developers, publishers, teachers and the studens. But for educators to make insightful use of computers, we need to understand the extent to which learners can have rich and rewarding experiences with them. The computer that permits the learner to problem solve on a very personal level will be the tool for which we will only find more and more uses.

Few students exercise any degree of control over films, books, workbooks, television programs or other instructional aids that they use in school. For some students, reading a book or watching a film may be as active an involvement as using a computer program. Those with the opportunity to write books or produce films may find those processes more exciting than computer programming. But there are very few students who will ever have the opportunity to use the equipment necessary to create books and films. These same students will however, have the opportunity to use a computer as a tool to build something, whether it is a program they want to write, a world they want to simulate, or a term paper that they want to word process.

The educational computing environments will be even more exciting and rewarding if our students can take real advantage of the full range of computing experiences. When these experiences are very active ones, where students are in control of the computers, we will make the best use of both the potential of the machines and the potential of the learners. Educators are the ones who must make computing environments with these learner-driven activities happen as as soon as possible.

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VALUE CONFLICTS IN NEW COMPUTING DEVELOPMENTS: WITH SPECIAL ATTENTION TO COMPUTERS AND SCHOOLING

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Introduction

Computer-based technologies are powerful and their use is increasingly widespread. Long distance telephone calls are routed with computerized switches. Airline reservations are recorded on centralized data systems which allow flexible changes of flight plans mid-trip. The bills and checks we receive from businesses and government agencies are frequently generated by computers, as are dunning notices, personalized form letters, and mass mailings. These are only a few of many possible examples; the use of computers has become pervasive and as much a common part of our lives as automobiles, telephones, typewriters, televisions, radios, airplanes, and plastics.

It is generally recognized that as people have adopted technological innovations such as automobiles or electricity, they have significantly changed the ways they spend their time, the people with whom they frequently interact, and other important aspects of their social worlds. Unfortunately, developers and promoters of new computing modalities have tended to characterize computing applications as intellectual tools rather than instruments of purposive social action (for example, Pappert, 1979, 1980). They have also tended to focus on relatively easily specified technical attributes and anticipated costs and benefits rather than organizational settings. As a result, social impacts of new computer-based technologies are frequently overlooked and often poorly understood.

Developing an understanding of the impacts that computers have on our lives, and what choices we have in using them, is important to all of us--but particularly important to educators. Each of us interacts with computers on a routine basis in our personal lives. Professionally, educators are also finding computers playing increasingly important roles in the administration of their classes, in their own continuing education efforts, and in their curricula. To the extent they are able to identify the impacts of various computer applications, they can better understand how to turn computer use to serve their interests and their students. Perhaps more important, to the extent they are able to communicate an understanding of the broader implications of computing to students, they will be helping to develop a public who will themselves make better informed choices about their engagements with computing.

Computing is, of course, not a simple, well contained technology--it is a technically and socially complex medium which has been adapted to such a wide array of uses that sharp generalizations are difficult (Kling, 1980). This paper does not attempt to frame a definitive model of the impacts of computing that will apply to all computer applications, or all organizational settings. Rather, it identifies some common ways of conceptualizing computing, and suggests some alternative, more socially cognizant perspectives. These perspectives are then used to examine some computing developments with which most of us are familiar. In doing so, we hope to demonstrate the importance of broadening the scope of organizational and societal factors considered when the impacts of computerized applications are examined.

Personal Knowledge of Computing

As our first step, let's examine how we know about computing developments through our own interactions. All of us interact with computer-based technologies in our daily lives, in our encounters with computerized billing systems, airline reservations, and the IRS. If we participate in a computing world, we may also use computerized systems to analyze data, prepare text, play games, or even just hack around in writing programs. From these personal encounters, amplified by a haphazard collection of news stories and gossip, we form concrete impressions of what computerized systems are good for, how they work, when they foul up, and what interests they serve.

Although most of us interact with computers frequently, few of us can claim direct experience with and knowledge of the full array of computing developments. There are so many different modalities of computing adapted to so many different social worlds that intimate knowledge of the complete "world of computing" is simply impossible even for computer experts.

Consider a technologist who specializes in electronic mail systems--one of several technologies which comprise office automation technologies. He has accumulated very detailed information about which mail systems have nice facilities for saving old mail and which don't, and which facilities make it easy to delete mail from people you don't know so that you aren't overloaded with mail. He knows about the costs for preparing, sending, and saving messages on various electronic mail systems. Developing this expertise takes attention and time. While he is a specialist in electronic mail, he is almost a layman in understanding other computer-based technologies such as urban information systems (Danziger, et al., 1982), artifical intelligence, military command and control systems, or EFT (Kling, 1978).

The many modes of computing in current use are extremely diverse. Furthermore, many computing technologies are not merely gadgets built of hardware and software and placed in social settings, but are also the focus of social movements--people and organizations that believe the modality of computing is worthwhile, and who promote its development and use. These computer-based social movements include:

1. Computer Assisted Instruction

2. Personal Computing

3. Office Automation ("office of the future" including electronic mail and teleconferencing)

4. Urban Information Systems

5. Medical Information Systems

6. Simulation/Gaming

7. Material Requirements Planning

8. Electronic Funds Transfer (EFT) Systems

9. Artificial Intelligence

These computer-based social movements hardly exhaust the different modes which are being developed and implemented today. There is no "automated payroll movement," but thousands of organizations have automated their payroll preparation. Other modes of computer use, such as complex statistical analyses in the social sciences or numerical analysis in the physical sciences, are simply part of larger scientific movements which emphasize quantification of some research strategy which is dependent upon computing when the number of samples and variables become large. Even the simplest labels, such as "personal computing" or "medical information systems," allude to whole families of computer applications. Each of these families, in turn, may have many specialized variants in use in many different organizations or social settings.

Storylines

One way to make sense of this bewildering array of computerized technologies is to adopt a simple "storyline" about computing, which renders order to this chaos. Three common storylines are:

1. The cavalcade of progress. "Computers enable people to communicate and compute in ways heretofore impossible. They increase people's efficiency, while reducing the costs associated with people's execution of particular tasks" (see, for example, Evans, 1979).

2. Technology is dehumanizing and out-of-control. "Computerized applications foster the depersonalization of services, bring with them new problems and inefficiencies, and are exploited by managers to control, deskill, or eliminate workers' jobs" (see for example, Braverman, 1976).

3. Technology is neutral. Technologies do not have a politics; they can be used for good or ill. If the "interesting" versions are used "properly," then they can enhance the quality of life in the societies that use them. Much depends upon what society "decides" to do with new technologies.

These simplified storylines underlie many accounts of computing. They help simplify the buzzing confusion. Whether we favor one or another of these storylines, they all are simple to comprehend. They are also context-free--they can be applied to almost any computerized (or other) technology. Even if you don't understand how computers work, you can make sense of these themes. Each may carry a grain of truth, but the truth of each is neither proven nor disproven by the examples usually proffered. Each storyline carries moral weight with an implicit value stance about what is good or bad for people (Kling, 1978).

The primary virtue of such storylines is cognitive simplicity; none of us has the time to study each computer application we encounter in order to evaluate its merits and dilemmas.

These storylines implicitly make two assumptions:

- computerized applications are independent forces which "arrive" in an organization, and then must be reacted to;

- computerized applications are value-free instruments with a uniform set of impacts which can be identified without reference to the groups that use them, or the organizational settings in which they are used.

Each of these assumptions, we believe, introduces some significant biases into many examinations of the impact of computerized applications (Kling, 1982). In the following sections, we examine some specific storylines and these related assumptions in more detail.

Computers as Causal Instruments

The word "computer" is often the subject of direct assertions about important social actions. We hear that "computers increase productivity," "computers dehumanize jobs," "computers make learning exciting," "computers improve decision-making," and that "computers are revolutionizing American society." At best, these are shorthand codings for extremely complex sets of events. Computers are not active independent forces, but are instrumentalities which have consequences under special and rather complex conditions.

Consider the example of price scanners in supermarkets. In some cases, the markets which adopt these computerized devices lay off clerks. But this is not an abstract issue of "computers versus jobs" or "computers eliminating jobs." These compact descriptions ignore the role of powerful actors, the supermarket owners and managers.

Storeowners hope to reduce costs by carefully replacing workers with capital equipment. Scanners don't show up unexpectedly in supermarkets like crabgrass invading a lawn. Scanners are expensive and purposely planted. If you are hit by a car you don't say "that's a case of technology versus people." You want to know who was in the driver's seat. Statements like "technology versus people" or "computers cut jobs" imply that there's no one in the driver's seat.

The development of supermarket scanners involves important social choices about the organization of work which are obscured by emphasizing "technology" and "jobs" and neglecting the possible social choices. Supermarket owners can deploy scanners at the checkout stands and have checkers use them with or without abandoning item-pricing. The market owners claim that they must abandon item-pricing to save sufficient labor costs in order to make the scanners economically efficient. If that is the case they could introduce scanners and raise their costs, or wait until scanners are cheaper. The arguments advanced by market owners are difficult to evaluate because good data about the costs and pay offs/of scanners are scarce.

This example also illustrates a common role played by computerized technologies as catalysts of social conflict. Market owners are said to be seeking ways to reduce costs. Possibly computer systems provide a useful means, and certain price-marking jobs are probably eliminated. However, one byproduct of eliminating these jobs is to reduce the job market for women and part-time workers. It also reduces the ability of consumers to audit their purchases at the checkstand to be sure they are not being overcharged.

In such cases, it is facile to attribute the outcomes such as the removal of item pricing to "computers." Computers are a critical instrument which enables supermarket owners to consider the feasibility of both removing item prices and reducing their direct labor costs. But to neglect the role of the supermarket owners or managers misleads. It leaves no one in the driver's seat.

This example also illustrates another critical aspect of computing. Most people don't simply interact with computers or computer applications. We deal with computerized systems embedded in relatively complex social orders (Kling, 1982). In the case of supermarket scanners, a customer deals with the price-marking policy of the store, a data-base of prices which is kept up-to-date by clerical staff, and policies for having checkers rapidly scanning the goods which are managed by the floor supervisor who can keep track of the productivity of each checker. A person who is at the receiving end of any of the socially important computer applications--airline reservations, computer assisted instruction, long-distance dialing, the IRS tax auditing systems, police wants and warrants systems--is inextricably embedded in the organizational world which it supports. Dealing with computing entails dealing with the organizational arrangements which surround the technology.

Similarly, if computer applications are introduced to schools on a mass scale, they will be shaped by the organizational imperatives of public schooling. First they will be integrated into curricula and become the subject of courses, syllabi, and regular testing. Second, their deployment will be bound up with the political economy of schooling in general and the internal economies of the individual schools. Students in richer schools will fare better than poorer ones; those schools that can attract a cadre of talented and inspired teachers will offer their students more interesting and varied opportunities than schools where talent and inspiration married to instructional computers will be rare.* In these ways computerization is no different than other interesting, but specialized, complex and relatively expensive resources,** except that many people with interesting ideas about how to use computers for children insist quite vehemently that computerized technologies have special properties as social resources (see especially, Pappert, 1980).

Value Conflicts in EFT Developments***

We've seen that computing developments cannot be assessed in isolation from the organizations that use them. Our example also suggested that computers may catalyze conflicts between different groups that are impacted by their use. To examine the latter point in more detail, we'll examine another computerized technology with which most of us are familiar--electronic funds transfer (EFT) systems (Kling, 1978).

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*People with these talents are still uncommon, and have good occupational opportunities in private industry. In the next decade, at least, they will be difficult to attract to poorer or more troubled schools.

**The costs of computing are largely not those of the machinery, even though computers and terminals are relatively scarce in most schools. Software, operational support, and related curricular materials greatly increase the overall costs of mounting a rich computer-based curriculum.

***This section and the next one draw upon more extensive analyses of EFT development which have been published in Kling (1978).

EFT systems are composed of an array of different technologies which transfer funds electronically between accounts. They include networks for automatically clearing checks while debiting and crediting accounts, directly debiting and crediting individual bank accounts from point-of-sale (POS) terminals in retail stores, and providing cash on demand 24 hours a day.

EFT systems represent a particularly rich source of illustrations of value conflicts because they have now been in use for a significant period of time, because their adoption and promotion have involved substantial commitments on the part of the financial institutions that use them, and because their diffusion has affected a broad cross-section of the public at large. Conflicting storylines about EFT systems are readily apparent in both popular and academic literature.

At one extreme, some analysts identify emerging EFT systems with social progress. For example, Long claims that:

> "EFTS is happening because it is a better way. All arguments about the sufficiency of the present paper system are meaningless. Television did not come about because the radio system was overloaded or was breaking down, nor did radio or the telephone develop because the mail was about to collapse. Neither were these systems built because the public was crying for their development. They came about simply because they represented a 'better way' of communication" (Long, 1974).

Such proponents of EFT systems point to their ability to reduce the cost of paper processing, reduce petty theft, and support convenient add-on services such as automatic payroll deposits. They sketch an ultimate scenario of a checkless and cashless society, in which integrated EFT systems transfer money instantaneously and efficiently. While Long's comment was written 8 years ago, the storyline is common.

At the other extreme, many analysts and policy makers have pointed to major and unresolved social and technical problems associated with EFT developments. Maintaining consumer sovereignty in markets within which EFT services are provided, the development of reliable systems, and the protection of individual privacy have been among the focal issues engendering controversy and debate (Budnitz, 1979; Rule, 1980). In fact, the diffusion of EFT applications has not yet delivered anticipated benefits fully in many instances; and, while EFT systems are widespread, they are for the most part operated without large scale integration.

The importance of these issues, and the sense one makes of them, is inextricably linked to the value orientation of the analyst (Kling, 1978). At this point, the field has matured sufficiently that at least five distinct value orientations, each resting on its own assumptions about what social goods should be maximized, can be identified:

1. Private Enterprise Model: The preeminent consideration is profitability of the EFT systems with the highest social good being the profitability of the firms providing or utilizing the systems. Other social goods such as consumers' privacy or the need of the government for data are secondary.

2. Statist Model: The strength and efficiency of government institutions is the highest goal. Government needs for access to personal data on citizens and needs for mechanisms to enforce obligations to the state would always prevail over other considerations.

3. Libertarian Model: The civil liberties as specified by the U.S. Bill of Rights are to be maximized in any social choice. Other social purposes such as profitability or welfare of the state would be sacrificed should they conflict with the prerogatives of the individual.

4. Neo-populist Model: The practices of public agencies and private enterprises should be easily intelligible to ordinary citizens and be responsive to their needs. Societal institutions should emphasize serving the "ordinary person."

5. Systems Model: The main goal is that EFT systems be technically well organized, efficient, reliable, and esthetically pleasing.

In different instances, policies and developments may support, conflict with, or be independent of these models. Each of them, except the Systems model, has a large number of supporters and a long tradition of support within this country. Thus EFT developments which are congruent with any of these positions might be argued to be in "the public interest."

Perceptions of benefits and problems depend upon one's values and commitments. To illustrate this point, we'll examine some of the meanings and conclusions each perspective generates when brought to bear on some specific areas of controversy: market arrangements, consumer protection, and the privacy of personal financial transactions.

Market Arrangements

According to advocates of laissez-faire markets, the class interests of consumers and suppliers are best served when goods and services are bought and sold under conditions of a perfectly competitive market: (a) there are many buyers and sellers, none dominant, who may easily enter and exit the market and alter their business associates; (b) each party has complete information about a product or service through its price (all costs are internalized)(Mansfield, 1975). According to the theory, the long-term interests of all parties are best served in perfectly competitive markets; the largest number of goods will be produced at the lowest overall price. Both Neo-populist and Private Enterprise values would be jointly served by these arrangements.

As conditions in a particular market depart from this theoretical ideal, Private Enterprise and Neo-populist values may increasingly conflict. If a market is dominated by few suppliers, prices may be too high and the market will "inefficiently" produce too little. If all costs are not internalized in the price of a good, the market will price it too low, too much will be produced, and the real costs to consumers will be excessive; Private Enterprise criteria will dominate Neo-populist values. (For example, the price of gasoline doesn't include the cost of cleaning up smog.)

Neo-populist critics of American enterprise often equate size and market power. In their eyes large organizations should not be trusted to act in the interests of broad publics. The Big Three auto makers, "big oil", and "big government" all merit distrust. The American banking industry with 19,000 banks of different kinds and sizes might appear highly competitive. However, banking is highly concentrated in local markets and nationally. In many cities a handful of banks have the majority of accounts. In 1973, the 100 largest banks, 0.5% of the banks, held 70 percent of the funds on deposit. Through bank mergers and acquisitions of bankholding companies, this industry has become more concentrated during the last decade. Since banks are authorized to operate in a given city or state, competition is currently focused on local rather than national markets, which are also highly concentrated.

Some advocates of EFT services argue that banks should be allowed to extend their services via terminal networks into new markets. Banks have been limited to operate within only one state, and some states prohibit branch banking, although these limitations are being fought and removed. According to advocates of extended banking services, these laws are simply archaic. It should be possible, in their eyes, for the residents of Eugene, Oregon to have easy access to the services of the Chase Manhattan Bank, Citibank, Bank of America, Security Pacific, and the Chemical Bank of New York by allowing them to place teller machines in convenient locations, like a row of candy machines, or a cluster of gas stations on the corner of an intersection.

Representatives of smaller banks and consumer groups believe that the expensive EFT costs can be more easily afforded by the larger banks. They fear that EFT developments will further accelerate the concentration of the banking industry. After all, it is more likely that large banks such as Citibank or Bank of America will extend teller machines to Eugene than will a small bank such as Laguna Federal Savings and Loan. Those who fear a further increase in the concentration of the banking industry, fanned by extended bank terminal systems, argue that bank terminals should be mandatorily shared. In that way, if Citibank were to place a teller machine in Eugene, Laguna Federal Savings and Loan could also offer services to Eugene residents over the same terminal at a fair fee.*

In these debates, consumer groups utilize Neo-populist criteria. Bankers utilize both Neo-populist and Private Enterprise criteria in asserting their preferences.

Consumer Convenience and Protection

If a person uses an EFT system, what protections does he have if transfers are made without his authorization, if he wishes to stop payment, or simply if there is an error? What kind of control does the individual have over his transactions? What kind of liability does he and the EFT provider have? In consumer protection, as in other market issues, the positions taken by various parties seem to hinge in large part on _a priori_ value commitments. People who trust current market structures or who view the recent history of regulation as inimical to their own interest or a broader public interest advocate reliance upon current market forces to select the best services. In their view, Neo-populist and Private Enterprise values can be jointly served. Other analysts view the American economy as increasingly controlled by several hundred large corporations which are usually protected by the regulatory agencies that were originally supposed to oversee them. According to these analysts, reliance upon current market and regulatory arrangements would not serve the broad public. They point to the vigor with which specific industries have fought consumer reforms such as truth-in-advertising laws and the Fair Credit Reporting Act. Neopopulist advocates have been active, pressing for laws which limit the financial liability of consumers in case of errors in EFT systems, limit liability for unauthorized transfer, and increase consumer control by mandating stop-payment or reversible payment mechanisms.

In 1978, the U.S. Congress enacted a special law, informally called the EFT Act (EFTA) which improved the kinds of protections for consumers using many kinds of EFT services.** It covers all

*Some states, such as Iowa, have legislated mandatory sharing, while other states, such as California and Massachusetts have not.

**Title XX of the Financial Institutions Regulatory Interest Rate and Control Act of 1978, Pub. L. No. 95-630 § 2001, 92 Stat. 3641 (1978) codified in 15 U.S.C. § 1692.

transactions initiated through electronic terminals (e.g., telephone bill payment, automated teller machine, preauthorized debits and deposits) but not those initiated with paper instruments (e.g., truncated checking). It mandates that financial institutions make disclosures in "readily understandable language" about the timing of transfers, charges, who to notify in event of unauthorized transfers, etc. It specifies that consumers can be liable for unauthorized transfers, and that their liabilities ride on a sliding scale. While the law is ambiguous, a common reading suggests that consumers are absolved of financial responsibility if they report the loss or theft of an EFT card within two days, while they are completely liable for unauthorized transfers if they wait over 60 days. Between these periods, they can be liable for up to $500 (Broadman, 1979). The EFTA also specifies some procedures for resolving errors.

On the other hand, the EFTA does not enable consumers to reverse or stop payments, nor does it prevent employers, creditors, or public agencies from requiring that a person use an EFT-based service to transact business. Also, many of the recordkeeping, liability, and error resolution procedures will work best for people who are sophisticated in their financial dealings, who keep good paper records, who are especially alert, and who are adept at resolving conflicts with "bureaucratic" organizations. Those people who are less "bureaucratically competent" will probably have some troubles (Budnitz, 1979).

The EFTA is a compromise. It provides more protection to consumers than private enterprise advocates desired, but far less protection than neo-populists advocated that Congress provide. As long as EFT systems are discretionary, they will most likely be used by those who can best cope with them. While they promise greater convenience for many routine transactions when they work well, they require substantially more sophisticated symbolic and reorganizational skills to detect and resolve problems when difficulties arise.

Privacy of Personal Transactions

In the popular conception, computers and concerns about privacy go hand in hand. Privacy connotes a complex array of issues: what information shall be collected about a person; how shall a person know about, complete, or correct a record (due process); to whom and under what conditions shall personal records be made available (confidentiality)? A common view treats privacy as an elementary social exchange. People who wish a service relinquish certain information so that the provider may make a sound decision.

While this view embeds privacy of personal data in the exchange between providers and clients of a service, it misses the ways in which much financial data collected by organizations in the late twentieth century is passed off to a wide array of third parties who in turn use it for a host of purposes which are well outside the control of the original client.

There are many EFT technologies with subtly different details. I shall illustrate privacy issues in EFT with the example of automated check processing (ACP)* systems and bank records. Any ACP system would record to whom each person writes each check. This information, along with the date of the transaction, a check identifier, and the amount of transaction would appear in one's local bank record. Record of each payee is necessary as a possible receipt and for the customer to audit his account. All this information is available now, since each bank microfilms every check cashed against one of its account holders and keeps it on file for six years.

Such records are a rich social resource. U.S. Supreme Court Justice Douglas once noted that:

> "In a sense, a person is defined by the checks he writes. By examining them the agents get to know his doctors, lawyers, creditors, political allies, social connections, religious affiliation, educational interests, the papers and magazines he reads, and so on ad infinitum."

In EFT systems, disclosure of information is the primary privacy issue. Typically, such data are sought by police and grand juries conducting legitimate investigations, and also these same agencies acting against their political enemies. With manual records the cost of finding out whether a particular individual wrote a check to a particular party or group is prohibitively expensive. With ACP systems, they would be neatly filed in machine-readable form for six years, under the provisions of the Bank Secrecy Act of 1970.

The array of personally sensitive data which would be more accessable is compounded in other EFT-related systems. Point-of-sale networks can be used to track the movements of particular individuals. Credit card or debit card files will also contain records of hotels, restaurants, and other personal activities.

Libertarian criteria emphasize system designs, organization practices, and laws which minimize intrusiveness, maximize fairness, and maximize the control individuals have over the content and confidentiality of their records unless there are major, competing concerns. Advocates of Statist and Private Enterprise positions emphasize the needs that large organizations have for information, the costs of implementing due process procedures, and the infrequency of abuse.

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*Check truncation, a procedure in which a paper check is kept by the depository institution or the first bank to receive the check, is an example of an ACP system.

In 1978, the U.S. Congress passed the Financial Privacy Act of 1978 which extended the individual's rights regarding financial data kept about him by his bank, credit union, or similar organization. During the 1970's, there were several important court cases which reduced the extent to which a person could have property rights over records about him (e.g., control their release to third parties). The 1978 Financial Privacy Act legislated such property rights to individuals for their financial records. These rights are partial, rather than complete. For example, the Act requires both that a bank inform its customers of the general conditions under which it discloses information to third parties (e.g., employers, public agencies, market research firms), and that it inform a customer if data about him has been subpoenaed by a court, but it does not require that the customer be informed whenever data about him has been released to a third party (OTA, 1982). Nor does it require public agencies to obtain a court order to obtain data about a customer. Nor does it limit the period of time that a depository institution should keep data about a customer. This law, like the EFTA, is a compromise between parties with different values. In addition to advocates of Libertarian and Private Enterprise values, advocates of Statist values were major actors in arguing that public agencies should have effectively unlimited access to financial data to pursue investigations and other mandated activities. Nevertheless, in the net, Libertarian values have suffered somewhat with the development of EFT-based services.

Differing Incentives for EFT Developments

By explicitly identifying value stances, we've been able to make some sense of the meanings various interest groups have assigned to particular issues related to EFT systems. Focusing on value orientations also sharply illustrates a final important aspect of computing's social impact. To the extent that value orientations conflict, it is impossible to develop policies that will optimize all parties' goals and interests simultaneously.

To understand how conflicts are resolved in the marketplace, it is important to recognize that even if EFT systems can foster some form of social progress, they are costly and will be developed by organizations with specific incentives. While many EFT systems are to be used by the larger public, they are selected, financed, and developed by financial institutions, retail firms, and public agencies which embed them in their own operations. EFT systems have been most forcefully advocated and developed by groups which employ predominantly Private Enterprise or Statist criteria for social choice. The following four examples include two that illustrate predominately Private Enterprise criteria and two that illustrate Statist criteria:

1. Supermarkets and small business suffer large losses from bad checks. Computer-based credit authorization services enable a merchant to diminish his losses.

2. Firms that advertise by mail often define potential customers by demographic characteristics. Knowledge that a person recently purchased a similar service is a better predictor of the likelihood that he will purchase a given service than is his membership in some demographically defined group. As financial transactions become automated the pool of potential market data either for internal use by large retail firms or for sale by credit card firms could increase substantially and provide merchants with more effective mailing lists.

3. The Federal Reserve Board (Fed) processes about 10 billion checks annually for member banks, but is prohibited from passing its costs back to the banks. Banks have been steadily leaving the Federal Reserve System since World War II. The Fed provides special loans and market information in exchange for member banks' maintaining relatively high reserve funds on account without interest in the reserve system. If the Fed administered a national EFT infrastructure, it could increase the accuracy and timeliness of its data about transactions in the economy. If automated check processing systems could lower the cost of check handling, the Fed could diminish its overhead. Improved information and reduced reserve requirements might entice banks to re-enter the Federal Reserve System and thereby help increase the Fed's effective control over monetary policy.

4. By the end of 1975, more than 32 million people were receiving Social Security benefits. Automating the transfer of credit to Social Security recipients could save a large fraction of the costs of preparing and mailing monthly checks. In addition, theft of checks from post boxes would be eliminated.

To understand computing developments like these, it helps to distinguish benefits from incentives. An incentive is an expected good that induces a party to take action, while a benefit is any good derived from the action taken. Incentives precede benefits. It may benefit individuals to receive fewer unwanted advertisements, but the incentives for developing special-interest mailing lists would be the decreased costs of advertising borne by retailers. Some incentives, particularly those that emphasize competition for new customers, also promise benefits to consumers through convenient new services and faster credit through pre-authorized payments. However, cost-savings to EFT-using institutions is more problematic. The little publicly available data on which to assess the claims for cost savings indicate that most EFT systems become cost effective only with very high transaction volumes. The high capital costs of EFT systems and the high volumes of business which they require makes consumer acceptance vital.

Some incentives are more important than others to EFT-using organizations. It is unlikely that individual banks would save a substantial portion of the cost of paper handling with EFT systems. Rather, fear and hope drives many private organizations into developing EFT systems. A firm that develops EFT related services may gain new customers; one that delays much longer than its competitors may lose out.

While Private Enterprise and Statist criteria encourage many organizations to develop specific EFT arrangements, some consumer convenience (a Neo-populist value) may accrue from them. However, no one argues that enhancing Libertarian values are either a major incentive or a likely consequence of large-scale EFT developments. Lastly, advocates of Systems criteria and consumer convenience, a Neo-populist criterion, may favor more integrated services (e.g., fewer cards and terminals).

The relatively few incentives offered by EFT developments for advocates of Libertarian or Neo-populist criteria for EFT developments may be underscored by reversing our analysis. EFT technologies may help solve some of the problems faced by profit-making firms or public agencies in carrying out their activities. But advocates of Neo-populist criteria, who stress institutional and legislative reforms to render large organizations more accountable to the public, are unlikely to view EFT systems as an important strategic instrument. Similarly, Libertarian analysts, who are concerned about minimizing the intrusiveness of organizations into people's private lives, are unlikely to consider EFT technologies to be important means for protecting individual liberties (Rule, 1980).

Computers and Schooling*

EFT systems are now beginning to appear in many different cities, but they account for only a tiny fraction of all financial transfers; computers for instructional purposes are also just

*In this paper I emphasize schooling, rather than education. By schooling I mean the rather narrow range of activities that take place in schools. By schools, I mean elementary, middle, and high schools, as we know them in the U.S. They may be public or private, more or less structured, and they are characterized by those sets of societal arrangements to require attendance of specific age groups in teacher-supervised classes for the study of graded curricula (Sanchez, 1976: 147). If a parent teaches her children at home according to a curriculum approved by a legal authority (e.g., local or state board of education), that should fall well within this conception of schooling. "Schooling" is not the same as "education" or "learning". In the United States, school age children spend about 13% of their time in required schools (Fraley, 1981: 6), and perhaps 33% of their time sleeping. About 54% of their time is not accounted for by required schooling or sleep, and doubtless they learn a good deal during these other hours.

beginning to become commonplace in American schools, but only a tiny fraction of students have any extended contact with them. We are also witnessing the "infancy" of computers in school instruction.

There is little consensus about how computers should be used and integrated into school curricula. Some argue that they should be used to teach "computer literacy" (Winkle and Mathews, 1982), and often tacitly identify "computer literacy" with programming skills and knowledge about the "workings" of computers. Others emphasize the special role that computer-based systems can play as instructional aids, but they vary considerably in the extent to which they value "routine" strategies such as using computer programs to automate drill and practice in existing curricula, or whether they find drill and practice thoroughly pedestrian and argue for more progressive, discovery-oriented learning in richer, student-driven computerized environments (Bork, 1980; Pappert, 1980). In addition, several companies have begun to market courseware for computer systems. The larger companies, such as the SRA division of IBM emphasize materials like drill and practice which are easily integrated into standard curricula, and can be easily purchased by many school boards without requiring that the organization of schooling in the United States be fundamentally altered. Other, smaller companies, such as Terrapin, Inc., are emphasizing more intellectually innovative materials, such as Turtle Geometry (Pappert, 1980) which appear to be most easily integrated into the organizational style of open classrooms.

Many of these efforts are marked by strong advocacy and salesmanship (Bork, 1980; Pappert, 1980). Despite the small and vigorous industry of many teachers, courseware developers, and marketing specialists, it is difficult to find coherent and extended accounts which suggest how different forms of learning with, through, and about computers fit into a larger portrait of schooling in the United States. Most accounts which discuss computer literacy simply indicate that computer use is becoming widespread in the United States, and assert that "well educated" people need to be able to understand or "cope with" computerized technologies in the larger social order. Most discussions of computer assisted instruction emphasize the micro-social learning situation and the kind of intellectual richness or cognitive skills which can be enhanced through the author's favorite style of CAI (see, for example, Taylor, 1980). While many of these accounts are interesting and suggestive, they do not go very far toward examining how instructionally oriented computers in schools will alter schooling, if at all.*

*For an interesting exception, see Mowshowitz's (1976) account which discusses some of the early CAI experiments in the context of school reforms in the United States. Also, see Oettinger and Marks (1969).

Value Positions Relevant to Schooling

What does the increasing spread of computers in school curricula mean for students, teachers, parents and others in the communities which adopt instructional computing? Will the kinds of things that children learn in school and the ways they learn them, be altered in some fundamental way? (These "things" include cognitive and social skills, as well as a broader array of beliefs about how American society is organized and one's place within it.) In addition, will schooling in the United States be more equitable or inequitable for children?

Based on our previous discussion of EFT developments, I do not believe that these questions have specific and predetermined answers. However, we can gain important insights into their answers by developing an analysis which parallels my discussion of EFT arrangements. First, we should identify the major value criteria which educators and others use to identify what good schooling should emphasize. Then we can examine how different arrangements for organizing school education with and around computers influences what will be learned and who will have access to different kinds of education in school.

The literature and debates about what schools are and can be in the United States is extremely diverse. I suggest that the following three value positions capture some of the main concerns of those who care about the relationships between schooling and how people live and work in the larger society:

1. Vocational Match Model: Good schooling arrangements are those which enable students to develop the cognitive and social skills necessary for living and working in the society they will find when they leave school. The character of the social order is largely independent of schools (see for example, Forbes and Gisi, 1982; Shane 1982).

2. Progressive Schooling Model: Good schooling arrangements are those which encourage students to develop their intellectual curiosity and to develop social skills which support relatively democratic group life.

3. Egalitarian Schooling Model: Good schooling arrangements are those which enable students of all social backgrounds to have equal opportunities in employment by virture of the cognitive and social skills they develop. Moreover, good schooling arrangements teach children values and social skills which support more egalitarian and less hierarchical social orders (e.g., cooperation and appreciation of diversity rather than sharp competition).

These value positions help identify the key elements of rather complex arguments about the appropriateness of basic skills, computer-assisted instruction, open classrooms and other curricular reforms. They also help identify the connections between a population of "schooled children" and the larger society in which they live and will work.* Proponents and critics of specific school reforms often anchor their main arguments in one of these three positions, although few people maintain a rigid fidelity to one value model exclusively. For example, John Dewey is usually identified with the progressive orientations but some of his writings emphasize vocational matching (see for example, Feinberg and Rosemont, 1975; Sanchez, 1976: 80-85). Identifying these themes in the writings of school reformers is also difficult because of the differences between what people believe about the way that a certain kind of schooling operates in the United States in contrast with their preferences about how it should operate. Thus, some reformers of egalitarian persuasions criticize North American public schools for acting primarily as those who value vocational matching would applaud (for example, Sanchez, 1976). Nevertheless, these value positions can be found in many books, articles, and discussions about "good schooling."

Two other value positions are also sometimes argued, but rarely in print. These are variations of the Private Enterprise and Statist value orientations which we discussed as pertinent to EFT developments. In discussions about schooling, the major actors to anchor their arguments in Private Enterprise criteria are the publishers and manufacturers of curricular materials and school products. They are concerned that schools be sufficiently uniform and stable in their preferences for materials that the producers can find large markets and keep their development costs to a minimum by spreading them over many buyers and several years. The variation of the Statist position is heard from those school administrators, teachers, and parents who are concerned that schools be so organized that they are easily manageable at many levels of social aggregation (from the order in the classroom to curricula that are sufficiently standardized so that students can easily transfer from one school to another without "losing time"). Despite these complexities, value orientations provide us a special vantage point from which to examine computing developments in American schools, much in the way that they help us understand the social choices in the deployment of EFT technologies.

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*These three value positions are tentative constructions and their utility should be carefully explored before "freezing" them. Not all value positions will provide equal analytical bite. For example, Chesler and Cave (1981:27) identify three value orientations which they believe highlight important differences in the intent and outcome of schooling strategies: reactionary, conservative, and revolutionary. These labels are defined relative to a whole society, rather than for a strategy for organizing schooling within a single society; they don't provide us any analytical leverage here.

Computer Literacy

Computer literacy is an attractive metaphor for indicating some skill in dealing with computerized systems. Most of the debates today hinge on differences in belief about what kinds of skills are seen as relevant, and different conceptions of "computerized systems." The narrow conceptions of literacy emphasize skills in manipulating some computerized device such as programming a micro-computer or operating a word-processing machine. A broad, socially-rich view assumes that these skills may be useful, but are far from sufficient in helping people understand such matters as the opportunities and problems of large scale EFT developments or supermarket scanners.* An analogy between computers and automobiles might prove instructive. Advocates of literacy-as-computer-manipulation are advocating a kind of learning similar to driver education or automotive mechanics. If cars (or computers) are widespread it is doubtless useful to teach people how to deal with them in rather concrete and practical ways. Moreover, such people will have more appropriate skills when they enter the full-time labor market (thus the narrow literacy position is congruent with vocational-matching educational values.)**

*An intermediate view assimilates "computer literacy" more to cultural sophistication than to linguistic fluency and technical mastery (Marvin, 1981). In this conception, dealing with computers hinges on learning how to deal with the computing cultures within which computers are embedded (see also Kling and Scacchi, 1979).

**It is instructive to read the argument for computer literacy as vocational matching (Luehrmann, 1980) in light of Tyack and Hanson's (1982) observations about reformers who advocated vocational education in the United States around the turn of the century:

> "The literature on vocational education is a fascinating index of the way in which the new educational managers could perceptively diagnose the severe problems created by the new forms of corporate capitalism and then provide paltry remedies. It also exemplifies their faith in the power of public schooling to correct structural inequities by improving individuals, to reform the society not by direct means but by teaching youth. Advocates of vocational schooling wrote study after study documenting the ill-paid and deadening character of the subdivided and routinized work available to those on the bottom of the system. They argued that it was so exploitative that child labor should be forbidden by law. But at the same time few suggested any fundamental changes in the character of work for adults or thought of altering the balance of power between workers and employers in industries. They placed their hopes on a better system of vocational training that would help workers to be more productive and to understand the larger significance of the work they performed" (Tyack and Hanson, 1982:111).

The broader view of computer literacy emphasizes the ways in which computerized systems are integrated into the social order, much as we have seen with the EFT examples discussed earlier. In this conception, a person's understanding about how "computers work" and what they are good for depends on both understanding the machinery and the social order within which it is used. Providing a child with a micro-computer may help her understand what software is and how "it" works, far better than a textbook description could do (Luehrmann, 1980). But access to a micro-computer would do little to help that child understand why banks have a three tier liability system for the unauthorized use of debit cards, or why the U.S. Armed Forces have trouble developing a workable multi-service command and control system for the unified military commands, after 15 years of development and $1 billion expenditure (Kling, 1982). Understanding these matters requires appreciating how computer-based technologies are integrated into social worlds (Kling, 1980).

Certainly, using computers and developing a sense of competence and skill through mastery of programming a relatively flexible and accessable machine can be rewarding and helpful for many children. The issue here is very different, though. To refer back to our analogy with automobiles, the broader view of computer literacy holds that understanding the role of cars in American society is not equivalent to having acquired skills as a driver or mechanic, however fun or useful they may be. Rather, it requires understanding the development and deployment of automobiles in American cities and in the economy at large so that one can appreciate the importance of oil in American life, why the demise of Chrysler or the automobile industry cannot be taken lightly, etc. Those who advocate a broader view of computer literacy typically hold to more egalitarian values of schooling also. They assume that it is not sufficient for schools to simply educate children to "fit" into society, but that schools should, in part, educate children to understand the workings and myths of the society they live in (Mowshowitz, 1976; see also, Friere, 1981).*

Furthermore, those who hold egalitarian values toward schooling would seek ways to have student's schooling in computer literacy (as well as other topics) not simply reflect a hierarchical job market with many jobs which allow little initiative and a small fraction of jobs which offer considerable discretion, intellectual challenge, and deep personal rewards.

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*To the extent that this socially rich conception of computer literacy depends upon students having access to accurate portraits of social life in America, this vision is unlikely to be realized in most public and private schools. For an elaboration of this point, see Fitzgerald's (1979) examination of the changing portraits of American society which have been emphasized in high school history books. Historical fidelity is not their strength.

Computer Assisted Instruction

There are many ways that computer applications and environments can be designed to assist students learn or improve certain (usually) cognitive skills. The most structured and least intellectually exciting are drill and practice programs which are written to support basic skills such as reading, elementary mathematics, and other highly structured intellectual domains (Suppes, 1980). (These programs can also spin off progress reports about the tempo and development of each student in a class.) The middle range of CAI technologies are simulations which allow the student to explore the dynamics of a physical system or a simple economy by asking her own questions (Bork, 1980). The high end of CAI technologies are rich environments such as Turtle Geometry which enable students to explore mathematical ideas by providing them computational tools which are suitable for many "experiments" and an environment which is driven by the student much more than by the courseware (Pappert, 1980).

Only a tiny fraction of school age students in the United States are now exposed to CAI in any form. Clear trends are difficult to identify, and the shape of things to come may diverge radically from the current pattern of developments and adoptions. Nevertheless, the present is instructive, to provide some insight into the larger social forces which will influence the futures that inspire CAI pioneers (Taylor, 1980). In 1982, there are about two dozen firms which sell educational courseware. Most of the materials (by title), and the largest firms concentrate on drill and practice and similarly structured packages. While the pedagogy of rote learning and the structuring of these media often incite contempt from developers of intellectually richer materials and media (Bork, 1980; Pappert, 1980: 21-35), they are the most easily integrated into the standard school curricula. The use of less directive media, such as Turtle Geometry, probably hinges on an open classroom organization. The major experiments with Turtle Geometry are taking place in an open and relatively experimental school in the Dallas school system (Fiske, 1982) with the support of Texas Instruments and in a progressive suburban school district (Newton, MA) without explicit industrial support (Zonderman, 1982).

There is much to be optimistic about during the next decade. First, the cost of the cheapest computers may still decline somewhat, while their computational power, graphical capabilities, and associated I/O (e.g., auditory drivers) will be substantially magnified. Second, the richness of the software available for the popular machines and also the quality of the more popular kinds of courseware will improve. Also, more schools will doubtless purchase computers and courseware for instructional use. But these are all "endogenous" elements; they do not directly translate into an altered form of schooling in the United States. At minimum, little else need change except the sheer presence of computers and the shift of some coursework from paper and pencil to terminal and display. In that case, computerized technologies would be like multi-color textbooks and felt tip pens--widely used, adding some interest, but having little fundamental impact on schooling nationwide.

Again, we can turn to our value models to help appreciate the alternative kinds of schooling which these instructional technologies are most likely to provide. Advocates of progressive education and student-centered learning will most favor the richer, student directed technologies. (They may also favor those drill and practice systems which allow self-pacing for students who require remedial skills.) While the "content" of drill and practice systems can be drawn from any discipline or skill instruction and testing can be framed around right and wrong answers, simulations and computational environments are constrained to those symbolic worlds for which someone can build an explicit symbolic representation. It is easiest to do this for knowledge domains in which the underlying relationships can be mathematically modelled (e.g., physics force laws, simple economies, Turtle Geometry). However, the kinds of symbolic worlds which appear in games like Adventure suggest that a larger class of symbolic universes can be transformed into a computationally accessable representation. These are not unlimited, although it is easiest to say that at any given time, they are bounded by the scope of Artificial Intelligence technologies of that period.*

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*In practical terms, it is doubtful that one would find programs in the next decade which could answer important questions about U.S. history, for example, in intellectually satisfying ways. A drill and practice program might store many facts about the outbreak of World War II, and a simulation might model the relative strength of world armies of the period, but the programs we know and understand would be hard put to answer arbitrary inquiries about why U.S. forces were surprised at Pearl Harbor on December 7, 1942, how the British staved off severe V2 attacks, why Hitler broke his nonaggression treaty with Stalin, or the rationale for and effects of the Allied saturation bombing of major German cities. If pedagogy is more than simply propaganda then a key point in discussing questions like these in a classroom is not simply "to get" a "correct answer," but to examine how people and nations act. The underlying pedagogy is unlikely to be completely replaced by some specially good "World War II" or "foreign policy" simulation.

While simulations in principle help one examine the dynamics of a given situation, one would need models of individual and collective behavior which link expectations, cultural preferences, and the "drift" of collective situations in shaping policy action and large scale social responses. It is an understatement to hold that decent models of such explanatory scope are well outside the bounds of contemporary theory.

For a host of reasons too complex to discuss here, it is doubtful that CAI of any sort will substantially replace printed books in social studies or literature. Thus, educators, school boards, and parents who value progressive educational approaches and who are drawn to CAI, may employ drill and practice systems and some of the richer computerized environments as part of a larger curriculum.

Those who believe that their schools should emphasize vocational matching will see the adoption of CAI technologies somewhat differently. Suffice to say that there is little use for most school graduates to have a deep appreciation of physics or a love of mathematics to find employment in our economy as it now exists, or is likely to exist in the next few decades. Even if there is a continuing shift from employment in agriculture and manufacturing to services and information handling, many of the jobs require relatively limited skills and a temperament conditioned to work in complex rule-laden organizations. It is most likely that those who are educating students for these labor markets will prefer CAI systems which are most consistent with structured classrooms and basic skills (even if they enlarge these skills to include elementary computer programming or word processing or machine operation). Simultaneously, students who aim at jobs which hinge on a college education and more sophisticated scientific and formal language skills, and which require more independence, are more likely to be taught in schools which have more student-centered teaching. The richer modes of CAI might appeal to vocational matchers who are selecting instructional materials for this more elite segment of the school age population.

Those who prefer egalitarian values might have no a-priori preferences for any special mode of CAI. They would, however, be concerned that classrooms, with or without CAI, foster cooperation between students rather than sharp competition; that students not be sharply "tracked;" and that there not be vast gaps in the kinds of educational resources which are available to schools across the United States. Today, CAI systems are relatively expensive, and thus they are most easily affordable by the wealthier (or subsidized) school districts. Many people expect the costs of CAI to be substantially reduced in the next decade. If CAI systems can be reduced so that their costs are comparable to textbooks or typewriters, the best served students will be those who have teachers who are most skillful in teaching with computer-related materials. These teachers, like skillful teachers today, are not uniformly distributed throughout the public and private schools. To the extent that wealthier districts attract a disproportionately larger number of them, it is likely that CAI systems, in themselves, can do little to redress existing inequities in American schooling. In fact, to the extent that artful teaching with CAI is even more demanding of skilled teachers, CAI systems may exacerbate inequities in American schooling. Unfortunately, educational outcomes may hinge more critically on the intervention of skillful teachers in the use of intellectually richer environments rather than the more routinized drill and practice applications.

Open Issues in Computers and Schooling

The most common points of departure for discussing instruction about and through computers in the schools is to take advances in computer hardware for granted, and to ask how rapidly new technologies can be taught with and through them (see Taylor, 1980 for many examples). In this framing, the problematic elements are the difficulties in finding high quality courseware, of convincing school boards and teachers to adopt innovative teaching technologies, of training teachers to work in computer-centered environments, of finding ample funds for these ventures in a time when school expenditures are problematic. In this framing, the outcomes of instructional computing are "better" cognitive skills and "computer appreciation."

I have sketched an alternative way of asking what computerized technologies mean for schooling in the United States based on competing value positions. From these vantage points, different forms of computer literacy and CAI appear differentially attractive and workable. In short, those who value schooling as an institution for channeling students into different slots in the labor markets will find narrow conceptions of computer literacy and many kinds of CAI attractive. This does not mean that vocational matchers will always value computer literacy as a basic skill to be taught in parallel with the three R's. Nor does it mean that they will eagerly seek CAI at every juncture, or be forgiving about costs, teacher training, etc. It simply means they will select those modes of instructional computing which are consistant with their vision of schooling, and reject others.

The current arrangements for schooling in the United States tend to favor vocational matching (Gintis and Bowles, 1975), although there are some compensatory funding programs to reduce the more extreme inequities in some states (e.g., post-Serrano, California). Vocational matching arrangements are also consistent with having a fraction of schools administering progressively oriented programs, such as open classrooms (Sanchez, 1976). However, those who value egalitarian schooling will value broader forms of computer literacy and an equitable distribution of talented teachers. Overall, current schooing arrangements are so organized that the largest markets for curricular materials will be those which support relatively narrow forms of computer literacy and relatively well structured forms of CAI. These are the markets which I'd expect the firms which value profitability to emphasize, although there are always niches for small, specialized suppliers.

This analysis has emphasized the pedagogical side of schooling; pedagogy is not the only issue in organizing schools and working in a classroom. Many teachers value orderliness, particularly in "traditional" teacher-centered classes. There's a good chance that those kinds of instruction about and through computers which will be adopted on a large scale are those which enhance, or at least do not erode, the extent to which teachers can maintain control over the attention of the children they supervise. (Thus, computer-based programs which can be done by individual children would be preferred to those that hinge on small groups cooperating.) This is a hypothesis, not a firm prejudgment.*

In this brief section, there are many questions which I haven't addressed--the role of computer managed instruction, the relations between students and teachers, the likelihood that many parents will prefer to teach their students at home rather than in teacher-staffed schools, etc. I suggest that the value-model approach developed here helps illuminate some of the key social forces and dilemmas that underlie these issues.

Conclusions

It is common to view technologies as potent agents of social change (Evans, 1977), but the most significant technologies are diffused through modern societies over several decades. Automobiles, telephones, electricity, central heating, television, and birth control did not act as independent, powerful forces in the United States. They were shaped and fit so that the larger social order was not radically uprooted. There is evidence that computerization develops similarly within public agencies (Kling and Kraemer, 1982). It is also likely that EFT technologies and instructional computing will be similarly "absorbed" over several decades.

In the short run, when these technologies substitute for less technically sophisticated alternatives, the values of key actors--developers, resource controllers, and users--play a critical role in setting the stage for later developments. Later on, new styles develop; automobiles do not function like horseless carriages and photocopiers don't function like automated carbon copiers.

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*I find it remarkable how much the literature on the more student-centered forms of CAI emphasizes the technology at the neglect of the real children who will use these devices and the real classrooms in which they will be taught. See Taylor (1980) and Pappert (1980) for examples where the technology is foregrounded and the students and classes are truant; see Oettinger and Marks (1969) for an alternative approach which is sensitive to the social contexts of real schools. CAI technologies are now cheaper and more sophisticated, but many issues remain unchanged.

In the short run, institutional styles dominate the use of new technologies. Hospitals which use computers heavily are much more like hospitals which are hardly automated than they are like some other kind of institution--a bank, a grade school, or an architectural firm. Thus, asking about how a technology shall be "best used" is asking questions about the larger social order in which it is embedded. Identifying key values at issue in a given institutional area--here banking and schooling--helps identify the kinds of interests that easily align with different modes of computerization.

A key issue is not whether or not computers are used in banks or schools or libraries or manufacturing firms. Rather, much depends on how they are used, what infrastructure of resources and legal arrangements accompany their use, and what interests the arrangements serve. Much is written about promise of computers in many spheres of American life, including schools. Despite the billions of dollars spent each year on different forms of computerization, we have little systematic data about the ways that computing is being integrated to public life in the United States (Kling, 1980). In the absence of systematic and high quality data, we must rely upon scattered reports and a priori models.

In the analyses presented here, laissez-faire EFT developments best serve Private Enterprise and Statist values; in schools instructional computing best supports Vocational Matching. conversely, EFT developments will not serve Neo-populist or Libertarian interests without special legal and institutional supports. Similarly, instructional computing in American schools is unlikely to serve Egalitarian values very well without special institutional support.

At this time, both EFT developments and instructional computing are in their infancy. There are still many open social choices, and the future of these developments is still to be made.

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THE MICROCOMPUTER -- AN ENVIRONMENT THAT TEACHES: EXPLORING THE HIDDEN CURRICULUM

Henry F. Olds, Jr.

The use of the microcomputer in classrooms and homes has many implications for the learning of those who use it. Some of these are obvious; but many are not so obvious and deserve serious consideration. I want to consider here some of the kinds of environments for learning that computers create and the impact these environments may have on computer users.

Discovering the Hidden Curriculum

Psychologists and sociologists who have been interested in what children learn in the classroom and how they learn have frequently distinguished between the formal curriculum and the informal, or hidden curriculum. The formal curriculum consists of the content and skills that are defined and articulated as the "course of study." It usually expresses what the society expects children to learn in school. And because this curriculum is explicit for the most part, it is also considered to be largely under control.

Most observers of our schools also recognize that the formal curriculum is only the tip of a huge iceberg and that most of what is learned in schools is hidden, poorly defined, unarticulated, and not well controlled. Most innovations in education are efforts to improve the transmission of the formal curriculum. Little attention is paid to the hidden curriculum because it is too vast, too complex, too hard to see (particularly when viewed with a microscope through a rear view mirror). In our passion for our pseudo-scientific capactiy to measure things, we have assumed that what is important in education is what is easily measurable. So we have limited our vision to what we can define and put our callipers on.

In over twenty years of watching changes in education, I have learned that significant and lasting changes occur only when the entire structure of the enterprise is somehow altered, not just a tiny fragment. Many change efforts so completely ignore the hidden curriculum that insertion into the system is almost immediately rejected by the host, much like our bodies reject alien diseases.

My position is that the classroom (and the school) must be viewed as a total environment that teaches. Changes in that environment, if they are significant, will effect all aspects of the environment. Any change that is not significant will not only have little effect, but will quickly be rejected or so totally assimilated into normal practice that nothing noticeable results.

It is my prediction that the advent of computers into classrooms will make a major difference in how education happens in our schools. Typically, most educators are assuming that the difference will be in the formal curriculum, and they talk about teaching more content in less time, teaching students on a more individualized basis, keeping better records of student progress, freeing the teacher to teach more complex concepts and skills, etc. I fear, as usual, that they are inspecting the elephant by looking at hairs on the end of its tail.

I think the computer will make a major difference because it places within one total environment that teaches another total environment that teaches. In my mind, it therefore exponentially increases the learning possibilities -- it does not merely add on. Think of it this way. It is not:

$$\text{New Learning Environment} = \text{Learners} + X + Y$$

It is:

$$\text{New Learning Environment} = (\text{Learners})^{X + Y}$$

Where X = Teacher + Books
Y = Computer + Software

There is another scenario, of course. Our school systems could try to restrict the use of computer technology narrowly to the role of audio-visual aid for more efficient transmission of the existing formal curriculum. If that happens and is successful, we could well find the computer taking its place alongside the 16mm and overhead projectors in the A-V closets.

It's not likely to happen that way, not because our educators are so much wiser, but because our society already senses that new forms of education will be required for a world in which computers will deeply alter not only the way we do things, but also the way we think about doing them. Already many computers have found their way into schools not because school boards have decided to use them, but because parents' organizations have bought them and insisted on their being used.

The Hardware Dimension

The best way of understanding what is going on in a total educational environment -- both the formal and the hidden curricula -- is to become a student of the human interactions that are a product of that environment. For example, let's consider the changes that have come about with respect to computer hardware. In a very short period of time, we have moved from very large and very expensive computer installations with relatively few terminals for a select group of students to small, relatively inexpensive microcomputers that can become a readily accessed tool for everyone in any classroom. Today, teachers can put computers in their cars and take them home overnight or for the weekend. In the very near future Allan Kay's vision will become a reality -- every child will have a notebook-sized computer to carry to and from school each day.

When the hardware resources were large, scarce, and expensive, use of them had to be authorized by someone in control of computer time allocation. To a lesser degree, computer use in schools must still be authorized because available hardware is scarce. This scarcity has some important implictions for how the computer is seen and used. For example, it is rarely possible for the computer to be used for word processing in schools because the composing process is too time consuming. Similarly, using the computer for serious problem solving, which might involve searching data bases, constructing analytic models, or even writing extended programs is still limited by the scarcity of resources. Someone must still authorize how the computer is used and when it is used.

But soon the computer will be just about as available to everyone as the hand calculator is today. How will the school react? My sense is that most schools are still unsure about acknowledging the reality of the hand calculator as a tool which makes pencil and paper arithmetic almost completely obsolete. Drill and practice on application of the algorithms for pencil and paper computation persists -- even computers have been enlisted to insure that the old methods don't change! Few math classes that I know of have replaced the pencil with the calculator and are teaching new algorithms for making quick estimates to be sure that the answer supplied by the calculator is reasonable.

Will schools react to the advent of the handheld computer in the same way? If they do, I fear that the hidden message to students will be that what goes on in the classroom is, far more than ever before, irrelevent and worthless. It would be a shame -- maybe even a national catastrophe -- if that turns out to be the case.

At this point, I am still optimistic. The attitude of many teachers who are beginning to use computers in schools is open to the possibilites they permit. There is a reasonable willingness to risk the chance that embracing computers as a new tool for learning means rethinking to some degree the nature of learning in an evnironment that has now changed significantly in some exponential way. To some degree, not yet well understood, the nature of education is changing, and fortunately there are many teachers who are willing, even excited to venture into exploring uncharted territory.

The Software Dimension

Most of the interesting aspects of how computers will effect education arise from consideration of the impact of various kinds of software. While the hardware provides a very general tool, the software makes the tool useful to people and determines to a degree what kind of tool it will be.

If you ask people what the major advantage of the computer is, they will respond with ideas like it's fast, it's accurate, it's thorough, it's inexhaustible, etc. Educators, in particular, also point out that it is interactive, the sense being that there is something in this interactive potential that is particularly important for education. They may be right, but what has impressed me is the astonishing range of attitudes about what the nature of that interaction is.

I would like to suggest that understanding fully, in all its complexity, the nature of the interaction between the computer and the user is critical to understanding how the computer will effect education. And, as I have suggested above, we must look underneath the surface (the explicit intentions) to the hidden impact of this interaction.

The CAI Model

The strongest and most dominant model we have today of what the nature of the computer/human interaction ought to be has been passed down to us from a previous era of scarce computer resources. It was a time when a handful of educational psychologists worked with a handful of computer specialists to create software that would demonstrate the potential of this scarce and expensive technology. They decided, for whatever reasons seemed obvious at the time, that computers should best be used to assist and to manage instruction. Assisting came to mean carrying out routine instructional activities in a mode designed to improve upon the teacher's capacity to do so. In theory, then, the teacher would be free to instruct students about more complex and important matters. Managing came to mean keeping careful track of the student's performance and directing the student to appropriate new material based on past performance.

Since most efforts to improve education in the past fifty years had used the modern factory as a model, it was not surprising that early applications of computers to education were aimed at making education more efficient and cost accountable. Because computers were clearly able to assist and manage manufacturing processes efficiently, it seemed reasonable that they could provide similar help for educational processes. Behind closed doors, discussed softly so as not to upset anyone or create bad press, many of the developers of early CAI and CMI software talked of the day when slow, inefficient, mistake-prone teachers would be relieved of most educational responsibility, and computers would carry out most of the serious aspects of instruction.

If computer technology had continued to be relatively scarce and fairly costly, those in control of its use might have prevailed in insisting that its proper function was to assist and manage instruction. Twenty years ago, few would have predicted the silicon revolution. When microprocessors burst upon the scene, those who had been pioneers in CAI immediately leaped to the stage and proclaimed that now the miracle of CAI could become a universal cure for the ills of a slow and outmoded educational system. In their enthusiasm for presenting their particular vision of using the computer in education, they neglected to pay attention to the fact that advent of the inexpensive microprocessor completely changed the relationshiop of man to the computer. Put very simply, what was once expensive and inaccessible became, almost overnight, cheap and available.

With cheap and available technology, all the potential of the computer can be explored by almost everyone. No longer must the technology be limited to applications determined by a small, vested group. In education, what was once the province of the educational psychologists and computer science technicians can now be open to teachers and parents and kids -- and professional educators whose interest is in expanding the potential of the technology, not in limiting it.

Let's now consider the CAI model of computer/user interaction:

1) The computer presents some information on the screen and poses a question (the stimulus).

2) The user responds by constructing an answer of his/her own or by selecting from a range of answers presented with the question (the response).

3) The computer evaluates the user's response based upon a predetermined formulation of the correct reponse.

4) The computer provides the user with some feedback to his/her response, usually in the form of a judgment that the responses was either correct or incorrect (the reward).

5) The computer keeps track of the user's performance (the record).

6) The computer provides a new stimulus, the choice of which is based upon the user's performance record.

On the surface, this model seems reasonable. To many it represents fairly well what education is about. Everyone ought to have the experience of learning from a program developed on this model. If your choice of programs is good and if you use the program conscientiously, you will probably learn something. And if it is something you very much wanted to learn, you may be justifiably pleased with the program's effectiveness. Good CAI can indeed teach effectively.

But it's important to consider some of the hidden aspects of this approach to education. First, it places the computer in contrtol of the educational process. It maintains that the computer is both necessary and sufficient for learning. And it places the user in a submissive and tightly constrained role.

Just below the surface, CAI teaches that:

- Learning is in control of some unknown source that determines almost all aspects of the interactive process. To learn one must suspend all normal forms of interaction and engage only in those called for by the program.

- Learning is an isolated activity to be carried on primarily in a one-to-one interaction with the computer. Normal inter-human dialogue is to be suspended while learning with the computer.

- Learning involves understanding (psyching out) how the program expects one to behave and adapting one's behavior accordingly. One must suspend idiosyncratic behavior.

Learning (even in highly sophisticated, branching programs) is a linear, step by step process. In learning from the computer, one must suspend creative insights, intuitions, cognitive leaps, and other non-linear mental phenomena.

My observations of people using CAI materials on computers have produced the following data:

People are willing to give control of the learning process to the computer for relatively short periods of time if

a) they are clear about what they want to learn and what the computer can teach them.
b) they are highly motivated to learn some specific subject or skill.
c) they can easily control the duration of interaction and are free to shut it off when they have had enough.

People crave human interaction, particularly when they feel they have learned something and want the chance to tell someone else about it. Therefore, to the extent that CAI is successful, time on-line needs to be mixed with plenty of opportunities for human interaction.

People will spend considerable time exploring what's "in the head" (or, for some children, "in the heart") of the computer because they become fascinated with what makes the program "tick," how the program "thinks" or how it "feels." The more "intelligent" or "sensitive" the program pretends to be, the more most users will try to outwit it. (Discovering the various ways the program will respond to wrong answers usually produces great delight!) The more "up-front", clear, straightforwar and consistent the program can be in responding to the user, the less time and energy the user will spend trying to prove that he/she is smarter than the program, or in worrying about how the program "feels."

To the extent the program permits, people love to jump around within the program structure, particularly when they feel they have somehow developed (probably in some non-linear way) an understanding of what the program is trying to teach. If they are locked into a tightly constrained sequence, they become frustrated and bored and very resistant to continuing interactions with the program.

A Simulation Model

I would like to contrast this CAI approach, and what I observe people learning from it, with two other approaches to the use of the computer: one carefully contrived to engage children in a different kind of learning, the other deliberately structured not to teach at all but rather to provide a tool for facilitating learning.

In the Search simulations, the computer plays a significant role for learning, but it is not central. The program explicitely insists that the interactions among a group of people are critical for learning. The computer is necessary for learning, but not at all sufficient.

In Geography Search, the learner becomes a member of a ship's crew on a voyage of exploration. Background information needed to undertake the voyage is provided in a booklet (books are still wonderful for reading). The computer provides the crew of learners with data needed for each day's sail and keeps a record of the voyage's progress. The task of the crew is to decide how to interpret the data and what actions to take next. There is nothing to learn directly from the computer. The learning takes place as your crew attempts to apply its growing knowledge of navigation to the task of finding gold in the new world. Or, on a somewhat more sophisticated level, learning occurs as one wonders how events in the simulation compare with actual historical events or with real problems in navigation.

The problem solving involved is close enough to being real to engage the full mental faculties of each crew member and to profit from the special talents and capabilities that each member of a group can contribute to a cooperative endeavor.

With programs like this, students are being taught some very different ideas about learning:

Learning is an essentially human activity that is totally under human control and direction.

Learning is inherently cooperative in nature and dependent upon human interaction. What people know is what people are able to reach collaborative understaning about.

Learning is not a matter of adapting one's thinking to the thinking of someone in control, but more a matter of contributing to a shared understanding of something and finding ways to share that understanding.

Learning proceeds best in an environment where it is safe to make errors and to learn from those errors.

Learning is both exciting and pleasurable because it almost never proceeds in predictable ways. At times under certain conditions, a person's capacity to learn can be truly astounding.

From classroom observations, one gets a totally new perspective on the interactive nature of computing:

There is very little interaction with the computer. The computer program is a catalyst for multiple levels of human interaction.

No group of people, or individual within a group, learns the same things at the same time. There is both wide variety amidst much commonality. The computer program provides a map for learning but with no constraints on the extent of exploration.

People working collaboratiely learn so much about how to make the group process work. Though the computer program sets a goal for this process, the many options for making the process work are open for experimentation.

The most significant educational value of simulations is that they allow major mistakes to be made without catastrophic consequences. Given the opportunity, people can improve substantially in their capacity to profit from their own mistakes.

Though the computer program provides an extrinsic motivation for performing well, the motivation that is intrinsic to performing well dominates people's behavior.

A Tool Model

Finally, a third kind of program teaches a different approach to learning because it produces a totally different range of computer/human interactions. SemCalc (which stands for Semantic Calculator) turns the computer into a sophisticated calculator, which can both calculate with numbers and with the referents for those numbers. It permits the user to carry out problem solving in a world where numbers almost always refer to something. For example, consider the following problem: At Billy's birthday party, there were six cupcakes for eighteen children. How many cupcakes were there for each child? A typical student response to this problem would be to say the answer is "three" (Most children divide the larger number by the smaller number, whatever the circumstances!). The answer is wrong on several counts. First, and most important, the answer must have a referent. Three what?

By keeping track of the "whats," the problem solver becomes mindful that a problem's solution must be stated in the same semantic terms as the problem's original question. So, in the above problem, if the proper referent were attached to the number, the answer would be "three children per candy bar." Now there is nothing inherently wrong with this answer because it is true that there are three children per candy bar. However, by comparing this answer to the original question that was asked, it is clear that this answer is not the answer desired. Therefore, the number that was calculated is also probably wrong. A recalculation of the problem produces the answer 0.33333333 candy bars per children.

Now a shrewd student might notice that there are still some problems with this answer. First of all, the numerical portion of the answer seems much too precise for the circumstances described in the problem, so some thought must be given to the most apropriate form for reporting the answer. Secondly, the original question asked how many candy bars per child, and the answer of candy bars per children is not quite the same, so the student must make a slight semantic adjustment here if it is warranted by the circumstances.

This approach (formally known as dimensional analysis) has been a time-honored technique in college physics courses and is now made available through the computer to students of almost any age. It places in the student's hands a powerful analytic tool for exploring the solving of problems involving quantities. Like its less sophisticaed cousin, the hand calculator, it carries out manipulations of quantities with ease. But also like the hand calculator, it has no intelligence and no explicit instructional purpose. It is purely a tool, as useful as the intelligence of its user, and also subject to the limitations of that intelligence.

I believe that SemCalc reinforces the same attitudes toward learning as the Search simulations. However, it goes a bit further in placing the computer in the role of tool and the person in the role of autonomous inquirer. Implicitely, it teaches a most significant lesson about computer use: that this technology can be immensely helpful to persons in their efforts to explore and understand their world, but that it will always reflect back to them the limitations of their own vision and wisdom. This may be the most important lesson that computers can teach us for surviving and prospering in an electronic, information-rich society. Also, such learning may be the only antidote to a dangerous but growing tendency for people to trust the seemingly smart machine over their own intelligence.

The most hopeful sign I have seen recently is that there is a growing number of computer programs -- still small compared with the mountain of CAI materials available -- that use the computer effectively as a learning tool and not as an instructional medium. We need good CAI to teach some things. I have no arguement with the limited use of good CAI. But, far more important, we must help our students learn about the power of the computer as a tool for extending the reach of a person's intelligence, even consciousness. And in every decision we make about how we shall use computers in education, we should consider carefully and sensitively all the possible implications of our decisions for those who look to us for wisdom and guidance.

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EA 014 917

THE MICROCOMPUTER REVOLUTION

Harold C. Kinne

The year of 1982 represents the first year of the new era of the microcomputer. The dramatic events of the summer of 1981 completely changed the microcomputer marketplace and in some manner legitimized business use of the very small computer. The change has been seen in all aspects of the marketplace; in new hardware, new software, and a new user profile.

Microcomputers are only 7 years old - the birth of the microcomputer industry can best be attributed to the cover story on the MITS "Altair" computer kit in the January 1975 issue of Popular Electronics magazine. The Altair was the first computer kit to be offered utilizing the newly developed microprocessor and its sales history astounded the world. Within the first month after publication, MITS had firm orders for their estimated first three years of production! Major manufacturers jumped on the bandwagon and by mid-1977 fully assembled computers were offered through a growing network of computer retail stores. Many stores assembled computers from kits and sold them with their own assembly guarantee. Most provided consulting advice, service for both software and hardware, and provided repair facilities. The computer store was the marketing phenomenon of the 1970's. The first computer store opened in July 1975 in Santa Monica, California, there were 50 stores open by mid-1976 and nearly 500 by mid-1977. These stores carried many brands of computers in both kit and assembled form. Many of the early computer manufacturers did not survive in a very competitive market. The "survivors" of these early computers still viable today are the Commodore PET, which is said to stand for personal electronic transactor, the Apple II, and the Tandy Radio Shack TRS-80 Model 1.

The Commodore PET was first demonstrated at the National Computer Convention in Dallas, Texas during June 1977. The Apple 1 was built by two young men in California using money obtained by selling their van -- money taken in in sales was used to produce more which were sold to get money to build more, etc. The acceptance of the Apple 1, a printed circuit board, led to the design of the Apple II with its high-impact plastic, space-age case and the delightful logo of a rainbow colored apple with a bite out of it! Apple had the sense to obtain professional business management; many competing companies failed to survive because they did not have good business management. Excellence of product is not necessarily an indicator of business success, in the microcomputer business at least. The Tandy Corporation entered the market with the TRS-80 Model 1 and frankly, Tandy did not know what they had when they first sold this computer. For several years Tandy, primarily a leather handicraft and electronics company, reacted to their small computer sales -- the tail seemingly wagged the dog -- until they finally came to grips with computer technology a couple of years ago. With their string of dedicated computer centers as well as some 7000 retail outlets, Tandy is today a force to be reckoned with.

These then, Commodore, Apple, and Tandy, were the first successful entrants into the small business marketplace. The major shortcoming of the early versions of these computers from a business viewpoint was the lack of a random access storage device. The audio cassette tape used for storage provided only sequential access to stored files and was far too slow for most business applications. The development of the floppy disk brought businessmen into the small computer marketplace in growing numbers during the last years of the 1970's. Many other manufacturers combined an existing computer system with their own business software and marketed the combination as a privately labeled business system. There were dozens of these systems available ranging from truly excellent to barely adequate. By the end of 1980, there were probably 600,000 small computers performing some kind of business function in the United States alone.

These business microcomputers and certain of the minicomputers were frequently termed "Small Business Computers", or "SBC"s. Most people linked "Small" with "Business" and considered these machines as computers for use with small businesses only. To an extent, this was a valid assumption. Language capability was largely restricted to BASIC, an interpreted and relatively slow language, and storage capacities were small, being measured in kilobytes rather than the multiple megabytes found with the larger main-frame systems. The available business programs were poorly written and difficult to maintain. The traditional Data Processing professional and the Chief Executive Officers of major corporations did not feel comfortable in the hobby environment of the small computer store or with the casual life style of the small computer programmer; they stayed away from small computers almost entirely.

In 1980, at the National Computing Convention at Anaheim, California, Apple introduced the first of a new series of business oriented small computers designed to appeal to the DP professional and the senior business manager; the Apple III. This introduction, unfortunately, was premature as quality control was not yet up to satisfactory levels and the Apple III was effectively withdrawn from the marketplace and reintroduced after the problems were resolved in November 1981. The Apple III had a built in disk drive, an 80 column screen display so that word processing applications were feasible, a 10-key pad so beloved by accountants, and an electronic spread sheet forecasting tool called VisiCalc.

In February and April of 1981 two new machines entered the marketplace which really introduced the new business small computer characteristics but in which the business features were camouflaged by other features of the new machine. In February, Vector Graphic introduced their System 3 featuring a 5 megabyte Winchester hard disk which matched in size the adjacent 5 1/4" floppy disk drive. In April, Osbourne Computers introduced the portable Osbourne 1, a computer in a briefcase or small suitcase configuration.

By the first of June 1981, the Apple III, Vector Graphic System 3, and the Osbourne I were the precursors of the new generation of business small computers, or BSC's. The entry of the first large manufacturer into the marketplace occurred on June 9th, 1981 when Xerox introduced their Model 820 small computer and the characteristics of the BSC became apparent to one and all. These characteristics seem to be:

1. The CP/M operating system to provide access to a wealth of proven software programs.
2. VisiCalc or an equivalent electronic spread sheet forecasting system.
3. An 80 column display for effective word processing.
4. A typist's keyboard and 10-key pad.
5. A system cost under $5,000.

The Osbourne portable computer had all of these characteristics except for the 80 column display. The display of the Osbourne scrolled horizontally as well as vertically so you could see the right edges of a business letter with a little manipulation. If you accept this display compromise, the Osbourne 1 is a BSC. The Vector Graphic System 3 cost was in excess of $5,000 but it included a Winchester hard disk. That capability would bring the equivalent cost of any other system above $5,000 so the megabyte storage capability was the necessary compromise with the Vector Graphic machine. The Apple III meets all the characteristics except for CP/M. With a "brain transplant", actually inserting an additional microprocessor into the motherboard, it too can run under CP/M and might be considered a true BSC. The Xerox 820, however, was the first to meet all the characteristics without modification.

Xerox had the BSC marketplace all to itself until August 11th when Hewlett Packard announced the HP-125. The HP-125 met all the BSC characteristics and was designed to look like a professional, business capable machine. Hewlett Packard was the "newest entry" for only some 24 hours however.

On August 12th IBM made its blockbusting announcement of the IBM Personal Computer and changed the small computer marketplace forever. In announcing the IBM Personal Computer, IBM broke with its own tradition in several aspects. For the first time IBM put its logo on non-IBM produced components -- the printer is an Epson (Seiko) printer from Japan and the CRT is of foreign manufacture. For the first time IBM sold through non-IBM retail outlets, namely Computerland franchise stores and the newly announced Sears Business Centers. For the first time IBM provided non-IBM software; Microsoft BASIC language, Peachtree accounting software, and VisiCalc.

Response was amazing -- somehow the entry of IBM and Xerox legitimized the small computer and Data Processing professionals and senior managers began to show up in small computer retail outlets where they would not have been caught dead a year or two before. The entry of IBM and Xerox seems to have made businessmen realize that there was something to the business small computer, that it was not going to go away, and that they should get out and look seriously at them. They appear to have done just that and the sales of Apple, Tandy Radio Shack, Commodore and others went up as well as those of IBM, Hewlett Packard, and Xerox. This change in attitude toward the small computer marketplace had a positive effect on sales of all small computers. The extensive advertising campaigns put on by these larger corporations has kept the small computer in the public eye and may well have contributed to this widespread acceptance. By the end of 1981, there were estimated to be about 1 million small computers at work in the business world. Our best guess currently is that an additional million will be sold during 1982 and that this market will double in the next 18 months to 2 years.

New computers for this marketplace are being announced seemingly every day. At the Computer Dealers Exposition, COMDEX, last November the Fortune 32-bit computer was unveiled. In the fall of 1981 the Victor 9000 was shown - a machine designed by the designer of the original Commodore PET. In January of this year, Tandy announced the TRS-80 Model 16 business computer system and an upgrade kit for their current Model II business systems. Cromemco, one of the oldest of the California computer manufacturers, announced new models that fit the BSC criteria. A joint venture between TRW and the Fujitsu group in Japan announced a business computer called the Affinity 16. As of this writing, Apple, Digital Equipment Corporation, Xerox, and Tandy have all indicated that they will announce new products in the late spring of 1982, probably before this paper is presented. 1981 was the microcomputer industry's first billion dollar year. 1982 should clear the two billion dollar hurdle easily and a five billion dollar per annum industry seems to be in the cards for the middle of this decade at the latest. With growing educational and social uses for small computers, with their demonstrated business utility, and with their pervasiveness throughout our complex society, our lives may never be the same again.

Special Interest Sessions

EA 014 918

A MICROCOMPUTER/VIDEODISC SYSTEM FOR DELIVERING COMPUTER ASSISTED INSTRUCTION TO MENTALLY HANDICAPPED STUDENTS

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The hardware and software system and instructional programs described in this paper were developed by the staff of the Interactive Videodisc for Special Education Technology Project (IVSET). The project is funded by a grant from the U.S. Office of Special Education, and is currently being conducted at Utah State University. The primary goal of the project is to develop and field test a system to provide Computer Assisted Instruction (CAI) for mentally handicapped students.

Because traditional CAI methods assume reading skills they are not suitable for a majority of the population of mentally handicapped students. Consequently, it is necessary to use spoken instructions. Recently developed videodisc players coupled with a microcomputer provide the technology to deliver spoken instructions.

The hardware for the Micro Computer/Videodisc (MCVD) System consists of a Pioneer Model 7820 III Videodisc Player, an Apple II microcomputer with two 5 1/4" floppy disc drives, a SONY 12" color monitor and a Corroll Mgf. touch panel built into the monitor. The videodisc player was selected for its rapid, random access capabilities. A typical search and retrieval of an instruction or feedback segment takes less than 1 second. The touch panel is a light interrupt system that allows the student to interact with the system by touching the monitor screen. The Apple II controls the system through computer programs and an interface device (slot board). Both were designed and developed by IVSET Project staff. The videodisc system consists of the player and the videodisc. In this paper the videodisc system is referred to as the videodisc. The videodisc is the storage medium. It has the approximate size and appearance of an LP phonograph record. It is capable of storing 54,000 individual frames of video or 30 minutes of audio and motion video on each side. It also has duel audio tracks.

The 7820 III player is the industrial videodisc model, which has its own microprocessor and has rapid random access capabilities. Any position on the videodisc can be accessed and retrieved in less than 3 seconds. It has excellent still frame capabilities, and the audio and video reproduction is excellent.

The system interacts with the student by presenting an audio instruction and the associated visual image on the monitor.

The student responds by touching the image of an object on the monitor screen. When the student touches the screen, two light beams transmitted from each axis of the touch panel are interrupted, and the point of interruptions is detected by the touch panel. The X and Y coordinates are then transmitted to the computer. The computer program in the microcomputer contains the correct coordinates for each segment of instruction. The coordinates transmitted by the touch panel are compared to these correct coordinates.

On a correct response, the microcomputer responds by finding and retrieving a segment on the videodisc which contains audio and visual positive feedback. Other possible response conditions are an incorrect response, and a non-response. Recorded segments are contained on the videodisc for these response conditions as well as a variety of feedback, including animation and motion picture sequences.

Each segment of instruction has associated parameters that specify the number of times a student must respond correctly to advance to the next instruction segment. As the student interacts with the system, data are collected by the microcomputer and stored on a floppy disc by the Apple disk drive.

Six instructional programs have been developed for use with the MCVD system to date: (1) Matching Sizes, Shapes and Colors, (2) Time Telling, (3) Identification of Coins, (4) Functional Words, (5) Sight Reading, and (6) Directional Prepositions. The first four programs have been field tested with moderately mentally handicapped students. Programs 4 and 5 are presently being field tested in elementary resource rooms.

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EA 014 919

PROFESSIONAL COMPUTER EDUCATION ORGANIZATIONS--A RESOURCE FOR ADMINISTRATORS

Dick Ricketts

> "Continuous training...is of particular importance in knowledge work. The very fact that knowledge work, to be effective, has to be specialized creates a need for continuous exposure to the experiences, the problems, the needs of others, and in turn, for continuous contribution of knowledge and information to others."
>
> Peter F. Drucker

The Northwest Council for Computer Education expected that as many as 500-600 people might come to its annual two-day conference this spring. Over 900 attended. Though the fee was $20, NCCE cleared over $11,000. The first Rocky Mountain Computer Conference sold out five weeks in advance. According to Dolan, "One speaker said that the four teachers who rode with him spent the four hours driving home in constant conversation about various sections they had attended. He reported later that he had never seen these folks so fired up; 'They talk more about that meeting and how they want to implement computing in their classes than I've heard them talk in five years.'"

Across the United States and Canada, professional computer education organizations report similar results. Many of these groups did not exist five years ago. Now they are producing newsletters, sponsoring programming contests, or participating in software swaps.

This work is done by volunteers, many of whom are driven by a sense of urgency. Their reasons for acting through professional computer education organizations are in part traditional:

1. Members view their work as an important contribution to society.
2. Members find a measure of self-fulfillment through participation.
3. Members recognize that organizations:
   a. "Facilitate a more effective cooperation among members of the profession.
   b. "Promote a more general and methodical discussion of problems relating to education.
   c. "Create means for the authoritative expression of public opinion.

d. "Make collective action possible.

e. "Maintain and advance the standards and ideals of the profession." (Report of the committee to form the American Association of University Professors.)

This list applies to all professional education organizations. The urgency computer educators feel comes from the change--the emergence of computer civilization and change in instructional computing. Logo and Pascal are competing with BASIC as the language of choice for teaching programming. New and revised instructional software is becoming available faster than it currently can be reviewed. Prices of equipment decrease and capabilities increase. In 1976, $1000 would buy a computer that stored 16,000 characters and had primitive graphics on a black and white screen. By 1983, $1000 will buy a computer that stores 64,000 characters and has good quality graphics on a color screen.

By planning for or finding money for staff to attend conferences, administrators show they are aware that computer education is becoming more important and that instructional computing may contribute greatly to effective schools. Richard H. Hersh, Associate Provost, Research, at the University of Oregon has listed attributes of effective schools:

ATTRIBUTE	POSSIBLE COMPUTER SUPPORT
Clear academic and social behavior goals.	A data base program that relates student achievement to these goals.
Order and discipline.	Peer pressure to respect computer equipment.
High expectations.	(1) Programs that provide feedback so that staff and students can see improvement. (2) The operation of computer equipment. (3) Programs that facilitate investigation beyond the normal curriculum.
Belief by teachers in their efficacy.	A data base program that provides teachers with reports of student progress.
Pervasive caring.	Computer programs should be user-friendly. People care.
Public rewards and incentives.	"Free" computer time for students who achieve agreed-upon goals.

Administrative leadership.	Word processing to communicate more effectively in less time.
Community support.	Computer fairs and demonstrations before community groups.
High academic learning time.	Inherent in running programs.
Frequent and monitored homework.	Gradebook programs that generate letters to parents regarding homework status.
Frequent monitoring of student progress.	Reporting routines in computer-assisted instruction systems.
Curriculum (and materials) closely related to goals.	(1) Programs written or modified by staff (a time-consuming effort). (2) IEP-generating programs.
Variety of teaching strategies.	Logo, text editors, graphing programs, etc.
Opportunities for student responsibility.	Student-written programs for school use, student aides, students teaching adults.

Administrators are exercising leadership regarding these and many other issues. Since nobody can specialize in everything, administrators need to ask the computer education staff for ideas and information about costs, feasibility, and effectiveness of computer-related innovations. The staff in turn can tap contacts and information available through their local, regional, or international organizations. If a proposal is implemented, educators who have made presentations at conferences can provide effective inservices.

It is possible for educational agencies and professional computer education organizations to work together more formally. SOFTSWAP, an outstanding example, has distributed hundreds of programs to thousands of locations at low cost. Computer-Using Educators (CUE) and the San Mateo County Office of Education made this arrangement:

CUE agreed to:

1. Provide guidance in the selection, evaluation and cataloging of software.
2. Provide assistance in the selection and evaluation of hardware.
3. Provide publicity and support through its newsletter and members' contacts.

4. Provide funds for the software exchange as needed and as approved by the CUE Executive Board.

5. Seek external funding through federal projects, industry grants, etc.

6. Seek donations of supplies and equipment through contacts of CUE members with industry.

The San Mateo County Office of Education agreed to:

1. Provide a central, permanent, accessible and secure location for the software library.

2. Provide clerical staff to assist visitors in operating equipment and in duplicating the non-copyrighted programs.

3. Develop procedures for filling requests for software received by telephone or by mail.

4. Purchase a limited amount of commercial software selected to represent exemplary programs in various subject areas.

5. Organize and maintain a catalog of available programs.

6. Provide professional staff direction for the project.

(From the Report to the Board, San Mateo County Office of Education, 333 Main St., Redwood City, CA 94063, May 7, 1980, "Microcomputer Center," prepared by Ann Lathrop.)

Each organization is doing what it can do best, and the result is benefitting education throughout the United States and Canada.

Administrators may not often be involved in such arrangements, but they can improve schools continually by making use of professional organizations. They can ask their staff to show them items in professional publications that address school concerns; they can inquire about conferences or meetings staff attended; and they can talk over results when the staff puts into practice what they have learned. Using professional organizations as a resource will make administrators and staffs more productive.

A Note About Organizations

Almost every brand of computer has a user's group, something like a fan club populated by enthusiasts. Members eagerly offer advice and opinions regarding that brand.

Local computer educator groups offer friendly, informative meetings. They are an excellent resource for a person considering buying a computer for personal use.

Three international computer organizations are of most interest to K-12 educators. The Association for Computing Machinery (ACM) is a professional organization primarily for computer scientists, but they have an elementary and secondary schools subcommittee (Dr. David Moursund, University of Oregon, Chairman). Local chapters are often willing to participate in educational projects if asked. ACM's address is 11 West 42nd St., New York, NY 10036. (212) 869-7440.

The Association for Educational Data Systems (AEDS) is concerned with both administrative data processing and instructional computing. Local chapters place their emphasis according to the composition of their membership. AEDS sponsors an annual programming contest for students, and some chapters offer scholarships to high school students. AEDS' address is 1201 Sixteenth St. NW, Washington, D.C. 20036. (202) 822-7845.

The International Council for Computers in Education (ICCE) is concerned with instructional computing and with teacher education. Organization Members are autonomous, and many are affiliated with other organizations. ICCE is the youngest of the three organizations and is growing rapidly. ICCE's address is Department of Computer and Information Science, University of Oregon, Eugene, OR 97403. (503) 686-4429.

Several specialized and regional professional organizations exist, and many educational organizations take some interest in instructional computing, The National Council of Teachers of Mathematics in particular.

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LITERATURE RESOURCES RELATING TO COMPUTER SCIENCE EDUCATION IN SMALL COLLEGES

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Introduction

The development of academic computer science has generated a rich literature over the years, however, those of us charged with the responsibilities for programs, especially in smaller colleges, sometimes find it difficult to remain current in all its aspects. At this time there is intense pressure on all of us to implement new programs or expand existing ones due to an equally intense pressure from students hoping to enter the computer field. All this is further complicated by the fact that expanding faculty positions is at best difficult, and even when a position is granted it is next to impossible to fill it with a qualified individual.

As a result it becomes all the more important that we learn from each other what approaches to computer science education are most effective. With various professional societies moving ever closer to some form of accreditation for programs in computer science, it becomes an urgent matter to have a good understanding of the nationally recommended curricula and knowledge of the experiences gained in their implementation.

It is the purpose of this paper to briefly identify key resources regarding computer science education at small colleges. As such, the major emphasis is on the reference list appearing at the end of the paper. Included in it are significant papers and reports dealing with computer science education which are either written by individuals at small colleges, or are addressing topics which are of particular importance to individuals at small colleges. This reference list is preceded by a brief discussion which classifies the material into appropriate topics.

As in my literature review, there are, no doubt, significant omissions. Some are intended, others were simply missed. The reader of this report is encouraged to communicate any thoughts on other references which should be included to the author.

Background

This review will, for the most part, consider only materials published after 1978. An extensive review of the literature of computer science education for the period 1968-1978 has been prepared by Austing, Barnes, and Engel (A7). Another key background document is the compendium of curriculum material recently prepared by the Education Board of the Association for Computing Machinery (ACM). This document includes the significant reports prepared by ACM prior to 1978 as well as some of the more recent works (E1). There are eight reports on the following topics:

1. The 1968 recommendations for undergraduate programs in computer science.
2. The 1972 recommendations for graduate programs in information systems.
3. The 1973 recommendations for programs at small colleges.
4. The 1973 recommendations for undergraduate programs in information systems.
5. The 1978 recommendations for undergraduate programs in computer science.
6. The 1980 recommendations for master's level programs in computer science.
7. The 1981 recommendations for educational for educational programs in information systems.
8. The 1981 recommendations for associate level programs in computer programming.

As such, this document represents, perhaps the most important single source to supply background information for curriculum planning.

The Recommendations of the Professional Societies

The major professional societies have prepared recommended, or model, curricula of interest to the small colleges, which may be classified into five groupings:

1. The undergraduate program in computer science by ACM (A6).
2. Programs in information systems by ACM (N2, C12).
3. The undergraduate program in computer information systems by the Data Processing Management Association (DPMA) (A1).
4. The general mathematatacal sciences program by the Committee on the Undergraduate Program in Mathematics (CUPM) (C6).

5. The undergraduate program in computer science and engineering by the IEEE Computer Society (IEEE/CS) (C1).

While the IEEE/CS, DPMA, and ACM reports emphasize major programs in computer science, the CUPM recommendations consider how computer science fits into the mathematics curriculum and suggests a minor in computer science.

There have been a number of articles which review the curriculum recommendations. Nunamaker has prepared a discussion of the ACM curriculum in information systems (N3). An evaluation of the DPMA model was presented by Mitchell and Westfall (M14). Finally, there have been several reports comparing the ACM "Curriculum '78" with the IEEE/CS Model Curriculum. Among these are the articles by Engel and Garcia (E5, E6).

The implementations of these guidelines, especially as they relates to the small college, has been addressed by a number of authors. Among those addressing the implementation considerations with "Curriculum '78" are Fosberg (F3), Miller and Peterson (M10), Davies and Gargantini (D4), Mayer (M4), Engel (E3), Lopez (L5), Worland (W6), and Winrich and Petersen (W5). Specific details on how "Curriculum '78" might impact student development was discussed in position papers for a panel moderated by Dale (D1).

How the interaction of "Curriculum '78" and the Model Curriculum of the IEEE/CS might be used in a curriculum implementation was discussed in a panel moderated by Rine (R2), and in papers by Mitchell and Mabis (M13), and Powell (P1). The implementation of programs in information systems was considered by Barrett (B4), Gerlash and Goroff (G1), and Swanson, Hatch, Lane and Sondak (S8).

Accreditation mechanisms have an obvious relation to the implementation of proposed curriculum models. The general area of accreditation was addressed in a panel discussion moderated by Dalphin (D2), and the specific area of accreditation in information systems is addressed by Gorgone, Sondak and Konsynski (G2).

Course Related Issues

A great deal of material has been prepared covering aspects of particular courses. Courses are considered at all levels of the curriculum and the articles tend to concentrate on particular problems encountered and solutions found.

The beginning course, or courses, has received the greatest coverage. Gruener and Graziano (G5) and Lemos (L2) discuss studies of the first course and the teaching of programming languages.

Several papers consider alternative approaches to the first course. Stoddard, Sedlmeyer and Lee (S7) and Stoddard and Leeper (S6) consider the issue of depth of coverage. Szalajka and Walch (S10) discuss the integration of theory and practice. Dersham (D6) presents a modular approach. Bowles (B8) discusses the use of microcomputers at this level. Riley (R1) considers the role of problem solving in the first course. More general discussions of the first course are provided by Benard (B7), Behorooz and Sharma (B5), and Meinke and Beidler (M7).

Descriptions of the second course in the curriculum sequence are presented by Noonan (N1) and Meinke and Beidler (M6). The role of style and good programming practices is discussed by Alpert (A4), Roth (R5), and Rohr (R4). More general topics are also considered. Crenshaw (C10) discusses team projects. Miller (M9) considers methods for the evaluation of student work. Cleveland (C4) presents a method of teaching programming languages. The special role of Pascal within information science programs is discussed by Merritt (M8).

Descriptions of aspects of intermediate and advanced computer science courses include a discussion of tools to assist in the teaching of data structures by Beidler and Meinke (B6), description of a hardware course by Cook (C8), and discussion of a machine independent assembler by Luce (L8). Systems programming has received considerable attention including a discussion of the problems students of such a course may have when they leave school by Conner and DeJong (C7), a laboratory to support the course by Lees (L1), the use of projects in the course by Wadland (W1), and a general discussion by Winner (W4). Rohr (R3) considers tools to be used in a compiler construction course.

Additional courses have received attention in the literature. These include systems analysis and design by Goroff (G3) and Spence and Groat (S5), Computers and the Law by Roth (R6) and Koltun (K1), graphics by Moore (M15), microcomputer studies by Lin (L3), firmware development by Cook (C9), and natural language processing by Fosberg (F2). Stalajka (S9) discusses the special needs for statistics in a computer science program, and Schrage and Sharp (S1) consider the supporting computer laboratory necessary throughout the curriculum.

Program Related Issues

Philosophical issues regarding computer science programs, especially at small colleges are presented by Agresti (A2), Brackett, Nestman, and Spees (B9), Crosland and Codespoti (C11), Cameron and Karian (C2), Chrisman (C3), D'heedne (D7), Horton (H7), Mitchell (M12), Mein (M5), and Smith (S3). These issues expanded to cover all of academic computing at minority institutions are discussed by Marshall (M1, M2), Marshall, Alderman, and Jaeger (M3), and Hamblen, Jones, Lewis, and Marshall (H4).

Jensen, Tonies, and Fletcher (J1), and Fairley (F1) present descriptions of an undergraduate program in software engineering. Minors and other sub-major course sequences are discussed by Linder (L4), Ellison (E2) and Ahlgren, Sapega and Warner (A3).

The special role of mathematics in the computer science curriculum is covered in a paper by Hintz (H6), and in a panel discussion moderated by Archibald (A5). Additional program related topics include an accelerated program by Shamara and Behforooz, (S2) work experience by Dersham (D5), the use of an advisory board by Grout and Hyams (G4), behavioral objectives by Baldwin (B3), service courses by Mitchell (M11), and the role of structured programming by Weiner (W3).

Other Material

Perhaps the most complete description of what is going on is contained in the comprehensive survey of computing in U.S. higher education by Hamblen and Baird (H3). This is supplemented by a collection of interpretive reports based on the survey and edited by Hamblen and Landis (H5). Specific attention to the data as it relates to small colleges was prepared by Engel (E4). Lopez, Raymond and Tardiff (L7) also prepared a survey of computer science offerings at small colleges.

The initiation or expansion of programs usually requires an evaluation of need. Hamblen (H1, H2) has prepared comprehensive reports on the projected demand for computer scientists by states, as well as the projected supply that is to be anticipated. Bailes, (B1), and Bailes and Countermine (B2) consider the related question of faculty to teach in computer science programs. Codespoti and Bays (C5) discuss a method for the preparation of faculty.

Additional material of interests includes discussions of the personal computer in the curriculum by Walstrom and Rine (W2), and Lopez (L6), and programs for adult continuing education by Solntself (S4) and practicing programmers by Danielson (D3).

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THE USE OF MICRO-COMPUTERS IN EDUCATIONAL EVALUATION

Mark M. Greene, Ph.D

Good afternoon! It is a pleasure to be here today.

In the present paper, I would like to share with you my experience in acquiring and using a micro-computer for educational evaluation.

For the past 14 years, I have worked as an evaluator at the Northwest Regional Educational Laboratory in Portland. For 12 of those years, I have directed a program at the Laboratory which provides contracted services to local school districts, State Departments of Education, social service agencies, colleges and universities, as well as some organizations in the private sector. In general, my staff and I provide eight forms of service. The services include:

- Third party evaluation
- Evaluation consultation
- Evaluation training
- Applied research
- Planning
- Technical review
- Training in the areas of monitoring and technical assistance
- Accomplishment auditing

In general, however, the work has been concentrated in the area of third party evaluation.

In order to understand our program's involvement in micro-computers, I believe that you will need to know something about our work load.

Within our program, there are three principal investigators. Between us, we work on roughly 90 individual projects per year. Some of the projects are single classroom activities, while others are district-wide programs. Moreover, the projects are sponsored by a diverse array of funding sources such as:

- ESEA Title I
- ESEA Title IV
- Bilingual Education
- Migrant Education
- SDIP Title III
- Special Education

As you can well imagine, each of the funding sources marches to a different drummer. This means that our staff is faced with individual timelines and reporting requirements that represent a considerable challenge. During the spring and summer months, simultaneous deadlines for final reports are a common occurrence--which brings us to our reasons for using the micro-computer.

I. Reasons For Using A Micro-Computer

A. Massive Quantities of Data

As is evident, our staff is faced--at any one time--with massive quantities of data. The data may represent fifty children screened in a Head Start program or it may be derived from 700 students in a Title I program. Our challenge, then, is to accommodate the massive quantities of data from varying sources.

B. Multiple Analyses

Once having confronted the massive arrays of data, a second challenge emerges. That challenge entails the conversion of the data into useful information. Generally, such a conversion will require multiple analyses of the data. That is, we have rarely found it possible to extract the meaning from data after one pass through the machine. Moreover, there is something about the immediate access to additional analyses that is quite appealing.

C. Staff Differentiation

Considering once again the challenge of large quantities of data--we learned early on that data reduction and analysis procedures can be routinized. That is, it is not necessary for a single individual to handle every data transaction from start to finish. Nor is it cost/effective to do so. (Moreover, as graduate students and former graduate students are aware, some aspects of data handling are more appealing than others.) Thus, one of our strategies has been to divide the data handling operation into relatively routine "chunks" which can be handled by various members of the support staff. And, it is the micro-computer which enables us to differentiate among staff assignments.

II. Reasons For Selecting the Apple

About three years ago, the micro-computers entered the mainstream. Knowing that we would eventually acquire one, we entertained a number of selection criteria.

A. Capacity

The capacity of the machine to store data was the foremost consideration. Having previously worked with three generations of desk top calculators, almost any storage capacity whatsoever would have been welcomed.

B. Available Software

The availability of software was another serious issue. Having suffered through some severe software limitations with the programmable calculators, we were hoping to find a machine for which useable statistical software would be abundant.

C. Availability of Individuals Who Could Develop Software for the Selected Machine

Again realizing that pre-packaged software has limitations, we were interested in selecting a machine which used a commonly employed language. In this case, BASIC (or some close derivative) was the language of choice. We hoped to be able to use BASIC since the use of a common language or dialect would improve our opportunities for (a) modifying extant statistical packages, and (b) developing new ones.

D. Potential for Linkage with Client Computers

The possibility of linking our micro-computer with those of clients was a fourth criteria. Our interest here was, again, based on the notion of differentiation of tasks. If we could select a machine that was compatible with our clients' machines, then the possibility for reducing our data handling load would be increased.

E. Availability of Support Service

A fifth consideration was represented by the concept of support for the machine. Knowing how difficult it had been to obtain service for exotic, programmable calculators made us keenly aware of the service-support issue.

F. Potential for Upgrading

In one sense, our experience had been the same for each of three generations of programmable calculators. Specifically, even though we bought "top of the line" equipment, we also seemed to be buying "end of the line" equipment as well. Once we had purchased an item, it was predictable that within two years, a new model would enter the market. We hoped to avoid that problem by buying a micro-computer with ample potential for upgrading.

G. Relative Speed

Again, considering the amount of data to be processed and the ever conflicting deadlines, we were hoping to reduce the data processing time considerably over that of the desk top calculators.

H. Known History/Reputation of the Equipment

For our program, "down time" is virtually intolerable. We simply need reliable equipment.

I. Relative Cost

The equipment selected had to be within the means of our Program.

J. Redundancy/Compatibility

Based on a cautious view of mass produced electronic hardware, it seemed reasonable to select equipment that was compatible with other operating equipment within the organization. Thus, the back-up capability of other micro-computers seemed to be an important consideration.

Having established the foregoing criteria, we selected an Apple II. In retrospect, however, not all of the criteria for selection worked. For example, the capacity of the micro-computer to store data is a good reason for getting away from programmable calculators, but did not assist us in distinguishing between the leading varieties of micro-computers. This was also true of the relative speed criterion and the cost criterion. Additionally, not all Apples speak the same language--so the concept of working from data discs produced by our clients has had only limited success. Finally, the criterion of available software did not hold up and it became necessary to develop our own. For the most part, however, the remaining criteria proved to be useful.

III. Preparing to Use the Micro-Computer

The purchase of our Apple II was carefully timed to give us opportunity to adopt, adapt or develop some analysis programs before our annual data crunching festival. As it turned out, our estimates of the amount of preparation time necessary were only off by about a year.

In general, we found that the available data analysis programs do just that: they analyze data. Our needs, however, were for programs that would accommodate a certain work flow. That work flow (See Figure I) entails some eight or ten steps.

The work flow begins with (1) planning for data collection, (2) collecting the data, (3) reducing the data, (4) entering and verifying the data, (5) moving or selecting the data, (6) conducting one or more analysis, (7) moving or selecting the data again, (8) conducting additional or parallel analyses, (9) interpreting the results of the analysis, and (10) reporting the results.

The challenge facing our program at this point had seven elements:

a. To create a file system which could accommodate diverse data records;

b. To develop a data entry and editing procedure;

c. To develop data movement programs;

d. To develop programs for routine analysis;

e. To test and certify the programs;

f. To train our staff to use the system; and

g. To upgrade the programs periodically.

Essentially, the development effort took 14 months. My task was to define the structure and the specifications as well as to test the resultant effort. The programmer's task was to develop and upgrade the various routines.

The overall effort, then, was far larger than was anticipated, but the result is a data handling system that meets our requirements. There are, however, a few limitations to the system. Such limitations include:

a. The length of time required to train new staff to use the system;

b. An inherent limitation on the size of the sample which can be accommodated (about 400 cases); and

c. Data entry time based on keyboard or keypad is still the slowest part of the operation.

In general terms, however, the micro-computer represents a versatile, time-saving tool which has enhanced our efforts in evaluating educational programs.

FIGURE I

HOW THE MICRO-COMPUTER FITS THE WORK FLOW

1. Planning for data collection
2. Data collection
3. Data reduction
4. Data entry and verification
5. Data movement
6. Data analysis
7. Data movement
8. Data analysis

---Use of Micro-Computer

9. Data interpretation
10. Data reporting

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THE MICROCOMPUTER IN THE HIGH SCHOOL SCIENCE LABORATORY

Michael R. Haney

Science and technology seem a natural combination. Technology is a product of science so it seems natural to use technology in science. Scientific research at all levels is dependent on the technology available and schools would appear to be no exception. As the price and capabilities of computers become even more attractive, most educators agree that computers will be thoroughly incorporated into education. How then will computers change science education? That fundamental question leads in two different directions. Both are important and they are interrelated, but maintaining the distinction is crucial to using computers in a meaningful way in science education. It is this distinction that forms the foundation of this project and the reason it was begun.

It has become popular now to degrade the present curriculum in the face of modern technology as a "sabre toothed curriculum" steeped in anachronyms like the "QWERTY" typerwriter. It may be true that the present curriculum reflects limitations that existed before the computer,but the solution is not simply to incorporate tHe computer wherever it will fitnicely into the curriculum. Educators are at a rare point in the evolution of education. They can now re-examine the fundamentals on which the educational system is built in light of new technological capabilities that lift many of the restraints that have become part of the educational culture. Narrowing the view to just science, educators can now ask, "What is science?" and "What do we really want students to learn in science?"

Providing Tools for Teachers

Any science teacher who has worked in a science research lab, possible during vacations or while a student, was probably struck by the difference between what goes on in scientific research and what goes on in the high school. In research there are real problems to solve scientifically. Experiments must be designed, tested at every stage and predictions made of the outcomes. A refinement process goes on continuously to narrow in on the results. The researcher must always know the limits of the measurement and their effects on the results. After a hypothesis is tested, it may lead to additional hypotheses and experiments. Finally, the results must be communicated in such a fashion that others will understand the results and the process that produced them.

A researcher must have certain skills to carry out science. The ability to calculate, measure, extrapolate, design, communicate, construct models, research the literature, reason verbally and spacially are just a few of the essentials. The researcher applies all of these with imagination and intuition. There is simply no lab book with a recipe to follow.

Now consider the high school science classroom. Among other things, there is generally a heavy dosage of listening, book research, history of science, emulation and demonstration. These are all in addition to laboratory experiments and problem solving exercises. National Science Foundation studies reported by Weiss indicate that only a smallportion of science class time is actually spenton experimentatIon. Apparently, science teachers do not see student experimentation as a major priority in science. The reasons are attributed to lack of readily available equipment, prepackaged and ready-to-go. So it seems that in science classrooms, for whatever reasons, more time is spent teaching about science than doing science.

Our profession is now in a unique situation where we will be able to do whatever we are trying to do much better and more efficiently thanks to technology. It is important to decide first what it is that we want to do in science classrooms.

This project is based on three premises:

1. Science is primarily the process of examining, modeling, and understanding nature.

2. The best way to learn science is by doing science.

3. Computers can be a fundamental tool for doing science.

I do not underestimate the importance in teaching about science or in teaching basic science skills. Yet It is important to integrate some real science into the science curriculum so students can enjoy this

> "...adventure of the human spirit...an artistic enterprise stimulated largely by curiosity, served largely by disciplined imagination, and based largely on faith in the reasonableness, order and beauty of the universe of which man is a part." (Weaver)

The interrelated roles must be understood to appreciate the importance of each.

The Role Of the Microcomputer

The computer can play two different roles in the science classroom. These can be related to how we expect students to gain knowledge. Understanding this distinction clearly shows the purpose of science education and the focus of this project. The first role for the computer is as a teacher. The second role is as a tool for accessing, representing and creating knowledge.

Both roles relate the student and the local knowledge. This local knowledge includes the collection of skills, information, and abilities maintained at the school. What resources are open to the student depend on in part on the library or text book selection, the materials on hand, the portals to the larger knowledge bases (the outside world such as TV or radio) and the selection of staff. Together these factors make up the knowledge that is available locally to the student in the school--the local knowledge base.

In its role as teacher, the computer taps the local knowledge and delivers the information to the student. To implement such a system, educators ask such questions as "How do children learn?" and "What should they know?" and "Where can they get this knowledge?" Care is taken to select sequences which are seen as worthwhile and efficient. Students are rewarded and reinforced for the knowledge they gain. If done well they develop verbal, reasoning, and spacial skills. Computers are used in this role through CAI in tutorials and Drill & Practice. Simple simulations which have set purposes and predetermined learning outcomes fall into this catagory also. Special languages are available, such as PILOT, to help teachers author such materials.

In its role as tool, the computer helps the student interact with the local knowledge base. Educators would have to ask such questions as "What must children be able to do?" and "How can they use knowledge?" and "When should they use the knowledge?" Students would gain the abilities to access knowledge, to represent knowledge in models, and to create new knowledge. Examples of the computer in this role include Dendrite, an intelligent data base for science, MAMMO, an open-ended inquiry simulation and laboratory Input/Output.

There are inherent problems with using the computer in this second role. To use the computer as a tool, the students must first master the basic skills of science. The computer as a teacher may preceed the computer as a tool, but it should not exclude this second role. Where considerable time and money have been devoted to producing good computer teachers, very few resources, at the high school level, have been devoted to producing good computer tools. The reasons for this are extensive. First, it involves rethinking what we mean by science. Second, it requires an open-endedness that is not normally associated with science classrooms. If all students are doing the same lab, looking for a pre-known result, can this be considered a science experiment? On the other hand, can we expect teachers to spend hundreds of extra hours preparing individual projects? This leads to the third reason. Teachers need the tools and the preparation to cope with real science in the science classroom even if it is only on a part-time basis. The computer should make experimentation much more meaningful and manageable, but many teachers are not yet prepared to use the computer intelligently.

That then is the focus of this project. It is to provide teachers with a tool box. This tool box should be versatile, composed of fundamental parts, and durable. This project is intended to provide teachers with basic tools for using the computer in the science laboratory. Along with each basic tool is an explanation of how the tool is intended to work. A few basic demonstration pieces are done with each, enough so that the teacher can picture the versatility of the tool. Then to show the possibilities, sample applications are included ready for use in the lab, along with suggestions for other ways the tool can be used. The emphasis is on the incompleteness of the description. Unlike the traditional "tools" handed to teachers, these are as diverse as the teachers themselves and should find applications as numerous as the word tool implies.

The aim of this project is to make teachers intelligent users of this technology so they can, in turn, apply it to their classrooms. Eight modules were designed to help them foster science experiments in the high school laboratory. Of these, three are complete and several others are almost finished. These modules are interlocking. By that, I mean they share data in a common form, thus deriving the benefits of the features of all the modules. Teachers' guides have been written for the completed modules. Both complete examples and a short list of suggested applications in traditional high school science courses are included with each module. It is hoped that the actual applications teachers find will go far beyond anything I have designed or even imagined. These modules will be tested in over a dozen high schools this year.

An important consideration built into each of the units is the emphasis on the user making the critical decisions. Accordingly, the automatic compensation for data which a computer could easily manage has been minimized. The user must decide the durations, ranges, data types, and method of representing data.

Modules

Module 1: Introduction and Overview. This is an introduction to the entire system. It includes the philosophical groundwork necessary to put the modules into perspective. Also, the interlocking data features are explained, utility programs are documented, and relevant resources are listed.

Module 2: Scratchpad and Conversion. The calculations done in many science experiments are tedious. The time required often exceeds the learning payoff for the user. This unit is structured around conversion formulas. Some are built-in, more can be entered by the user. Each of these conversions can be used to do calculations requiring a single variable or to do complex calculations in a table form. For example, the user can build a table by selecting the headings for each of the columns. These headings can come from stored files on disk, simple sequences beginning at any integer value, hand entry, or calculation done by a conversion formula. The columns that result from calculations can be based on any (or all) or the previous columns or the totals or averages of those columns.

Module 3: Data Acquisition. For most uses, this unit requires additional hardware, an interrupt timer and an interface box. What is necessary can be built, the plans are included, for under $20. With this, the user can read in data through a paddle or button port at timed intervals or when triggered. Data can also be hand entered or read in from disk files. The data can then be displayed as a Cartesian, log, or histograph.

Module 4: Error. Data can be entered from other units and analyzed according to the standard methods.

Module 5: Data Manipulation. Although this combines the features of several different modules, it allows a wider range of features than were possible in the others. This includes special graphs like polar and log-log as well as curve smoothing features.

Module 6: Filing Cabinet. This represents a method of organizing information so that it can be updated and accessed readily later. Included are three searching schemes and a cross-reference table between storage methods.

Module 7: Control and Digital-to-Analog Conversion. With this module, the user will be able to output control or sound signals through the annunicator ports. These signals may be generated by the interrupt clock or from stored data.

Module 8: Data Based Information Retrieval. Undeveloped at this time.

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THE MICROCOMPUTER: A CAREER INFORMATION MACHINE?

by Michael J. Neill
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Information is a resource. For those who can afford it, it is a resource that can describe the present and reduce the uncertainty about the future. Like other resources, information has value. For centuries, governments, armies and individuals have bought, sold, bartered and consumed information. Those with accurate and timely information have been in good positions to control their own fates.

A democratic society has a stake in making information widely available. The choices people make based on complete and accurate information benefit both society and themselves.

Like any product, information is produced from raw material. For this product the raw material is data. Sometimes few data are required to produce information; often many data are required. Crafter who produce information must apply careful, thoughtful and systematic analysis to the data they use.

Quality information is the product of good data and/or good analysis. Where data are sparse, analysis must be excellent to infer patterns which describe or forecast. The characteristics of quality information must include:

- accuracy. Information should adequately describe current reality.
- relevance. Information should be personally useful and be presented in an understandable format.
- timeliness. Information should be received at a time which will make it useful to the consumer.
- availability. Information should be located in a place that is convenient for the consumer and the retrieval process made easy.

Effective use of information is as important as the quality of it. Teachers, counselors, librarians and others teach people how to utilize information tools. One author[1] blames the failure of information systems in organizations on the lack of proper training and involvement of users.

For the past twenty years computing has made possible the delivery of data. In a few areas where information is perishable, it too can be delivered by computer. Computer microization is seen by many as the tool which will dramatically alter the way in which

1. Lucas, Henry C., Why Information Systems Fail, Columbia University Press, New York, 1975

information is disseminated in a technological society. "Electronic publishing" or the new "information industry" will be in the business of delivering information to consumers in a manner which will pay for the relatively high costs of production/analysis. Successful enterprises will be those which focus on quality information. Consumers will soon see that poor information delivered on the latest technology is still poor information.

Models for delivery of quality information on large or mini timesharing systems have been in place for years. One such model is the Career Information System (CIS) housed at the University of Oregon. The Oregon Career Information System delivers local labor market and educational inform[illegible] to over 400 sites in Oregon. In addition, a National Career [illegible]mation System assists seventeen other operators to produce and delivery quality information to their constituents using similar software, training components and methodologies.

The Career Information System (CIS) has designed a system which delivers information for career planning purposes. Research shows that people planning careers require an accurate description of the labor market most relevant to them. In addition, they require information about preparing for a career, educational or training opportunities, schools offering these programs, financial aid, and even information on where to get more information. CIS pulls together occupational and educational data from widely scattered sources and produces coherent statements for the consumer. Although some good national data are available, most labor market and educational data are produced at the state and even the substate level. Consequently, CIS is a model for deliverying information based upon current, accurate, locally relevant data.

The information put into the system is derived from data collected and analyzed from sources as close to the local labor market as possible. Trained analysts review hundreds of documents for the purpose of comprehending the dynamics of the labor market. These analysts then write about occupations in easily understood language. Each occupation in the system is reviewed at least annually. Many pieces of information are updated as soon as the data are made public. Similarly, information about educational programs and institutions are reviewed annually by trained analysts on a schedule that coincides with the changes made by the institutions. Sources of data are referenced, catalogued and updated frequently.

In addition, information can be frequently updated by distributing tapes, disks, or other machine-readable information files to computer centers which operate the system. This update insures that some degree of information currency is maintained for users.

The components of CIS have been designed to access computer stored information via teletypwriter terminals and microcomputers or through a needlesort system with printouts of the System's information bound in book form. By storing and accessing the System's information in a computer system, the information can be easily updated. Computers also allow the flexibility of accessing any component at any time.

The information in a CIS is delivered either on computer systems or in a manual print or microfiche format. Computer delivery allows users to randomly access any piece of information and to sort quickly through occupational titles that match a user's interests and abilities. In a sense, computer power allows the user to simulate a variety of labor markets that might require his or her unique skills and interests. The details of individual occupations within that market are available by typing a few simple commands. Computer delivery has been found to be attractive and motivational for both youth and adults. In every survey of CIS users over 80% report that it is easy to use.

Occupational and educational information are integrated throughout CIS. Consumers are never left at dead ends in their search for personally useful information. Relevant information is all in one easily accessible place, not scattered throughout a variety of books, pamphlets and catalogs.

Proper training for users is as important as the information review. The history of many information systems in education and other public agencies suggest that users must see the benefits of using a system in order to justify altering current counseling practices. CIS actively designs, promotes and implements a program of training for personnel at all sites which use the system. In such training, users are taught effective use of a powerful system.

Some of the major components of the Career Information System are:

QUEST - an introductory questionnaire that allows users to identify occupations that would utilize their interests, aptitudes and personal preferences.

DESCRIPTION FILE - information on occupations that represent over 90% of a state's employment. Users may access an occupational description and receive a 300 word description of job duties, working conditions, wages, hiring requirements, and employment prospects. The descriptions can be localized to specific labor markets within a state.

BIBLIOGRAPHY FILE - information about the most pertinent publications for each occupation in the System.

VISIT FILE - names of local people available to discuss their respective occupations with interested individuals.

PREPARATION FILE - a statement for each occupation in the system that includes ways to prepare for the occupation, skills needed, licensing requirements and a cross-reference to appropriate postsecondary educational training.

PROGRAM FILE - information on postsecondary educational programs and a description of degrees offered, specialties, program objectives, courses and a list of schools in the state that offer the program.

SCHOOL FILE (State) - information on all two-and-four year colleges and licensed proprietary institutions in the state. Users may compare schools selecting the information they want from a list of over 70 different information topics.

SCHOOL FILE (National) - information on all four-year schools in the United States. Users may compare schools by selecting information they want from a list of over forty information topics. Users may also sort and produce lists of schools based upon selec'ed characteristics of the schools.

PLANNING SYSTEM FILE - information presented in greater detail for administrators who plan training programs and economic development strategies. The file includes program and occupational data, lists of major employers and references to major data and methodological sources.

CIS is an information system that utilizes the computer as a delivery mechanism. CIS is not a computer system or a piece of software. The information is delivered using conventional technology as well as computers. Of prime importance to information system designers is the quality of the product rather than the sophistication of the medium.

Publishers of printed information often are forced to sacrifice some measure of quality in order to market their product to the consumer. Encyclopediae, for example, are marketed to individuals, but soon lose currency and accuracy as the original books become dated. Annual updates are not integrated into the body of the book and make the product less useful. Libraries buy more expensive esoteric publications. College guides, business directories or indices to periodicals are common reference sources in libraries, but are typically not found in homes. The information is less available for individuals, but otherwise meet criteria for quality.

Publishers of electronic information will have to meet the challenge of producing, distributing and training people to use quality information. The microcomputer has opened up a new market for mail-order or retail outlet information systems. Once several technical and and legal questions are resolved, the distribution of information on microcomputers will offer several advantages over printed copies of the same thing.

These advantages include:

1. Updated material can be integrated into the electronic data base. Updates will produce new files rather than appendages to existing files.

2. Information can be accompanied by source data and the programs to manipulate them.

3. Interactive modules can instruct users on how to effectively utilize the information. Such modules can accompany the data base.

4. Information can be actively displayed in a variety of ways, including simulations, graphics and animation techniques.

5. Microcomputers can help to reduce the cost of delivering information. Existing systems often only transfer the cost from one budget to another.

6. Users will control the flow of information and can select items based on attributes coded to their interests.

The microcomputer is becoming accepted as an information medium. It may someday meet the expectations people had for television and print publications as vehicles for informing the public. Perhaps it is too early to tell whether the microcomputer will become an information machine as well as an entertainment machine. It's presence in the home, however, would lead one to believe that it's users will become more adept in its use and will demand that information delivery applications be sophisticated and of high quality.

COMPUTER ASSISTED PROBLEM SOLVING IN MATHEMATICS

Donald T. Piele

To the general public, computers are strongly associated with mathematics and mathematicians. This connection stretches back in time to the very beginning of the concept of numbers and their representation by a physical thing - from a pebble, to a bead on a wire, a mark on a piece of paper, the rotation of a mechanical wheel, to the state of an electrical relay, a vacuum tube, a transistor, and, now, of an integrated circuit on a single slice of silicon. This alliance between computing and mathematics is very real. Eminent mathematicians occupy critical positions on the list of men and women who have contributed to the advancement of automatic calculating machines. Blaise Pascal — invented the first machine capable of performing arithmetical functions; Gottfried Leibnitz — created an ingenious way to perform multiplication and division mechanically; Charles Babbase — devised the Analytical Engine, generally recognized to be the first programable computer; Ada, Countess of Lovelace — worked with Babbase, ultimately creating the complete specifications for his general-purpose computer; Howard Aiken — originated the idea of using magnetic relays to construct a general purpose computer; John von Neumann — contributed the concept of a stored program, a major step in the development of computers; Stanislaw Ulam — invented the Monte Carlo method for finding solutions to mathematical problems by random sampling with a computer; John Kemeny — co-authored the BASIC computer language; Patriek Suppes — pioneered the development of CAI; John McCarthy — developed the LISP language; and Seymour Papert — directed the creation of the LOGO language.

Ironically, the obvious computational power of the computer has led to some confusion about its use in the mathematics classroom. It is not uncommon to hear arguments against the use of computers in mathematics which are based upon the fear that students will no longer need to develop computational skills if a computer "can do the work for them." At the other extreme, some teachers enthusiastically endorse the use of computers as a tool to individualize the teaching of these computational skills. Both views place a heavy emphasis on the computational aspects of mathematics. But to mathematicians, the computational power of the computer has always been viewed as a service to the primary function of mathematics — problem solving. A common thread running throughout the work of the mathematicians who contributed to the development of computers is the desire to relegate to a machine the bookkeeping and computational chores that impede the creative work that humans do best — solving problems.

Problem Solving — Today

Teachers of mathematics recognize the importance that problem solving plays in their field. In its recent report, Agenda For Action [1], the National Council of Teachers of Mathematics identified the improvement of problem-solving skills as its primary objective for the 1980's. In a separate PRISM study (Priorities in School Mathematics) [2], problem solving — the development of methods of thinking and logical reasoning —

was identified by 95% of the teachers responding as the most important objective in the teaching of mathematics.

But in reality, students spend nearly all of their time today getting ready for problem solving. The first six years of mathematics in our schools are devoted to learning the four basic functions: addition, subtraction, multiplication and division. So much time is spent mastering these computational skills that almost no time is left for actually solving problems.

Problem Solving — Tomorrow

The use of computers in the classroom will bring, in the next ten years, increasing pressure for change in the mathematics curriculum. Specifically:

1) Computational activities will be handled more and more by the computer.

2) Software packages that extend the user's ability to investigate non-routine problem solving situations will replace many purely computational exercises.

3) Programs that place students in problem solving environments in which they can set parameters and make decisions while a computer reveals the consequences of their actions will become part of the curriculum.

4) Mathematical programming — constructing algorithms and running them on a computer — will become an accepted part of the mathematics curriculum.

In general, the availability of inexpensive microcomputers will make it possible for students to use a computer as a partner in the problem solving process. In some areas of the United States this is already being done.

Project LOGO

Over the past ten years, Seymour Papert and his collaborators at M.I.T. have been building a model for the role of the computer in the classroom very different from what is commonly seen today. In his recent book, Mindstorms, Papert describes his fundamental departure from the present:

> "In many schools today, the phrase 'computer-aided instruction' means making the computer teach the child. One might say the computer is being used to program the child. In my vision, the child programs the computer and, in doing so, acquires a sense of mastery over a piece of the most modern and powerful technology and establishes an intimate contact with some of the deepest ideas from science, form mathematics, and from the art of intellectual model building." [3]

The key to making this happen, according to Papert, is designing computer languages, "so that learning to communicate with them can be a natural process, more like learning French by living in France." He compares learning mathematics in his computer assisted 'Mathland' to learning French in France.

Papert designed the LOGO language as a first step in creating a computer environment in which young children could learn to use computers in a significant and masterful way. He convincingly illustrated in his book that programming in the LOGO language is "childs play."

The significance of Papert's work lies not so much in the development of LOGO or the fact that young children can easily learn to speak in that language. What is more important is that Seymour Papert, a mathematician — a person deeply interested in how people think and how they learn to think — has charted a completely new direction for the use of computers in the mathematics classroom. In the computer based learning environment, 'Mathland,' that Papert creates, students learn problem solving and mathematical concepts while programming the computer to carry out a certain task. Thus, students learn how to control a new intellectual tool, and problem solving becomes a natural and integral part of mathematical training. This is a radical departure from the traditional "programmed learning" role that has been associated with computer education. The LOGO project follows instead the wisdom of the ancient Chinese proverb:

I hear and I forget
I see and I remember,
I do and I understand.

What Can Teachers Do Now

What was done in the LOGO laboratory by Papert and his colleagues was done in an environment which was financially, technically, and philosophically strongly supported. Is this experiment really relevant to a typical classroom?

It is very doubtful that a teacher who is not comfortable with computers would choose to make them an integral part of the mathematics curriculum. It would be totally unrealistic to expect that a new computer based curriculum, no matter how well it was done or how much money was available for computer hardware, would be accepted by a teacher with no experience with computers. To be ready to explore the possibilities of such a new mathematics curriculum, a teacher must, at the very minimum, be computer literate. Thus, the first goal that faces any school district wishing to investigate seriously computer applications in the classroom is to develop an inservice teacher training program.

Computer Literacy For Mathematics Teachers

Much has been written lately attempting to define the meaning of 'computer literacy.' As one might expect, the term has a wide variety of interpretations. In the general sense, computer literacy has been defined as an understanding of:

1) What a computer/program can and cannot do.
2) How to program a computer. [4]

Disagreement on how much emphasis should be placed on goal 1) and goal 2) is the primary difference between two recent definitions of computer literacy [5,6]. Although the amount of computer knowledge that will be needed by teachers will differ, depending upon individual areas of interest, achieving goal #2 (How to program a computer) will be essential for all mathematics teachers. To be able to understand and apply the new instructional materials that will express concepts using the algorithmic point of view, the mathematics teacher must be able to understand elementary computer programs.

The First Step

There are probably as many ways to encourage computer literacy in a school as there are ways to write a program to solve a specific problem. One way to begin is to provide a sequence of inservice courses for teachers. Below is a sample sequence that has been used in a local (Kenosha, Wisconsin) inservice training program.

Course:

1) **Introduction To Computers.** A 4 week (8-hour) computer awareness course built around the Adventures of the Mind series of six 15 minute video tape programs about personal computers produced by Johns Hopkins University.

2) **Elementary BASIC programming.** A 5 week (10-hour) computer programming course. Training materials used were specially designed for teaching teachers and were produced by the Minnesota Educational Computing Consortium (MECC). [7]

3) **Advanced BASIC Programming.** A 5 week (10-hour) advanced computer programming course also using materials designed by MECC.[8]

4) **Microcomputer Applications For The Classroom.** A 4 week (45-hour) summer workshop on microcomputer applications covering the following topics:

   a) Classroom management software: record keeping, grading, worksheet and test making.

   b) Instructional software: how to make your own, how to evaluate that of others.

   c) Utility software: Higher Text, Higher Graphics, Word Processing.

   d) Languages: LOGO, PILOT

Each of the 4 successive courses adds another layer of sophistication to a teacher's understanding of computers. Not all teachers need to begin with the first course, and not all who begin at this level will finish all four courses. We have found that those who stuck with it and completed the summer workshop are now making substantial progress towards integrating computers into the mathematics classroom.

Beyond CAI

CAI (Computer Assisted Instruction), as traditionally conceived, has been one of the fondest dreams of educators. The possibility that the computer will one day make truly individualized instruction a reality seems reasonable enough. Unfortunately, CAI has so far proven more difficult to do well than was ever dreamed possible. As a consequence, programs ready for use today on microcomputer systems merely hint at the potential of which educators have dreamed. So what will teachers be doing with their microcomputers today?

In 1975, a survey of secondary level computer usage revealed the following mix of instructional computer activities: [9]

Problem-solving	25%
Programming	25%
Simulation and games	15%
CAI	13%
Guidance & conseling	15%
Other	7%

A 1980 ACM report on CAI in U.S. public secondary/elementary schools showed that: 90% of all school districts are now using the computer for instructional purposes; teaching computer languages is the number one use and; mathematics has the highest priority.

To the computer user, CAI and programming stand at opposite ends of the computer applications spectrum. The first use requires absolutely no knowledge about computers, while the goal of the second is a complete understanding of how to control computers. Between using the computer as a teaching machine and using it to learn BASIC lies a sleeping giant — Computer Assisted Problem Solving (CAPS).

Computer Assisted Mathematics Program — CAMP

The idea of using the computer to provide students with an algorithmic approach to mathematics and a chance to experience the problem-solving process first hand is not new. Fifteen years ago, it was the major emphasis of a pre-college program under the direction of David C. Johnson of the University of Minnesota named Computer Assisted Mathematics Program (CAMP). The program produced six books, one for each grade level 7-12, designed around the BASIC language in a time-sharing environment. The authors gave careful attention to identifying particular problem solving situations in which students could develop algorithms. The algorithms chosen were compatible with the mathematics curriculum of the grade level.

The result of the experiment, as reported by the authors, indicated that the computer was an invaluable device for demonstrating mathematical concepts. Also, the computer activities proved to be an excellent device for involving the students in problem solving. There were many instances in CAMP in which students were given the opportunity to design an algorithm, program it, and then run it on the computer. If it didn't work, the student revised the program and tried again until it "worked." This type of "real world" problem solving, which is difficult to implement successfully in the traditional textbook setting, was found to be inherent in computer problem solving activities.

In the early 1960's when the CAMP materials were being developed, the computer was not an easy tool to use. Programs were stored on punched cards and submitted to the computer in a batch mode. Modifying a program was a very time consuming process. The availability of computers for high school students was limited and for elementary students completely non-existent. In addition to these hardware limitations, the CAMP materials did not venture beyond the traditional mathematical algorithms found in the classroom texts. They did not introduce, for example, such programming strategies as recursion, backtracking, merging, sorting, and branching that are commonly used today to solve problems with the computer. As a consequence, programs like CAMP did not have a long lasting impact on the mathematics curriculum of the day. It was viewed primarily as an enrichment activity.

Computer Assisted Problem Solving — The Future

It seems inevitable that the wide-spread use of computers in the classroom will ultimately have a significant impact on the mathematics curriculum, although the resulting design is difficult to forecast. The best we can offer is an approximation. Below is a list of distinct programming categories that are closely related to mathematical concepts and skills:

Ability to program a computer to explore and/or solve problems in the following categories:

I. Numbers

1. Displaying patterns.
2. Transforming between bases.
3. Counting.
5. Searching for those that have mathematical properties.
6. Sorting.
7. Shuffling.
8. Generating at random.
9. Coding and decoding.

II. Words

1. Concatenation and decomposition.
2. Counting.
3. Sorting.
4. Shuffling.
5. Transposing.
6. Coding and decoding.

III. Simulation

1. Games of chance.

   a) Coin tossing.
   b) Random drawings or movements.

2. Games of skill.

   a) Board games.
   b) Strategy games.

IV. Problem Solving Skills

1. Backtracking.
2. Bisection.
3. Recursion.
4. Subgoals.
5. Trial & Error.

V. Graphics

1. Plotting.
2. Geometric designs.

All of these activities depend upon and reinforce portions of the traditional mathematics curriculum. Examples of the kinds of programming problems that fall into these categories are widely available [11, 12, 13, 14, 15,]. None of these sources has, however, developed materials to a point at which they could be easily used in a computer-assisted mathematics classroom. At present these materials are primarily for enrichment activities.

Conclusion

The development of a well-defined and interesting computer assisted mathematics curriculum is a long-term project and will not happen overnight. It will require the combined efforts of teachers, students, and curriculum developers working together to make it happen. No matter how long it takes, one thing seems certain — it is inevitable. As Donald Knuth has stated, "Perhaps the most significant discovery generated by the advent of computers will turn out to be that algorithms, as objects of study, are extraordinarily rich in interesting properties; and furthermore that an algorithmic point of view is a useful way to organize knowledge in general."[16]

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EA 014 925

COMPUTER LITERACY

POSITION PAPER AND RECOMMENDATIONS

Summer 1981

for

NORTH CLACKAMAS SCHOOL DISTRICT 12

PART I

by

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"...suppose for a moment that the automobile industry had developed at the same rate as computers and over the same period: how much cheaper and more efficient would the current models be? If you have not already heard the analogy the answer is shattering. Today you would be able to buy a Rolls-Royce for $2.75, it would do three million miles to the gallon, and it would deliver enough power to drive the QUEEN ELIZABETH II. And if you were interested in miniaturization, you could place half a dozen of them on a pinhead."

The Micro Millennium
by Christopher Evans

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TERMINOLOGY

The following definitions of terms are presented to aid the reader with vocabulary used in this document:

* Computer Literacy - the experiences and knowledge necessary to understand the effects of the computer on society and on the individual. It is also exposure to the applications and limitations of the computer and being attuned to the social, vocational, and governmental implications of computers.

  As a concept, computer literacy can be compared to reading literacy of the printed word. Knowledgeable people in the computer field believe computer literacy to be needed and valuable for all people to a level equal to their other abilities.

  The above definition is offered by this committee as a working definition of computer literacy for North Clackamas School District 12. There is much controversy over the definition in terms of content and quantity of knowledge required for computer literacy.

* Computer Science - the study of computers (history, social implications, applications and limitations, etc.) and how to use them (programming, problem solving, simulations, etc.), usually a course of study at the secondary level.

* Computer Programming - writing the instructions in a computer "language" so that the computer can do the work requested by the human operator.

* Computer Hardware - computer equipment including time-share terminals, hook-ups, and computers as well as micro computers such as the Apple, Pet, TRS-80, etc.

* Computer Software - the programs which can be used on a computer. These include programs for drill and practice, simulations, games, problem solving, etc. Also included are student and teacher-made materials as well as commercial programs or course work.

* Computing Teachers - teachers whose students use computers in classrooms or who teach the use of computers to students.

* Computer Education - instructional uses of computers in classrooms (as opposed to administrative uses of computers in offices). This term is used to cover any and all uses of computers in classrooms.

* Computer Assisted Instruction (CAI) and Computer Agrumented Learning (CAL) - these terms refer to methods of learning whereby computers assist the teacher in presentation of subject matter and/or improve student learning in a subject matter by some information or experience.

POSITION OF THE PAPER AND RECOMMENDATIONS TO NORTH CLACKAMAS SCHOOL DISTRICT 12

The position of this paper and the recommendation of the committee is that North Clackamas School District 12 prepare a PLAN FOR COMPUTER LITERACY. Such a plan would include programs for the following groups of people:

1. Administrators: inservice programs designed to provide computer literacy and to provide an understanding of student and teacher needs in the area of computer education.

2. Teachers: inservice programs designed to provide computer literacy and to give assistance for student computer literacy.

3. Students: a program that will provide computer literacy by the end of the twelfth grade. Special students would need to be provided with special programs which would meet their needs.

4. Parents and patrons: experiences to aid their understanding of the needs and priorities of computer education programs in their schools.

5. Finally, the committee makes recommendations to the District intended to assist with the formation of a PLAN for computer literacy. Included are suggestions for the purchase of hardware, a steering committee, consultants, software, field testing, the computer specialist's office and a computer-use center.

Recommended PHILOSOPHY for Computer Literacy Program:

The increasingly widespread utilization of computers is having profound effects on today's society. Computer education provides an understanding of the capability and limitations of computers. It provides experiences which assist students in developing awareness, attitudes, and knowledge for adapting to and coping with a changing society.

Recommended PROGRAM GOALS for Computer Literacy Program:

Students will gain a substantial level of computer awareness.

Students will develop an understanding of computers as aids to problem solving.

Students will develop an awareness of the effects and influences of computers on the individual and society.

Students will develop an understanding of the capability and limitations of computers.

A detailed explanation of each of the components to be included in the District's PLAN FOR COMPUTER LITERACY follows:

I. Administrators: inservice programs designed to provide computer literacy and to provide an understanding of student and teacher needs in the area of computer education.

A. An inservice program for District-level administrators should be provided. This inservice should precede all other inservice parts of the PLAN since these participants are the District's program decision-makers.

B. An inservice program for school administrators should be provided. This inservice should precede inservice for teachers.

C. Other suggestions for administrator inservice programs:

1. These inservices must be well organized, high quality programs which are motivational and fun as well as instructive.

2. These inservices could be organized to take from 4 to 16 hours depending on the intensity and depth of the instruction.

3. Guidelines which include processes for receiving computer instruction information and assistance and for appropriately using District personnel associated with computer education should be included in the inservices.

4. The inservices should be provided with follow-up learning experiences on a yearly basis. Such experiences, intended to keep District administrators current, could include a talk by a consultant, a "hands-on" workshop, a visit to view another district's instructional or administative computer program, or the presentation of a book for reading by all administrators, etc.

5. In addition, the members of the Board of Directors could be invited to participate in one of the administrative inservice programs.

II. Teachers: inservice programs designed to provide computer literacy or to meet their special needs.

A. Inservice A is suggested for teachers who teach computer education classes. This inservice is needed to provide up-to-date information and to improve understanding of computer instruction in the classroom. In addition this inservice is needed to provide assistance and incentives for these teachers to become the leaders of other teachers in the area of computer education. This inservice will include mainly junior high and high school teachers of computer science courses. The inservice should be presented prior to Inservice B, designed for all teachers, and after the administrator inservices have been completed.

B. Inservice B is suggested for all teachers who do not teach computer education classes. The inservice is needed to provide computer literacy and to provide an understanding of computer instruction in the classroom. This program would include elementary teachers as well as junior high and high school teachers who do not teach Computer Science courses. Media specialists, counselors and special teachers would also be included. This inservice should be presented after administrator inservices have been presented.

C. Other suggestions for these teacher inservice programs:

1. The inservice programs must be well organized, high quality programs which are motivational and fun as well as instructive.

2. They should be presented on an optional basis so that teachers who are already interested in computer education will be the first to participate in the program. Later, the program should be repeated for other teachers who wish to participate. Advertising should raise teachers' awareness of the program so that many teachers can be involved.

3. Inservice B for non-computing teachers would be most successful should a building or department TEAM CONCEPT be implemented. Building administrator, media specialist and computing teacher commitment and/or involvement is imperative to the success of the program.

4. Teachers (especially secondary teachers) should be given opportunity to explore computer applications in particular subject matters or disciplines.

5. In addition to providing computer "awareness," Inservice B should provide "hands-on" experiences for the teachers in order to achieve computer literacy.

6. Meaningful incentives (i.e., graduate course credit, payment, etc.) should be provided so that teachers will choose to participate in the inservice programs.

7. For best long term learning to result from teacher inservice the District is advised to place hardware and software in the classrooms of teachers participating in the inservice program. Tasks for teachers and students can then be part of the inservice requirements and the "hands-on" tasks will increase the learning of participants.

8. Incentives for Inservice A need to be developed so that present computing teachers will take responsibility for computer education leadership in their schools. Their responsibilities could include the following:
   a. Assisting with improved teacher literacy.
   b. Assisting teachers in the use of computers.
   c. Acting as school liaison with District computer personnel.
   d. Spearheading publicity and/or promotion for computer education programs to the parents/patrons of the school and/or District.
   e. Assisting with the collecting of needed and/or appropriate software for teacher use in the school.

9. Computing teachers from Inservice A should be involved in Inservice B in the following capacities:
   a. assisting with the implementation of the inservice/staff development program.
   b. assisting teachers from the same school in their learning and experimenting to reinforce the Team concept. Inservice B would be the beginning of a helping relationship between the computing teacher and non-computing teachers.

10. An incentive for computing teachers could be scheduling one period per day for assisting teachers with computer-related problems and needs. A building specialist could be designated with-in each building.

11. The teacher inservice programs should address the need for horizontal and vertical articulation in computer education within the District. Following the inservice programs articulation meetings should be set up through the office of the District computer education specialists. Teachers need to know what other teachers are doing and have done with both negative and positive results.

12. Community schools, PDC, Computer Services and other resources should be encouraged to provide computer literacy courses for teachers and community members.

III. Students: a program which will provide computer literacy by the end of the twelfth grade. Special students need to be provided with special programs which will meet their needs.

A. A K-12 LITERACY PROGRAM for all students should be provided.

1. Suggestions for the K-6 program include:

a. Exposure to computers
b. Familiarization with the keyboard
c. Completion of computer readiness tasks
d. Understanding of uses of the computer
e. Understanding of the history of computer use
f. Use of calculators

2. Suggestions for the 7-8 program include:

a. In-depth computer experiences
b. History of computers
c. Social impact of computers

3. Suggestions for the 9-12 program include:

a. Uses of computers
b. In-depth social impact of computers
c. History of computers

B. SPECIAL PROGRAMS are needed to meet special student needs.

1. Accelerated students need enrichment programs.

a. Elementary schools should continue to provide programming tasks for TAG students.

b. Junior high schools should provide programming tasks and other projects for TAG students. Or perhaps advanced computer science courses should be provided for advanced students (not restricted to TAG students) who have prerequisite skills.

c. High schools should continue to provide advanced computer science courses which include programming.

2. Low achievers and/or handicapped students need programs to work with computers.

   a. K-12 computer assisted instruction can provide drill and practice, tutorials, probem solving situations, etc. to improve achievement in a variety of subject matters.

C. Other suggestions for the K-12 computer literacy programs for students.

1. The K-12 LITERACY PROGRAM should, at first, include a variety of computer experiences for students with which teachers feel comfortable. Computer Assisted Instruction assists with student literacy and should be encouraged in a variety of subject matters as teachers locate or create software to meet their students' needs.

2. Computers should initially be placed in classrooms of teachers who have participated in inservice programs and have stated the need of hardware for student use.

3. Suggestions for curriculum for grade level teachers and guidelines for administrators could be organized and written by a team of teachers next summer. A core of computing teachers who are capable of the work are presently working in the District.

4. Much of the K-12 COMPUTER LITERACY PROGRAM could be integrated into the social studies curriculum. A possibility for organization of instruction at the secondary level is a team-teaching situation involving a social studies teacher and a computing teacher.

5. For a student to achieve computer literacy by graduation from high school few changes in present

curriculum would need to be instituted (as compared to implementing a math, science or art program for all students). Remember, the computer is only a tool about which students should learn.

6. For the first 2 or 3 years teachers experimenting with computer use in various subject matters will provide the foundation and leadership for a more solid curriculum in the future. Any curriculum in the near future must, of necessity, be flexible as teachers, students, and society achieve better understanding of computers and their uses.

7. For coordination of the SPECIAL PROGRAMS the TAG and Student Services departments would work with the Computer Education Specialist. Beginning attempts in these areas will largely depend on the initiative of teachers.

IV. Parents and patrons need experiences to aid their understanding of the needs and priorities of computer education programs in their schools.

A. A variety of suggested experiences for parents/patrons follows:

1. PTA and PTO's could be encouraged to provide programs for parents in order to make them current in the area of computer education. Such groups might be invited to participate in the funding of hardware/software for their schools.

2. Parents/patrons could be encouraged to participate in the teacher inservice program which provides personal computer literacy. Participation of parents along with teachers and other staff in the school has many rewards.

3. As computer education changes in the District, parent tea and coffee events could be encouraged through building advisory committees.

4. Building and District advisory committees could be given the task of making recommendations or stating options on the following:

a. Rationale and method of promotion for community approval for the use of calculators and computers as tools in instruction.

b. Needs assessment for hardware/software and calculators for their school.

c. Input for the formation of the plan recommended in this document for computer education.

d. Community Schools could be encouraged to provide computer literacy courses for community members.

V. Miscellaneous recommendations to the District to assist with computer education programs.

A. A flexible plan which includes short term and long range goals for the purchase of hardware is needed.

1. Short term goals should include the purchase of hardware enough to assist with administrator and teacher inservice requirements.

2. Long term goals should include the purchase of hardware enough to bring schools in line with each other and to supply hardware to teachers who wish to provide student experience on computers.

B. A flexible plan for the purchase, cataloging, storage, advertising, and distribution of software is needed.

C. Long range plans should include the defining of District minimum standards for computer literacy for students.

D. Administration needs to establish computer literacy among the District priorities.

E. A steering committee should be retained through the year to work with the District Computer Specialist for the formation of the PLAN for computer education.

F. College and university staff as well as staff from the Northwest Regional Educational Laboratory should be used as consultants for computer education.

G. When possible, field testing of particular parts of programs should be done. For example one or two elementary schools might field test the process for using calculators in math classes, or providing sixth graders with "hands-on" computer experiences, etc.

H. In order to assist teacher learning regardless of the person's stage of computer familiarity, the District needs to provide a computer-use location for staff. A teacher should be able to come to the location and, with minimal assistance from a staff member, be able to complete simple tasks and to experiment with simple programming of classroom materials.

This location could also serve as a District resource center for teachers. Books, journals and software for computing teachers' use could be housed at this location until other arrangements could be made in coordination with Instructional Media Services.

For easy implementation of this suggestion two microcomputers could be given space at the Computer Education Specialist's location. The secretary would be responsible for booking reservation times. At times when computers are not reserved, teachers could walk in and use them.

The rationale for the teacher-use location is to provide a non-threatening situation for teachers beginning to experiment and wishing to learn at their own rate. Promotion and publicity for this center could be handled through the Computer Specialist office and PDC.

I. The committee's recommendations for the District Computer Specialist's office follow:

1. Write guidelines for the purchase of hardware/software for administrators. This method will insure a standardization of equipment throughout the District, insure cost effectiveness, and contribute to eventual uniformity of instruction.

2. Coordinate the sharing and exchange of hardware/software among schools and departments for the next 2 or 3 years.

3. Coordinate the inservice programs in the District.

4. Work with PDC and EPC to raise the awareness of teachers to possibilities in the computer field.

5. Update the District on the "state of the art" periodically since computer education is a changing field. Much help and direction can be gained by staying current.

6. Provide leadership for the formation of the PLAN recommended by this document.

7. Coordinate and provide leadership for the various committees, departments, centers, etc. which are involved in computer literacy programs and computer use in instruction.

THE BACKGROUND OF THE STUDY

In January, 1981, the Instructional Computer Services Advisory Committee was formed to help the administration develop a plan of action for developing computer services to meet the needs of students in the North Clackamas School District 12.

Part of the Committee's task was to develop a five year plan of action for the instructional computer services program; the timeline of tasks was completed.

One of the tasks concerned the preparation of a position paper on computer literacy. The District administration designated a curriculum administrator to coordinate this project.

The Curriculum Coordinator brought together a team of professionals for one week in the summer of 1981. The team members consisted of teachers, a media specialist, a vice principal and a facilitator from the curriculum office to provide leadership for the team.

THE PROCESS FOR DEVELOPING THIS DOCUMENT

The week the professional team worked was divided into two parts. The first three days were given to researching the state of the art, and the last two days were spent planning for District computer education programs and making recommendations consistent with the research. (See Appendix A)

Doing the research

In the beginning the team brainstormed questions which needed to be researched; then, the team prioritized the questions and accepted only a few main questions for study.

Team members read books, journals, and conducted interviews to find answers to the questions. Each time a source addressed one of the committee's questions, a report form was completed on the resource. The form contained bibliographical information, a synopsis of ideas given by the author and the opinions of the reader.

Finally each member of the team took a question and reported the findings of the research to the total group.

Later, the team facilitator put together the material in this document using the research reports.

Planning for District Programs

The team constructed the following for computer education for North Clackamas School District 12:

- a philosophy
- program goals
- a definition of computer literacy
- recommendations for District programs for administrators, teachers, parents/patrons, and students

Later the facilitator used the information developed by the team to write the recommendations in this document.

EA 014 926

MICROCOMPUTERS: A CREATIVE APPROACH FOR YOUNG MINDS

Marilyn S. Buxton and Henry A. Taitt

Five years ago there were no microcomputers in the schools. Three years ago there were a few hundred. One year ago there were a few thousand, mostly in high schools. Next year we will be counting them in hundreds of thousands at all grade levels.

Why? What is being done with them? What should be done with them? How do they help reach educational goals? Will their current uses change? Will they change education? You will note that microcomputers are not ONLY in schools. They are becoming common in businesses and in homes. You can get one through the Sears or Penney's catalog or from your friendly neighborhood dealer. Is the whole nation turning into mathematicians and scientists? Of course not.

What has happened is that man has created a new tool, the most significant new tool he has designed in centuries. Man first used sticks and stones to extend his reach and strength. Most new tools since that time have, in more or less elaborate ways, extended his physical capabilities. The microcomputer makes it possible for man to extend his mental capabilities. It is a generalized tool that can be used in an endless variety of ways, in almost any field to serve many different purposes. It offers something to everyone. While experts in math, science and data processing have made this tool available to us, we will have to find out for ourselves how it can be useful to us. Our challenge today is to see what educators will do with this new tool to provide for a computer society.

Special Features

The microcomputer has several special features in common with other major tools such as the pencil and the telephone.

One Person Operation

A microcomputer keyboard is designed to be used by one person. It is possible to share it. In fact, two people can share one telephone receiver. They can take turns communicating with the person on the other end or one can listen in the top half while another talks into the mouthpiece. Neither is very satisfying. Nor is sharing a pencil. Nor is sharing a computer. It is often called a personal computer. It is designed for individualized use by one person.

Inexpensive

Computers were once so expensive (millions of dollars) that only the U.S. Government using our tax dollars could afford them.

No mere student could be allowed more than a fraction of a minute of its computing time. So, many terminals were set up where individuals who had carefully prepared their programs in advance by flow-charting, key-punching and painstaking review, could try them now to see if they worked. Micros have made all of that unnecessary and obsolete. For between $400 and $1,000, you can get your own. Many people spend that much per year for their telephone. They pay it willingly because their phone has become a useful part of their daily lives. Micros are rapidly going the same route.

Versatile

A microcomputer can be used for an enormous variety of tasks. We will continue to see its role increasing as a means of getting goods, services and information to our homes quickly and efficiently. Data storage and retrieval, calculation and computation, word-processing, music, environment control and entertainment are just a few of the more common uses today. Others are being developed daily by people who have needs and know how to make the microcomputer work for them.

Fast, Accurate, Maintenance Free, Far-reaching

Powerful and efficient, today's microcomputer is extremely fast (because it doesn't need to be shared), quite durable and very inexpensive to operate. And -- we can communicate with equipment out in the farthest reaches of the solar system by computer.

Immediate Feedback

The microcomputer makes it possible to type something in, try it, and see immediately if it works. It is also a marvelous way to learn from your mistakes. You can try alternatives and immediately see the results, discover your errors, correct them and try again. Through this process you can learn how to learn from your mistakes.

Goals of Education

As educators, we must first be dedicated to our purpose for being teachers; we must clarify our goals. Then we can see how microcomputers can help us reach those goals.

Basic Skills

In spite of the rigid interpretation and variety of meanings, most of us believe that the schools must continue to build basic and essential skills in each student.

These skills would certainly include effective communication as a two-way street -- expressing and understanding. We expect our students to master both written and spoken communication and many also try to excel at more subtle forms of communication through facial expression, body language and symbols and signs.

An understanding of computation, how to use numbers to find out what you want to know -- whether it's your batting average or how much money remains in your checkbook -- will continue to be important. While our hand-held calculators and computers will do the arithmetic for us, we will still need to know what should be done and what factors affect the total. Understanding of math principles and applications will replace mere ability to quickly recall sums and quotients.

Locating, acquiring, retrieving and applying information has always been important. We have taught library skills and research skills for centuries. Even our elementary students use personal interviews, telephone calls, correspondence and field trips to extend their information accessing abilities. As information and knowledge continue to expand, the ability to select what is worthwhile and useful will become increasingly important.

Problem-solving ability will continue to be a major goal. Reasonable and logical thinking based on valid information is a very difficult skill to teach but it remains a very important basic skill.

Creativity in thought and actions is a vital basic skill. Too often, creativity is thought of as art or creative writing because of their visibility. Teachers will continue to be challenged to develop creative thinkers in science, math, business affairs, social decisions and personal living. While some have tried to encourage creativity in students, most highly creative individuals report they developed their skills in spite of their schooling rather than because of it. We still have much to learn in this area.

Self-Image

Everything from drug abuse to war has been blamed on the destructive power of a person's self image as weak, defective, incompetent, unworthy and unlovable. Most of us become very good very young at hiding our negative feelings about ourselves. As teachers we must continue to have as our goal for students an enhanced sense of internal control, competence, self-expression, uniqueness, self-confidence and sense of purpose.

Employability

The ability to do some form of useful productive work, to adapt skills to new job situations, to take pride in a job well done and to provide for one's own support, are skills that are required both by individuals and by society, and will continue to be a goal of good teachers.

Diversity

Our national philosophy and structure require individuals with a diversity of skills and talents. Any successful team requires good players in all positions, each competent but different from one another. The nature of public schools encourages uniformity. Students are too often rewarded for knowing the same RIGHT answer, the answer that the teacher knows. The ability to consider conflicting viewpoints and to determine the best answer for this time, place and event is rare. Our pressures to develop minimum competencies often encourage us to give all students the same courses. Good educators must continue to build on unique, individual talents and to graduate students who are different from one another.

Microcomputers in Education: Two Challenges

The kind of microcomputer program one establishes must be in harmony with both the program's goals and the microcomputer's key features. There are two main ways to look at it.

The Microcomputer As a Tool to Help Accomplish Educational Goals

Because of its special features described earlier, the microcomputer can be an astonishingly effective tool for helping reach traditional and timeless educational goals. Basic skills, positive self-image, employability and individual diversity can be key elements in a carefully planned program. That seems at first like a sweeping grand and glorious (AND IMPOSSIBLE) scheme. We, too often, forget human unity. We think that when we break things out for special focus or study, they become separate things. But they are still part of the whole person. What is good for the person is often good for the separate parts as well. We may study the brain, heart function, physical stamina, good looks, blood circulation and lung function. Is it possible to plan a program to improve each of these? Of course it is! It would consist of a well-balanced diet, rest and exercise. And a well-balanced microcomputer program consisting of information, support, entertainment, relaxation and challenge can improve all of the basic skills we have discussed. It is happening now in many schools, private centers and homes across the country.

The Microcomputer as a Subject Itself

Because of the impact of the microcomputer on every level of our society, educators are being called on to prepare students for microcomputer use. At the present time, there is a great deal of confusion about what that means. Some of the most boring, worthless and least popular classes in nearly every field have titles beginning: "Introduction to . . .", "Orientation to . . .", "Survey of . . .". We have all suffered through these. There seems to be an unquestioned idea that a student should start an area of study by getting a broad overview of the field. Yet only a quick look at the real world outside of school reveals that most of the people who have an understanding or overview of their whole field began by getting excited about one tiny spot. The hobby enthusiasts spend hours working in their chosen area. They get very good at it. It leads them inevitably in larger and larger circles of skill and knowledge. How many small boys would build models if they had to start out with an overview of the history of model building, types of models to build, ways to display completed models, or descriptions of the country's best model builders. Or suppose we taught baseball to young children by requiring that they learn the names of major league teams, best players in each position, current batting averages and league standing before they could use a ball? Yet, how many kids collect baseball cards and drill themselves on these things because they first enjoyed playing ball?

We often see microcomputer programs with overview or literacy courses as the first introduction students receive. Others begin by allowing children to only respond to software previously loaded by the teacher. Some try to give every student exposure to the microcomputer as though computer knowledge were contagious and a student could catch it by looking at a microcomputer or even touching it for a few minutes. In an effort to serve many students with few computers, some programs attempt to work with several students at a time, sharing a computer.

We are encouraged however by the growing number of teachers who have discovered as we have, that there is a much more effective way to involve students. These excellent programs are being developed by teachers who are not at the mercy of computer experts, computer salesmen, or software publishers. These teachers have kept in mind their goals as educators, their responsibility to prepare students to use the technology available to them and the special features of the microcomputers. Good diet, rest and exercise can improve anyone's health and vitality thereby making each part function better. Good microcomputer programs are effective with all types of students -- kindergarten through college, adults from the community, business and professional people, gifted students, mentally retarded students, hearing-impaired students, behaviorally disturbed students, good and average and poor students. Impossible? No! It's reality! We have seen it happening in selected spots across the nation. A solid basic plan, good materials, a trained teacher and freedom to use the computer with the type of student the teacher knows how to work with produce it!

Basic Ingredients of a Sound Approach to Microcomputer Instruction

Remember the special features of micros:

(a) One person operation
(b) Inexpensive
(c) Versatile
(d) Fast, accurate, far-reaching
(e) Immediate feedback

Remember the challenges:

(a) Enhancing educational goals of:

(1) acquiring basic skills
(2) developing a positive self-image
(3) learning employment skills
(4) student diversity

(b) Preparing students for a technological society

A good program takes advantage of these features. That means that:

(1) Each person must have the computer to himself when he is using it. This can be accomplished by a scheduling which allows students a minimum of one-half to one hour sessions at least once a week. Not all students need to participate at the same time. Some schools change student groups each semester. Others have students come several times each week for fewer weeks. Still others schedule individuals at a learning center.

(2) Students must learn to control, command and communicate with the equipment. At all ages and ability levels we are finding young people who know how to:

(a) Create original programs on a microcomputer

(b) Load programs written by others, changing and adapting them when necessary

(c) Express and apply their musical talents, verbal skills, mathematical knowledge and artistic abilities

(d) Use the computer to do routine chores, help them with schoolwork, keep lists, and solve problems

(e) Enjoy the microcomputer for games, hobby applications and other recreation.

(3) Students will represent a diversity of skills and ability in operating the equipment and expressing areas of talent. This is true because each student must be guided and directed from within himself. He gains information from a variety of sources including instructional materials, but at his own pace. The teacher must support, stimulate and challenge him as an individual.

(4) A hobby-like enthusiasm must prevail. Students will have fun and their enjoyment will enhance their learning.

(5) Each student should learn through an individualized, self-paced, hands-on discovery method. He then can locate and correct his own errors and is not dependent on the teacher for answers.

The CREATIVE PROGRAMMING FOR YOUNG MINDS curriculum was designed specifically to enhance such programs. While these instructional materials provide the structure for learning programming skills, they are designed to gradually lead students from dependence on either the teacher or the materials to independent future learning. When guided by teachers trained in their effective use, children produce remarkable programs after only a short time. Only later, after they have been enticed by the intoxicating opportunity to command a computer, should students be offered the opportunity to learn <u>about</u> computers. We don't teach writing by first studying the manufacture of pencils. Like the pencil, the microcomputer is a tool for self-expression. Therefore, any good educational program must use the microcomputer creatively.

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COMPUTERIZED LITERATURE SEARCHING OF EDUCATION AND EDUCATION RELATED LITERATURE

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Introduction

Computerized literature searching allows the educator to become familiar with resources that assist individual teaching styles and methods, pupil needs, educational research and evaluation and curriculum materials.

Unfortunately, computerized searching of education or education related literature is surrounded by many myths. Some of these include: 1) Price. Estimates run from thousands of dollars to the "McDonald's attitude" where people expect change back from their dollar. Neither is true, different databases have different charges. 2) Coverage. An assumption exists that "everything" is in the computer, again untrue. The field is less than twenty years old. New databases appear periodically, but many sources still must be searched by hand. 3) The entire document is in the computer. The majority of databases contain bibliographic information that refer to a printed document, but do not reproduce the full text of it.

Database

A database is a collection of machine-readable records. In bibliographic searching, each record represents a reference to some type of printed document. Each record is made up of fields containing a piece of information about the record. Typical fields in a record include: accession number, author, title, source (journal citation or publisher), descriptors (controlled vocabulary), and an abstract. The fields available will vary from database to database.

There are many considerations in choosing a database. These include the scope and subject coverage, the types of documents included, the selection policy, the intended audience, the time period covered, the languages included, the searchable fields and the indexing principles involved.

Computerized searches are conducted by comparing your information to information collected in various databases. The computer searches the individual terms in the records in the database. Any information can be in a database, but usually it is bibliographic and refers you to a printed document. Many databases have print counterparts that can be studied as a visual representation of the information available, but other databases exist only as computer files and are not available in a printed copy. Access to the individual database files is through a search system. Today we will look at the Bibliographic Retrieval System.

Bibliographic Retrieval System

BRS is an online interactive computer system that is accessed remotely through a telecommunications network. "Online" indicates that you are in direct contact with the computer. "Interactive" means the machine provides you with information throughout the search, so you can change or end the search at any time. A "telecommunication network" is an alternative to traditional long distance phone charges. Using a local terminal, the searcher uses a telephone to "call" the computer system, and messages are transmitted via the communications network.

Preparing for a Search

To begin a search, first clarify your question and the type of search you want. For example, do you want a broad search for a lot of material, or a quick search for a few articles? Second, choose relevant databases. Third, divide your question into facets or word groupings and develop a list of keywords to describe your information needs. If applicable, to the database, list controlled terms from the Thesaurus for each concept.

The final step is to use Boolean Logic to formulate logical groups for the facets of your search. The term "OR" links your synonyms and broadens your search. The term "AND" overlaps concepts that appear within the same citation. The term "NOT" excludes a group of terms or bibliographic limitations.

Multiple Searches

Searches can be run through many databases. For example, a search on "sex differences in math for retarded students" could be run through ERIC (Educational Resources Information Center); PSYC INFO (Psychological sources); Exceptional Child Education Resources; Dissertation Abstracts; and the National Center of Educational Media and Materials for the Handicapped. Each of these databases collects different types of information. Your needs will determine how many different databases should be searched.

For Further Information

The appended bibliography identifies bibliographic search systems, books and articles explaining the search process, and database directories.

Selected Bibliography

Major Online Bibliographic Information Retrieval Systems

Bibliographic Retrieval Services (BRS)
702 Corporation Park
Scotia, NY 12302
Phone (800) 833-4707

Dow Jones News/Retrieval
22 Cortlandt Street
New York, NY 10007
Phone (212) 285-5225

Lockheed Information Systems (DIALOG)
3460 Hillview Ave.
Palo Alto, CA 94304
Phone (800) 227-1960

National Library of Medicine (MEDLINE)
8600 Rockville Pike
Bethesda, MD 20014
Phone (800) 638-8480

New York Times INFORMATION BANK
Mt. Pleasant Office Park
1719-A Route 10
Parsippany, NJ 07054
Phone (800) 631-8056

SDC Search Service (ORBIT)
2500 Colorado Ave.
Santa Monica, CA 90406
Phone (800) 421-7229

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Online Incorporated
11 Tannery Lane
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An Educational Psychologist Looks at Computers

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I. What is all the fuss about?

Are the questions we ask about computer languages, sequences of instruction, computer curriculum and motivation new to the educational psychologist or are they refrains on the ancient empirical vs. rational debate? Cary Lu, a computer designer, journal editor, and programmer, in Science '82 asks the question, "What good are home computers?" After destroying illusions that they can be used in a practical way to balance check books, do taxes, and file recipes, she asks "What is left?" Her conclusion is that for most honest people, games. She says computers make sense for those who really need them. If she is right, the question becomes "Who needs them?" She needs them, I need them. Why? Mainly to do more efficiently those things we already do. One does not need a word processor if one never writes and a word processor won't make a person a writer but might make one a better, or at least faster writer.

II. What do colleges of education need computers for?

It is often proposed that they can make education more motivating, more fun, and more memorable. While these may be worthwhile goals, it is challenged that the main purpose of education is to keep students amused. Schools and colleges need computers to do better those things they already do, including innovate.

III. Are there direct transfers from what we know about learning that can be used to help in the introduction of students to computers?

Yes, reinforcement theory, contiguity theory, and perhaps most important, social learning theory, give us much to tell educators about teaching prospective teachers how to introduce their students to computers. Specific examples will be presented.

IV. A description will be given of the way a computer was integrated into a university course in measurement, the beneficial effects on the students, the costs to the instructor, and the required support system. Questions will be raised as to the long term effect of the instruction on the goals for the course.

V. A description will be given of the education of one teacher into the use of micro computers, what happened when she returned to the classroom, and how her students viewed and used the computer. The results may be somewhat surprising to many. The majority of a random selection of children do not evidence much interest in the computer. Those who do become quite possessive of their skill and the machine. The arrogance of mathematical skill and computer knowledge starts early. Children self sort on their perceived ability. The sorting dimension may be problem solving skill. It is proposed that computers may not teach problem solving, but may be used by those who find they have problem solving skill.

VI. The thesis will be explored that computers are very functional tools. As they become more available to teachers they will be used in as many and unpredictable ways as are any good and versatile tool.

It will be proposed that we are now going through a period equivalent to the 1940s when parents were afraid to touch the baby for fear of warping its psyche. Some of our fears about the misteaching of computer skills may be as unfounded as were our fears of raising children were then. Interviews with successful computer users are the basis of this section.

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DIRECT INSTRUCTION MICROCOMPUTING IN PRIMARY SCHOOLS : MANIPULATION OF CRITICAL INSTRUCTIONAL VARIABLES*

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DIRECT INSTRUCTION MICROCOMPUTING IN PRIMARY SCHOOLS : MANIPULATION OF CRITICAL INSTRUCTIONAL VARIABLES

Amanda Gelder
Alex Maggs

Introduction

The increasing emergence of computers into diverse facets of daily life requires vast numbers of people competent in programming and general application. Consequently, with reading, writing and arithmetic, it is envisaged that computer literacy will become a basic skill. Microcomputers are currently used as instructional tools; that is, computer assisted instruction in many primary and secondary schools across Australia. Yet, rather than simply using the computer as an instructional device, the aim of instructors should be towards developing computer literacy.

The concept "computer literacy" involves more than knowledge of the basic keyboard functions. It involves skill in the use of computer languages to solve problems, the logic and the hierarchical systems involved. It is necessary for schools to move beyond use of computers in instruction to instruction in the application of computers. The next step, therefore, is to define the most effective method of instruction. Computing has frequently been considered a skill only obtainable by "bright" or "mathematically" able people. However, research conducted over the last ten years in reading, writing and arithmetic instruction, both in the U.S.A. (Becker, Engelmann, Carnine and Maggs, 1981) and in Australia (Maggs et al, 1980) has indicated that with effective instructional sequences complex skills can be acquired by all learners.

The Direct Instruction model is based on empirical behaviour theory with emphasis on the logical analysis and exact programming of concepts, operations and rules that constitute an instructional sequence. An instructional program is determined in terms of general case strategies which ensure that the learner is taught the minimum set of strategies to achieve the most effective generalization and transfer of learning.

A thorough examination of the Direct Instruction Model, across numerous research studies and programs of instruction (Cross, 1981) revealed four key instruction variables:

1. the structure of the teacher's oral presentation
2. the programming of the content area
3. the supervision by the teacher in the classroom
4. the format of the written materials.

Within the structure of the teacher's oral presentation, the following subvariables were delineated:

a) verbal and nonverbal signalling to inform the learner when to respond;

b) questioning the learner;
c) provision of feedback to the learner;
d) praising the learner;
e) pacing the presentation of the learning tasks.

The subvariables of programming the content area are:
a) teaching or not teaching a general rule;
b) teaching or not teaching examples of the rules;
c) giving or not giving examples of the rules;
d) reviewing or not reviewing the content area.

Teacher supervision involves:
a) monitoring the students;
b) correcting student responses.

The subvariables for the format of the written materials include:
a) presenting or not presenting a general rule first;
b) varying or not varying the response format;
c) providing or not providing practice items.

In addition, two modes of teaching presentation were possible, that is, oral presentation of content areas and written presentation of content areas.

The present study was twofold. It aimed firstly to teach a new complex skill to a large number of children. Secondly, the four key instructional variables delineated in Direct Instruction researcch were manipulated across four methodologies to determine the most effective method of instruction. The two aims of the study were complementary. Microcomputing was an excellent content area for instruction. It involved a cohesive, finite body of knowledge which could be analysed into sets of definitions, rules and procedures. The skills involved in microcomputing were wide, including reasoning, vocabulary and procedural knowledge, comprehension and application. Further, since microcomputing was a novel area in primary schools there were no contaminating effects from previous learning. The second value of the study was the trial of four alternative instructional designs and the production of relevant lesson materials in a new area.

A major difficulty in a project of this type was the conflict between emphasis on "academic engaged time" and "mastery". Academic engaged time has been defined as a sustained interaction between the learner and the instructional materials whilst performing at a high rate of success (Rosenshine and Berliner, 1978). Direct instruction research has shown conclusively that by using highly structured and effective instructional sequences more could be taught in less time. However, all learners did not begin at the same entry point. Therefore, some learners required longer periods of direct instruction to achieve mastery, that is, the acquisition of all skills instructed.

The aim to assess effectiveness of each of the four instructional methods meant it was not feasible for teachers to structure materials for individuals. Therefore, the period of instruction was specified for all classes.

Method

Instructional Objectives

While the method of instruction was manipulated, the instructional objectives and the content area were fixed. The aim was for primary school aged children to acquire computer literacy and computer programming skills. Therefore, the following instructional objectives were used in the project:

- Describe a computer.
- Define computer program.
- Define computer language.
- Describe how a computer operates.
- Describe the merits and demerits of computers.
- List different computer languages.
- Define execute.
- Define program execution.
- Define run a program.
- Define immediate and delayed execution.
- Comprehend that to write a computer program involves designing the program and coding.
- Comprehend that program lines are numbered in delayed execution, but not in immediate execution.
- Describe procedure for assigning line numbers.
- Apply procedure for assigning line numbers.
- Define data.
- Define variables.
- Comprehend how values are stored in variables.
- Identify values stored in variables.
- Define numeric and string variables.
- Identify the differences between numeric and string variables.
- Define an assignment statement.
- Write assignment statement for numeric and string variables.
- Define input statement.
- Write input statements for numeric and string variables.
- Define input statement.
- Write input statements for numeric and string variables.
- Identify arithmetic operators.
- Give the rules for ordering arithmetic operators.
- Write statements using arithmetic operators.
- Define print statement.
- Write print statement.
- Define GO TO statements.

A problem solving exercise was designed to encompass each of these objectives and to maintain attention and demonstrate the applicability in a real world situation of the computer skills acquired. The exercise involved putting an astronaut into space.

The primary school aged children were instructed in concepts ranging from the components of a spacecraft to scientific concepts such as velocity and fusion, mathematic concepts such as area and mass, and computer programming concepts. The children were taught BASIC language programming skills and applied these skills as required to solve problems; for example, how to calculate the room in a fuel tank? Such an algorithm required students to design flow charts and apply the BASIC programming language to solve the problem.

Throughout lessons information was taught on the basis of prerequisite skills. The content area was analyzed to determine the logical sequence of instruction so that students learnt the "general case".

The method of instruction depending on the manipulation of critical Direct Instruction variables did not influence the sequence of presentation of concepts, operations and rules.

Instructional Design

On the basis of the four instructional variables defined as crucial for effective learning, four methodologies were designed. The program materials provided for teachers followed these guidelines.

Method One. The first method was the most highly structured Direct Instruction model. Oral presentations were highly structured. The teacher gave rules followed by examples. The learners were required to repeat rules as a class.

In the written materials rules were emphasized using underlining and capitalization. The response format was varied to maintain learner attention. Both open-ended and multiple choice responses were included. The teacher supervised the students' written work. Correction and reinforcement was given after each exercise.

Method Two. The oral presentation was highly structured. Students were required to repeat rules or the teacher's instruction as a class. However, the teacher presented a series of examples before stating the rule so that learners were involved in a deductive process.

Underlining and capitalization were not incorporated to emphasize rules, again requiring the student to be more deductive. The form of questions and possible responses was limited. The teacher did, however, supervise the written activities of students and gave correction and reinforcement.

Method Three. As in method one, the teacher presented rules followed by a series of examples. However, class response was not required. Rather, the teacher selected children at random to repeat the rule.

In the written materials, rules were emphasized using underlining and capitalization. The form of questions was varied and multiple choice and open-ended responses were possible. However, in method three the teacher did not supervise the written activities of children. Correction and reinforcement were not consistently given.

Method Four. The fourth method was low in each of the four key variables. The teacher presented a series of examples before giving the rule. Individual children were randomly selected to repeat the rule.

The written materials did not emphasize rules using underlining or capitalization. The form of questions and types of responses were limited. The teacher did not supervise the written work of students or give consistent correction or reinforcement at the conclusion of each exercise.

On the basis of research evidence (Lockery and Maggs, 1982) it was predicted that the Direct Instruction Method One would lead to the most effective learning, and that Method Four, the least structured, would be least effective.

Presentation of Instructional Systems

These four methods were carefully scripted to allow teachers to present materials to their own classes. Each classroom was provided with a microcomputer for on-hand microcomputer experience, as required by individual lessons. An instructional unit lasting thirty-five minutes was given each day over a five week period. At the completion of all exercises a test was given to all classes. The test, consisting of thirty-five items, dealt with crucial rules within the lesson materials. The same test was given to each of the classes involved in the study.

Sample

Nine schools in the Sydney metropolitan area volunteered to participate in the study. Classes from Years Five and Six within each school were randomly assigned to one of the four methods. Thirty-one classes were originally involved in the study. However, in the course of the five week period three classes decided, due to other commitments, to withdraw from the course. Another six classes could not complete the final post-test. Therefore the final analyses were undertaken on results from twenty-two classes.

The schools involved in the study had no prior utilization of microcomputers in their curricula. All schools were, however, interested in advancing academic engaged time in a new content area - microcomputing. Four of the schools were independently administered schools, two were administered by the Catholic schools system and three were government schools. No results were obtained for one of the independent schools. The socioeconomic status of parents of children attending each of the schools was middle to high. Therefore, it was not predicted that socioeconomic status would be a discriminating variable. However, the administration of schools and policy on such factors as discipline, curriculum structure and teacher accountability varied between schools. Consequently, it was predicted that the results would reveal an interaction between school and method effects.

A total of 1045 primary school children were involved in the study. Approximately 945 children completed the exercises. However, the number completing the post-test, 633, was smaller specifically due to excessive end of year commitments.

Results

The post-test given to classes at the completion of the five week period of instruction included both multiple choice and open-ended responses. Each question tested a component of the instructional content including definitions, procedures and application of operations. For this reason, analysis of relations between sex, class, schools and methods and results of the post-test was on the basis of individual items. Each item is classified on results tables and in discussions.

Analyses of variance were used to examine different mean numbers of correct responses per question for each of the classes by method, school, class level and sex. It was found that there were significant differences between the schools on twenty-five of the thirty-five items.

The means and standard deviations (Table 1) clearly indicate that the results of the independent schools were superior to those of the three government administered schools. There were no significant differences between methods, classes or sexes.

Table 1 about here

Discriminant Function Analyses were undertaken to examine the interrelationship between school type, method and the test items. The first analysis included the two school types (independent and government administered) and the four methods. It was found that the first two functions were significant ($p < .000$; $p < .000$). Their eigenvalues and canonical correlations are shown in Table 2. The pooled within groups correlations between canonical discriminating functions and discriminating variables for each function are shown in Table 3, and the group centroids of the eight groups are shown in Table 4 and Figure 1.

Tables 2, 3 and 4 and Figure 1 about here

The results indicated that eight test items correlated above the designated (.30) cut off level in Discriminant Function 1. These were items 1 (.30); 9 (-.39); 10 (-.42); 11 (-.32); 13 (.30); 14 (.30); 16 (.37) and 35 (-.38).

In the second discriminant function, four variables correlated above the .30 cut off level. These items were 10 (-.30); 14 (.36); 15 (.34) and 17 (-.34). The co-ordinates of the group centroids on Discriminant Function 1 ordered groups on the basis of school and structured method. That is, the three independent school groups - methods one, two and three were linked with the government method one group. The second function clustered the independent methods two and four with the government method two and the independent methods one and three with the government methods one, three and four.

The results indicated firstly that method one clustered together independent and government schools and method four differentiated between the two groups. Secondly, when the designated method was two or three, the criterion for differences between groups was school rather than method.

The group centroids (Table 4) indicated that the first group including the independent school methods one, two and three and government method one had higher scores on items 9 - definition of a "sequential structure"; 10 - definition of a "conditional structure"; 11 - definition of a "repeating structure"; 17 - application of a conditional structure and 35 - definition of "raising to the power". The three government administered schools and the independent method four group had higher scores on item 1 - definition of a problem and items 13 to 16 - application of a refinement of an algorithm. The mean scores and standard deviations of the eight participating schools (Table 1) inferred that this trend was strongly affected by low scores in independent school one on these items.

The second Discriminant Function Analysis intended to evaluate the relationship between extreme methods, that is, methods one and four and the two school types (independent and government administered).

It was found that the first two functions were significant ($p < .000$; $p < .03$). Their eigenvalues and canonical correlations are shown in Table 5. The pooled within groups correlations between canonical discriminant functions and discriminating variables for each function are shown in Table 6 and the group centroids for the four groups are shown in Table 7 and Figure 2.

Tables 5, 6 and 7 and Figure 2 about here

The results indicated that fifteen items correlated above the .30 cut off level in Discriminant Function 1. These were items 1 (.32); 2 (.41); 4 (.32); 7 (.39); 8 (-.38); 11 (.34); 12 (.63); 13 (.46); 14 (.50); 15 (.60); 16 (.51); 17 (-.51); 24 (-.74); 25 (.33) and 29 (.32).

In the second Discriminant Function eleven items reached the .30 criterion level. These items were 1 (-.51); 5 (-.30);

6 (-.40); 7 (.67); 11 (.30); 23 (.43); 24 (.47); 26 (.67); 27 (.48); 28 (.56); and 30 (.58).

The coordinates of the group centroids on Discriminant Function 1 ordered groups on the basis of method. The two method one groups were superior to the method four groups. The second function ordered groups on the basis of school. The two independent schools had significantly higher test results on the discriminating items than did the two government administered schools.

The means and standard deviations Table 1 indicate that the method one group had higher scores on the items - 1 - definition of a problem; 2 - definition of an algorithm; 4 and 7 - procedures for classifications of problems; 11 - definition of a repeating structure; 12 - 16 - application of refinement of an algorithm, and items 25-29 - applications of Basic principles. The method four groups had higher scores on item 8 - procedure for classification of problems; item 17 - application of a conditional structure; and item 24 - definition of a variable. It must be noted (Table 1) that several classes reported a zero result to items 8 and 17 indicating that they were weak discriminators.

The independent school groups had higher scores on the following items - item 1 - definition of a problem; 5, 6 and 7 - procedures for classification of problems; 11 - definition of repeating structure; 23 - application of a Basic principle; 24 - definition of a variable; 26 and 27 - application of Basic principles; and item 30 - definition of the multiplication sign.

Discussion

While the present study did not anticipate differences between schools involved, this variable affected the results. The independently administered schools reported higher scores than did classes from government administered schools on items of the post-test. Since the study did not propose to be an examination of the relative merits of the Australian school systems potential causes were not elicited. However, given the differences between schools, the results indicated that implementation of the highly structured direct instruction methodology eliminated differences between schools.

The Direct Instruction System presented highly structured oral and written lesson materials. Emphasis was given to repetition of rules as a class and correction and reinforcement following each exercise. This system had more effective results than did the fourth method, which was low on each of the manipulated variables.

The study elicited differences between methods one and four in terms of correct responses on the post-test. There were significant differences between methods two and three. However, to effectively evaluate the significant variables within each method a more extensive research design would be necessary.

The other difficulty in empirical research of this type involves evaluation. Ideally, evaluation of instructional systems should be in terms of "academic engaged time" and "mastery". The time restraints prevented evaluation on the basis of these criteria in the present study.

However, the aims of the study were twofold. The empirical research was an essential dimension of the program. Equally important was the focus on microcomputing in education. Over one thousand primary school children were instructed in the definitions, procedures and operations involved in microcomputing and were given on-hand experience. The materials developed by Maggs, Hermann and Cross (1981) following popular, readily applicable subject matter - space exploration, will provide a valuable foundation for programs in microcomputing for primary school aged children.

Computer literacy is the basic skill of the 1980s. Computer involvement is evident in many aspects of everyday life ranging from household appliances, e.g. microwave ovens and digital watches to train timetables, credit card usage, tax returns and finally through to vast industrial, commercial and technological concerns. Therefore, computer literacy is not a luxury but rather a necessary skill for children today. The present study following this philosophy provided a foundation for computer literacy and microcomputing skills courses in primary school education.

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Table 1.

Means and Standard Deviations

Question Items	Independent 1 Mean	Independent 1 S.D.	Independent 2 Mean	Independent 2 S.D.	Independent 3 Mean	Independent 3 S.D.	Independent 4 Mean	Independent 4 S.D.	Independent 5 Mean	Independent 5 S.D.	Government 1 Mean	Government 1 S.D.	Government 2 Mean	Government 2 S.D.	Government 3 Mean	Government 3 S.D.	Significance NS
	School																
1. Definition	27.00	5.66	25.00	.00	29.25	2.75	34.00	.00	25.50	2.12	18.50	2.12	22.87	4.99	21.00	.00	NS
2. Definition	29.00	7.07	26.50	.70	26.75	4.03	31.00	.00	25.00	1.41	21.00	2.82	23.75	4.23	21.00	.00	NS
3. Procedure	26.50	6.36	27.50	.70	23.00	5.60	34.00	.00	27.00	1.41	18.00	1.41	19.87	4.05	15.00	.00	$p < .05$
4. Procedure	17.50	6.36	20.50	7.77	22.00	6.68	30.00	.00	20.50	6.36	18.00	7.07	13.75	4.92	19.00	.00	NS
5. Procedure	28.50	3.53	25.50	4.95	27.00	4.97	28.00	.00	25.00	1.41	22.00	1.41	19.37	6.07	21.00	.00	NS
6. Procedure	29.00	4.24	27.00	2.82	27.50	3.78	31.00	.00	27.00	1.41	21.50	3.54	22.37	4.31	19.00	.00	NS
7. Procedure	11.50	3.53	12.50	14.85	19.25	9.10	30.00	.00	27.50	.70	22.50	2.12	6.75	6.49	8.00	.00	$p < .05$
8. Procedure	30.00	5.66	27.50	3.54	.00	.00	.00	.00	27.00	1.41	.00	.00	9.50	13.18	22.00	.00	p .01
9. Definition	26.50	.71	24.50	4.95	21.50	5.57	31.00	.00	25.00	2.82	22.00	2.82	18.12	5.82	21.00	.00	NS
10. Definition	23.00	1.41	20.50	4.95	20.50	5.20	28.00	.00	26.00	.00	20.50	3.54	15.37	4.56	22.00	.00	$p < .10$
11. Definition	12.00	9.90	15.50	4.95	10.25	3.77	29.00	.00	20.00	.00	12.50	.70	10.12	3.56	19.00	.00	$p \nless .01$
12. Application	18.50	3.53	25.00	4.25	23.75	5.85	30.00	.00	23.00	5.65	12.00	.00	15.12	2.59	18.00	.00	$p < .005$
13. Application	13.00	.00	28.00	1.41	27.75	3.20	26.00	.00	26.50	.71	21.50	.71	21.25	4.89	22.00	.00	$p < .01$
14. Application	13.00	.00	28.00	1.41	28.00	2.94	25.00	.00	26.00	1.41	22.00	1.41	21.62	3.85	22.00	.00	$p < .005$
15. Application	9.50	3.53	27.50	2.12	28.00	2.45	29.00	.00	26.00	1.41	21.50	1.41	21.62	3.70	22.00	.00	$p < .001$
16. Application	7.50	.70	12.50	2.12	25.00	3.37	30.00	.00	21.50	2.12	20.00	.00	14.25	5.41	18.00	.00	$p < .005$

	Independant 1 Mean	S.D.	Independent 2 Mean	S.D.	Independent 3 Mean	S.D.	Independent 4 Mean	S.D.	Independent 5 Mean	S.D.	Government 1 Mean	S.D.	Government 2 Mean	S.D.	Government 3 Mean	S.D.	Significance NS
17. Application	12.50	2.12	5.00	7.07	.00	.00	.00	.00	12.00	16.97	.00	.00	.00	.00	22.00	.00	$p < .005$
18. Application	7.00	1.41	23.00	.00	17.25	4.35	31.00	.00	24.00	2.83	19.00	1.41	13.75	3.20	19.00	.00	$p < .001$
19. Application	5.00	2.83	23.50	.70	15.25	7.89	30.00	.00	25.50	.70	19.00	.00	12.37	4.72	18.00	.00	$p < .005$
20. Application	6.50	4.95	23.00	1.41	17.00	8.04	26.00	.00	25.00	1.41	19.00	2.83	13.63	5.31	17.00	.00	$p < .05$
21. Application	5.50	4.95	24.00	1.41	18.25	5.91	25.00	.00	23.50	.71	20.00	.00	13.87	4.39	14.00	.00	$p < .01$
22. Application	18.00	.00	14.50	4.95	16.25	4.19	28.00	.00	18.50	3.35	20.00	2.83	14.87	3.94	15.00	.00	NS
23. Application	13.50	6.36	21.50	.71	15.00	3.92	27.00	.00	26.00	1.41	20.00	1.41	12.62	3.07	7.00	.00	$p < .001$
24. Definition	27.00	4.24	27.00	1.41	21.00	2.70	24.00	.00	27.00	.00	20.50	2.12	16.63	4.17	20.00	.00	$p < .01$
25. Application	17.50	13.43	23.50	2.12	20.00	2.45	28.00	.00	24.50	.71	16.00	1.41	12.62	2.44	22.00	.00	$p < .01$
26. Application	8.00	.00	15.50	.71	7.50	6.03	26.00	.00	16.00	2.82	11.50	2.12	3.00	2.45	15.00	.00	$p < .001$
27. Application	12.00	8.48	12.50	4.95	11.00	2.94	18.00	.00	20.50	2.12	17.50	.71	4.25	3.37	18.00	.00	$p < .001$
28. Application	9.50	3.53	13.50	3.53	7.25	3.77	20.00	.00	19.50	2.12	6.00	7.07	3.25	1.91	8.00	.00	$p < .001$
29. Application	8.50	12.02	13.50	.71	12.25	5.91	22.00	.00	18.00	2.83	17.50	.71	10.75	2.37	14.00	.00	NS
30. Application	7.00	4.24	16.00	2.82	6.25	3.50	23.00	.00	19.50	3.53	10.00	4.24	2.13	2.48	7.00	.00	$p < .001$
31. Definition	16.00	.00	26.50	.71	21.50	6.46	24.00	.00	27.00	.00	21.50	2.12	16.12	3.72	21.00	.00	$p < .05$
32. Definition	27.50	.71	25.50	.71	23.50	5.00	25.00	.00	26.50	.71	23.00	2.83	21.25	2.43	21.00	.00	NS
33. Definition	10.00	1.41	25.00	1.41	17.75	7.76	24.00	.00	24.50	2.12	19.00	1.41	12.00	3.82	19.00	.00	$p < .05$
34. Definition	27.50	2.12	25.00	.00	22.50	5.80	25.00	.00	27.00	1.41	23.00	2.82	20.62	3.38	22.00	.00	NS
35. Definition	20.50	.71	26.00	1.41	14.00	11.88	20.00	.00	26.00	2.83	19.50	2.12	14.00	3.29	21.00	.00	NS

Table 2.

Pooled Within-Groups Correlations Between Canonical Discriminant Functions and Discriminating Variables

Variable	Function 1	Function 2
1. Definition	.30	.06
2. Definition	.12	.17
3. Procedure	-.03	.04
4. Procedure	-.19	.02
5. Procedure	-.03	.09
6. Procedure	-.03	.21
7. Procedure	.16	-.20
8. Procedure	-.01	.02
9. Definition	-.39	.02
10. Definition	-.42	-.30
11. Definition	-.32	-.04
12. Application	-.02	.04
13. Application	.29	.24
14. Application	.28	.36
15. Application	-.37	-.12
16. Application	.38	.01
17. Application	-.11	-.39
18. Application	-.13	.14
19. Application	-.11	.07
20. Application	-.00	.01
21. Application	-.13	.14
22. Application	.00	.03
23. Application	-.02	.05
24. Definition	-.02	.10
25. Application	.05	.21
26. Application	-.19	.08
27. Application	-.01	.03
28. Application	-.02	.03
29. Application	.11	-.16
30. Application	-.10	.09
31. Definition	-.21	-.07
32. Definition	-.03	.03
33. Definition	-.03	-.00
34. Definition	-.09	-.02
35. Definition	-.37	-.12

Table 3

Canonical Discriminant Functions

Function	Eigenvalue	Percentage of Variance	Cumulative Percentage	Canonical Correlation	Significance
1	840.14	79.39	79.39	.994	.000
2	207.31	19.59	98.98	.997	.000

Table 4

Canonical Discriminant Functions Evaluated at Group Means (Group Centroids)

Group	Function 1	Function 2
Independent - Method 1	-47.90	-7.58
Independent - Method 2	-13.12	14.13
Independent - Method 3	-19.27	-16.22
Independent - Method 4	11.67	6.91
Public - Method 1	-10.62	-7.89
Public - Method 2	21.20	9.70
Public - Method 3	42.17	-15.84
Public - Method 4	21.20	-8.96

Table 5

Pooled Within-Groups Correlations Between Canonical Discriminant Functions and Discriminating Variables

Variables	Function 1	Function 2
1. Definition	.32	-.51
2. Definition	.41	-.28
3. Procedure	-.01	-.16
4. Procedure	.32	-.28
5. Procedure	-.02	-.30
6. Procedure	.16	-.40
7. Procedure	.39	.67
8. Procedure	-.38	-.27
9. Definition	-.01	-.14
10. Definition	-.18	-.12
11. Definition	.34	.30
12. Application	.63	-.26
13. Application	.46	-.23
14. Application	.50	-.23
15. Application	.60	-.13
16. Application	.51	-.18
17. Application	-.51	-.06
18. Application	.13	.21
19. Application	.08	.22
20. Application	-.00	-.11
21. Application	.14	.15
22. Application	.03	.16
23. Application	-.04	.43
24. Definition	-.74	.47
25. Application	.33	.28
26. Application	-.10	.67
27. Application	-.02	.48
28. Application	-.22	.56
29. Application	.32	.18
30. Application	-.02	.58
31. Definition	-.04	-.18
32. Definition	-.02	-.17
33. Definition	.06	.13
34. Definition	-.26	-.12
35. Definition	-.28	.29

Table 6

Canonical Discriminant Functions

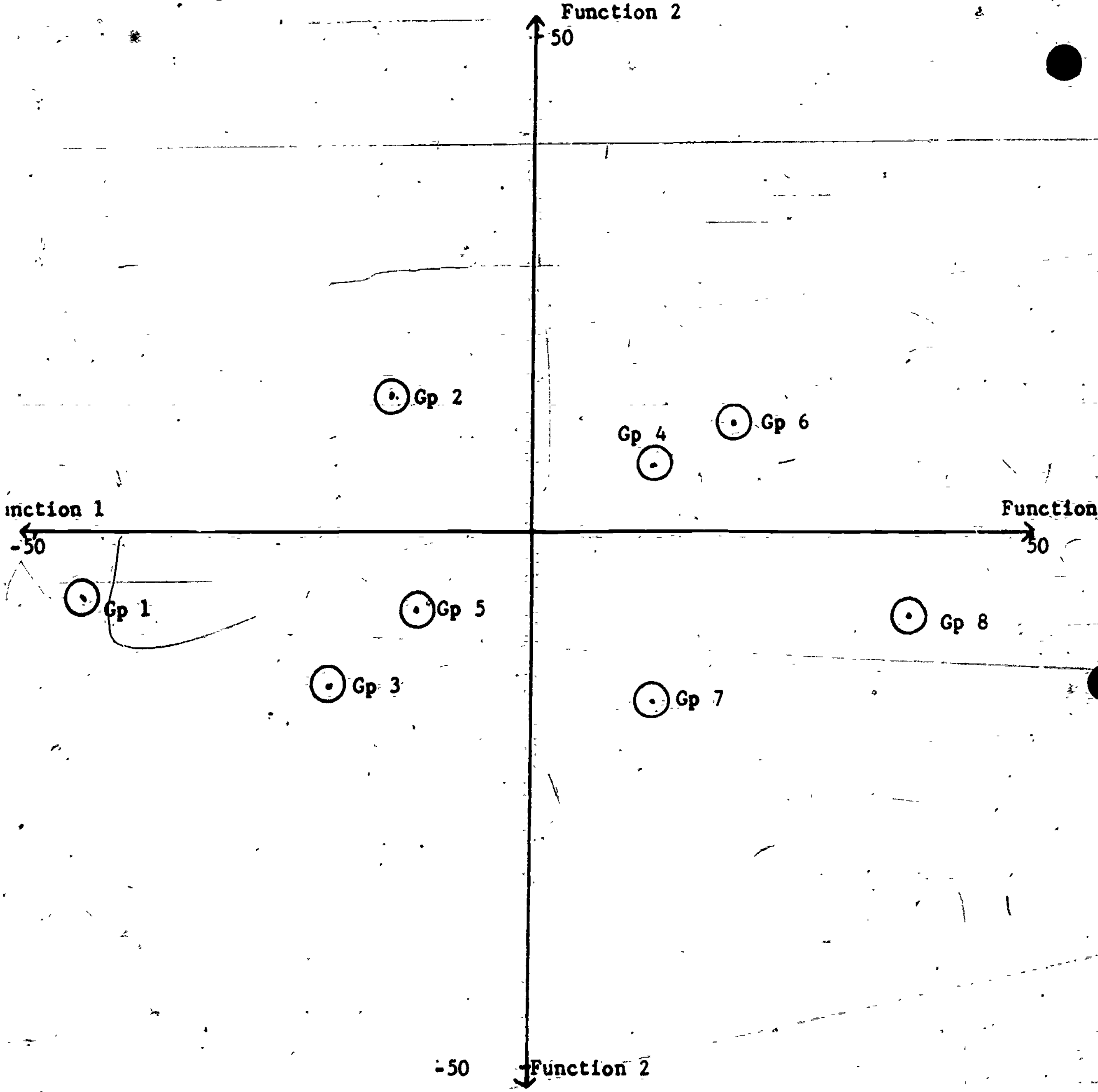
Function	Eigenvalue	Percent of Variance	Cumulative Percent	Canonical Correlation	Significance
1	1026.88	97.45	97.45	.99	.000
2	21.90	2.08	99.53	.98	.032

Table 7

Canonical Discriminant Functions Evaluated at Group Means (Group Centroids)

Group	Function 1	Function 2
Independent - Method 1	-40.64	-3.55
Independent - Method 2	-10.10	4.00
Public - Method 1	25.20	-3.65
Public - Method 2	17.99	3.02

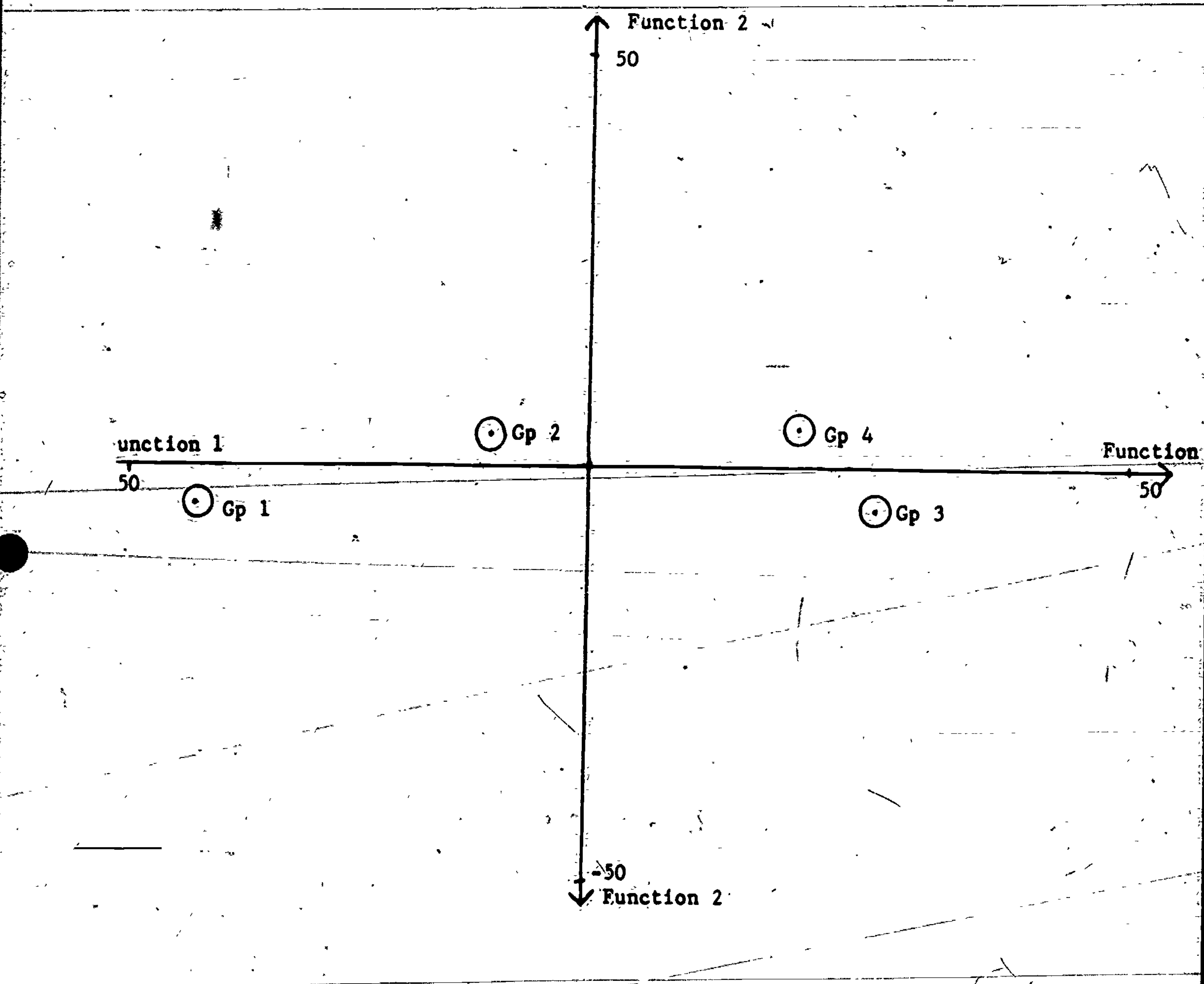
Figure 1. Canonical Discriminant Functions Evaluated at Group Means (Group Centroids)



Key

Gp 1 - Independent - Method 1
Gp 2 - Independent - Method 2
Gp 3 - Independent - Method 3
Gp 4 - Independent - Method 4
Gp 5 - Government - Method 1
Gp 6 - Government - Method 2
Gp 7 - Government - Method 3
Gp 8 - Government - Method 4

Figure 2. Canonical Discriminant Functions Evaluated at Group Means (Group Centroids



Key

Gp 1 - Independent - Method 1
Gp 2 - Government - Method 1
Gp 3 - Independent - Method 4
Gp 4 - Government - Method 4

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HOME COMPUTER BASED LEARNING SYSTEMS (HCBLS)

Jeremy Ross

Nothing has quite so engaged the spirit of young Americans, in the recent past, as has the Microcomputer Revolution. The advent of the personal or home computer system has drastically altered how we view the home, the school, and the office. Redefinition of these principal environments is now the focal point of various marketing campaigns on the part of the microcomputer industry. Traditional universal and compulsory education as we know it will certainly be affected by the influx of microtechnology into the schools. The rebirth of the home as workshop, studio, and laboratory will most certainly accelerate alternative modes of education and the process of "deschooling society". Meanwhile, new technologies, such as interactive video disk and teletex, will greatly increase the tempo of knowledge synthesis and information access.

Already home computer systems have proven to be of tremendous value in assisting individuals with various learning disabilities and/or handicaps. For example, a pocket computer can be used as an inexpensive portable telecommunicator for the deaf and hearing impaired. There now is a computer program for teaching deaf signing language. A microcomputer and line printer can be utilized to print text in braille. New external switching systems that replace a microcomputer's keyboard enable the handicapped person, through chin movements, head pressure or buffs of breath, to build complete messages and print, transmit or otherwise communicate them.(1)

On the other hand, vast changes in societal infrastructure, brought about by the Computer Revolution, will have to be balanced by a concomitant renewal of the spiritual-humanistic tradition and by an intellectual renaissance of some kind. Otherwise the prophetic educational utopianism and messianism of outstanding computerists may be negated by a vast 1984-style darkness as is often foreseen in the nightmare fantasies of our science-fiction simulationists. The social issues thus raised by the Information Age, must be studied and addressed by educators and given adequate attention if the great hope and promise indicated by the wedding of the human mind to digital electronics is to see fruition.

The Home as Learning Environment: An Overview

In antiquity, the birth of language and numbers was intimately connected with the concept of home and the family. An anthropology of the home as learning environment would reveal that during prehistory the family or tribe was often the central site of instructional activity. The birth of schools was connected with the development of spoken and written languages. At first schools were only for an elite few while the many learned folkcrafts and trades by apprenticeship to skilled practitioners of their art. Even amongst the elite of society many opted to educate their children themselves. Blaise Pascal, for example, inventor of the first mechanical calculator during the 17th Century, was entirely educated by his father who emphasized self-directed learning over the rote memorization of Latin grammar.(2)

The modern public school with its ladder system of grades K-12 was invented to met the needs of the industrial-military complex which began its ascendency at the turn of the Century. However, the mold for American education was set earlier, around the time of the American Revolution, when practical manual arts were stressed over the humanities:

> ...Rather than being taught for a better universe of world literature or for humanistic purposes, foreign languages were taught in order to fulfill professional needs, and for reasons of profit. The theory was that to be successful education and culture in America had to be practical...Arithmetic, rather than math, was taught, not for scientific enquiry, but as ciphering for accounting and bookkeeping. Thus, we have the three R's, each limited to the practical education of the manual arts rather than the humanistic education of the liberal arts.(3)

Just as the industrial revolution tore asunder the medieval commune and family structure, the microcomputer revolution of recent and future days may tear apart the existing relationships in society and give rise to a return of home values and home worksites. Community relationships may suffer as a result as persons increasingly withdraw into their computerized home/worksites. Interhuman contact may become increasingly electronic rather than personal as information networks and databanks replace physical learning and working environments.

Inadequacies of Public Learning Systems

Many social and educational critics have derided the sorry state of our public educational institutions (Holt, Illich, Papert, Silberman, etc.). The commomn theme of these criticisms is that the schools misuse children, prevent effective learning from taking place, stall and postpone the access to learning, and fail to adequately differentiate the socialization and custodial roles of schools from their mandate to train children in marketable skills. More extreme critics accuse the schools of downright insideousness:

In my new book, Teach Your Own, I assert that with very few exceptions, the social life of schools and classrooms is meanspirited, competitive, snobbish, status-oriented, cruel, and violent...In his book, Crisis in the Classroom, Silberman had this to say about the schools -and please note that this at the height of the supposed "permissive" revolution:

"Adults...fail to appreciate what grim, joyless places most American schools are, how oppressive and petty are the rules by which they are governed, how intellectually sterile and barren the atmosphere, what an appalling lack of civility obtains on the part of teachers and principals. What contempt they unconsciously display for children as children."[4]

This negative chorus is reinforced by the voice of Ivan Illich who calls for the de-schooling of society:

In schools registered students submit to certified teachers in order to obtain certification of their own; both are frustrated and both blame insufficient resources -money, time, or buildings-for their mutual frustration...[5]

Crucial Philosophical Inadequacies.

The more telling criticisms of Papert, inventor of Logo, to the effect that institutional education exhibits obsessional character traits and that traditional math education is based upon "a monumental and cruel fallacy in logic" are attacks upon the philosophical underpinnings of the schools. Many of the critics, like Papert, feel that the public schools are out of date and out of step with the tempo of the times, that their philosophical assumptions are based upon a myopia and, ultimately, serve bureaucratic and systemic ends rather than meet the real needs of students. Because of the schools' obsession with evaluation and also partly because of outmoded and inadequate curricula, schooling can result in the inhibition, constraint, fragmentation, and disassociation of the learning process.

Illich exposes the "phenomenology" of schooling and attacks the "non-conviviality" and untouchability of teaching tools in the institutional settings.

In my own essay, The Tao of Mathematics, I criticized the Euro-centric philosophy of school mathematics. This myopia consists in math teachers and "hidden curricula" that make mathematics into a linear, one-dimensional study separating it from the humanities and its sotiological significance. Papert also makes this point in his call for a restructuring of mathematics education to counteract "mathophobia" and the tremendous rift between the sciences and the humanities.

> To my ear the word "mathophobia" has two associations. One of these is a widespread fear of mathematics, which often has the intensity of a real phobia. The other comes from the meaning of the stem "math". In Greek it means "learning" in a general sense. In our culture, fear of learning is no less endemic (although more frequently disguised) than fear of mathematics. Children begin their lives as eager and competent learners. They have to learn to have trouble with learning in general and math in particular. In both senses of "math" there is a shift from mathophile to mathophobe, from lover of mathematics and learning to a person fearful of both...(6)

Public Opinion.

The 13th Annual Gallup Poll of the public's attitudes towards the public schools (Phi Delta Kappan, Sept. 1981) revealed a continuuing concern, on the part of parents, with the lack of "discipline" in the schools, use of drugs, etc. Only 9% of the public gave the schools an "A" rating, the majority giving them a "C". Teachers fared only slightly better than the schools, getting a "B" grade. There was a marked downward trend in the public's willingness to support the schools financially. 49% of those polled stated that the increase in non-public schools was a good thing.(7)

Official Criticisms. Nor do the public schools fair any better from criticisms by government officials. H. Bell, Secretary of Education under the Reagan Administration, has identified key areas of weakness in the system of American education:

(1) Not Voting: Only a minority of the 18 year olds (high school graduates and college students) register and vote.

(2) Not Knowing Foreign Languages: "To put it bluntly we are a bunch of monolinguistic bumpkins and American education is to blame."

(3) Not Training For Useful Work: "Whether we like it or not, the plain fact is that in spite of all the billions of dollars we are spending on education we still contribute mightily to that vast pool of people that make up the rolls of the unemployed."

(4) Declining Literacy: There is a "general decline in the literacy and academic competence of our students".

(5) Curricular Requirement Too Easy: "We are not as competent as we reasaonably out to expect to be in mathematics, science, English composition, history, economics, and many vocational and technical skills on the high school level. The curricular requirements are just too easy!"

(6) "A Very, Very Dreary Scene on the Landscape of Teaching": With regard to teacher education, "What is surprising is that not one single state has departed from the tradition of the dreadful sameness and mediocrity that exists across all states." (8)

The Deschoolers.

The most powerful and telling criticism of the inadequacies and deficiencies of the public school systems come from a brand of educational philosophers known as the "de-schoolers".

Ivan Illich. In Deschooling Society (1970) and in Tools for Conviviality (1973) Ivan Illich brilliantly argued for new educational "funnels" or "webs" as opposed to schools and their irrational authority to "define and measure the level of knowledge." Illich sees the schools as joyless, uncreative institutions which promote regimentation, dependence, exploitation, and impotence of 20th century man. Learning has become a commodity and, like any commodity that has been marketed, it becomes scarce and expensive. On the other hand, alternative educational networks can "heighten the opportunity for each one to transform each moment of his living into one of learning, sharing, and caring. In his concept of eutrapelia (graceful playfulness in personal relationships) Illich envisions a schooless world in which tool libraries, labs, gaming rooms, photo labs, offset presses are available to the public for joyful, self-directed learning. (9)

> If there were no schools ... if the goals of learning were no longer dominated by schools and school teachers, the market for learners would be much more various and the definition of "educational artifacts" would be less restrictive. (10)

Seymour Papert. Papert criticizes the "dissociated learning" that takes place in public schooling, the teaching of drilled arithmetic over the teaching of mathematics. He fears that the new instructional technologies such as microcomputers in the classrooms will be used to reinforce habits of dissociated learning rather than to promote learning of the "syntonic language" of math (11). Moreover, Papert advocates natural learning environments (like the home where we all first learned to talk) over the classroom:

I see the classroom as an artificial and inefficient learning environment that society has been forced to invent because its formal environments fail in certain essential domains such as writing, or grammar or school math. I feel that the computer presence will enable us to so modify the learning environment outside the classroom that much if not all the knowledge schools presently teach with such pain and expense and such limited success will be learned, as the child learns to talk, painlessly, successfully, and without organized instruction...

Schools as we know them have no place in the future.(12)

Ramon Zamora. Mr. Zamora, Author of several of the best instructional books in the Basic language, recently commented on Marshall McLuhan's prediction of an upcoming information age requiring learners "to explore interrelation and integration" as opposed to mechanical age which broke the world into parts or "subjects". McLuhan indicated learners would have to actually "unlearn what supporters of the traditional learning envbironments have been calling "education" for several hundred years!

Zamora says we can now dispense with the notion of "going to school" since we can now utilize the interactive potential of electronic and video media and moreover "the electronic media can free him to learn at any time, in any place."(13)

The artificial distinction between learning, working and recreating will begin to blur as schools, offices and entertainment locations become processes instead of places.(14)

Dr. Edward J. Lias. In an extensive and sweeping article on the subject of the re-orchestration of the world's knowledge (Computers and People, April 81), Dr. Lias identifies three forms for the re-arrangement of world knowledge into computer based forms which could greatly accelerate the deschooling of society: (1) General public information systems (2) Specialty data banks (3) Curricular Learning Systems. He states that in a survey taken at Ocean County College 70.5% of the students prefgerred CAL based instruction over classroom situations. Lias goes on to develop tables of information commands and what he terms "information instincts". These commands constitute a new type of "Query Language" for self-learners. They enable anyone to query the new informations systems at any required level of sophistication or depth for self-directed learning. The thrust of the article is that unless the major universities develop the vision to get involved with the electronic education mediums, they might not keep "their places in the sun" for very long.(15)

What is a Home Computer Based-Learning System?

As indicated by the preceding remarks, learning outside of traditional classrooms does not necessarily imply that the home will be the exclusive site of future learning. However, a home-based system can have a considerable degree of flexibility since the parts are modular and the computer itself can be of the very small, lightweight variety. The futuristics of the computer-radio wrist watch is not far off; this device could conceivably communicate with a larger, home-based system for instant update of data banks (see InfoWorld, March 22, 1982, page 1). What follows is a description of various possible systems for the home:

A. Starter System.

The Multipurpose Work/Learning Station. As a beginning system one can purchase a TRS-80, Apple II, Atari, or other personal computer . These machines can run canned programs for home record keeping tasks, home inventory control, etc. They can sort mailing lists by name, address, or other criteria and can catalog various collections. They can act as tutors, lab assistants, word processors, or gaming stations. Prior computer training is not necessary but some initial operating system or Basic Language knowledge is helpful. Both are available as low-cost quick courses from computer centers, stores, or local community colleges.

(1) A recommended starter system for the absolute beginner would be a 4K machine with a small line printer and cassette tape machine. The industry standard RS-232-C interface or a one-disk drive without interface are other options for a beginning system. A beginners system as just described should be priced at about $1000 and up.

(2) By General Purpose Workstation I mean the following uses of the system are possible:

(a) As a development system: To write and develop your own software.(Languages available for micros include: BASIC,PASCAL,FORTRAN,COBOL,LOGO,and many others).

(b) As an applications system: Use of canned programs for household inventory, mailing lists, data base management.

(c) Home management system: Use of word procesing software, Visicalc planning and forecasting, Profile or similar electronic filing system.

(d) Education system: use of home educational software for computer assisted learning , for simulations and gaming, for educational productivity: term papers, homework assignments, etc. When available, the microcomputer system can utilize educational and informational telecommunications networks.

Advanced System.

By an advanced home based learning system I am referring to any ultra sophisticated configuration with extra peripherals such as power controls, telecommunications software, and special home learning packages. Along these lines, one is limited only by how much one can afford on a system and the limits of one's imagination.

What Can You Do With These Systems?

Man-Computer Interface.

In his recent book on educational applications, Dr. Dave Moursund identified the following important uses of a personal computer to a student:

(I) A General Aid to Learning
(II) An Aid to Problem Solving
(III) An Object of Learning in Itself: The Discipline of Computer and Information Science.
(IV) Entertainment
(V) A Part of Their Future. (16)

There have been numerous articles and T.V. advertisements to the effect of "Dad, can I use the computer tonight?" etc. For example, in the May, 1982 issue of Boys' Life, there is an extensive article on the applications of home computers, becoming computer "literate", and home computer selection. As the man-computer interface is experienced by the personal computer user, the multifarious ways in which the machine can be utilized becomes of great importance. The following are some of the major areas of applications for home computers (17) that are either directly or only indirectly of educational value:

CAL. Computer assisted learning can provide your family with individualized, non-threatening drill and practice sessions on any subject, as well as with an interactive learning station. A CAL program can do the following specific things:

(a) Generate and present exercises.
(b) Provide immediate feed-back and generate periodic progress reports.
(c) Measure performance and automatically adjust difficulty levels.
(d) Record performance for later review.
(e) Design and print out worksheets, tests, answers.

As mentioned above, in general a personal computer can act as a general aide to learning, a problem solving tool, an object of learning, and an entertainment/communications station. However, with CAL there are actually two possible modes:

(a) Tutor Mode CAL — "student programmed by computer" and (b) Tutee Mode CAL — "student programming computer". Both are very different applications of the same mind tool.The first mode utilized for skill-building exercises, drills, reinforcement, encouragement, individualized instruction, etc. The second mode is used for exploratory learning,learning about learning,and more creative aspects of computer programming.

AI. Artificial Intelligence and Robotics is another one of those areas that could mean anything from power control over one's lights to elaborate robot systems. However, in the context of home computer-based learning , this topic is most closely related to the work of Papert and the Logo Language which has been used at MIT to teach very young children to program a cybernetic machine in the form of a turtle.

This application of AI can be considered to be a subset of Tutee Mode CAL if we restrict ourselves to a learning object such as Papert's Turtle. Turtle mathematics relates to the whole idea of making mathematics a natural language and of learning the principles of "Mathetics", Papert's term for principles of learning. Here the original idea of aesthetiks(learning through the senses) is joined with logic (Logo is a special computer language in which communication with the Turtle takes place).

Logo makes computers accessible to very young chiuldren. It provides them with a "computer-rich" world like the world they will grow up in rather than a mathematically impoversished world of mathophobic adults. This is Piagetian learning, learning without having to be taught.The computer, in this sense, is a carrier("germ") of cultural seeds.[18] The computer becomes, to the child, "an-object-to-think-with".

Instead of the "force-feeding of indigestible material left over from the precomputer epoch" the Logo language enables the child to use a "mathematically expressive medium".

Computer-Device Interface.

Peripherals. The gadgets and devices added to a computer to help it communicate with the outside world or provide it with auxiliary memory are termed peripherals. Mass or auxiliary storage devices (storage peripherals) are necessary to store and retrieve large volumes of data without taxing the computer's built-in memory known as the RAM memory.

Interfaces. An interface is a go-between device which enables a fast and efficient exchange of information and instructions with the so-called "real" or "outside" world. A computer interface actually converts data from the computer into a form usable by humans, machines, or other electronic devices and vice versa.

Terminals. Interface peripherals known as terminals are capable of input/output operations. "Smart" terminals have their own built-in microcomputers and can be used as "stand-alone" computers or as a connection to larger, more powerful microcomputers or main frame computers. Special graphics terminals are used for computer-assisted drafting and designing (CAD). Microcomputers with a special graphics circuit board are also capable of sophisticated high-resolution computer graphics. Graphics terminals or micros can be used with a light pen, a device that enables one to draw on the video display screen and manipulate the drawing.

Hard-copy. Printers and plotters can provide a permanent record of the computers output. Line printers can be either impact or non-impact. Non-impact style printers use an electrosensitive paper, are very fast but do not form characters as clearly as is possible with impact-style printers. Plotters are devices that electronically produce various graphs, on the video screen or on paper. Although printers can sometimes simulate plotters, actual pen or multi-pen plotters can produce sophisticated graphs and drawings including lettering in a few minutes or seconds.(19)

Modems and Acoustic Couplers. A modem is an I/O (input/output) device that lets a terminal or microcomputer communicate with another microcomputer or main-frame by a direct hook-up to telephone lines. Modem (modulator-demodulator) changes binary data into an audio signal. An acoustic coupler is a special modem that can convert computer generated signals into sound, and vice versa to allow interfacing between two computers via telephone lines. This allows an indirect connection to telephone lines by terminal or microcomputer. New "direct-connect modems" connect directly to phone lines and support both manual and auto-answer/auto-originate operation. They have built in microprocessors to control its automatic operations. This permits the use of simple ASCII commands from the host computer and nearly eliminates the software overhead usually required for the operation of sophisticated modems.(20)

Computer-Telecommunications Interface.

Home Video System Interfaces. Integrated video terminals (IVT) are now possible. These are devices that join personal computers to home video systems. Video disk can be used in a home learning station for individualized instruction, for self-teaching, for closed-circuit broadcasts and continuing education programs.(21)

> ...In the sciences, the video disc can demonstrate and simulate natural phenomena; in history, literature, and theatre, it can help in the analysis of dramatizations; in business, social studies, teacher education and value training, it can demonstrate and simulate human interactions; in physical education and technical training, it can depict motor skills; in mathematics, it can demonstrate physical relkationships and show graphs and charts; in music, in can show bowing and fingering techneques. Clearly, there is no lack of application for innovative, quality educational video discs.[22]

With microcomputer interface, the video disk system becomes a very sophisticated instructional device controlled by the learner. The microcomputer allows linear play, manual frame access, automatic stops, random foward access, and general programmed control.So-called "smart video discs" can utilize a technique known as branching to constantly monitor a student's progress for a particular lesson and either promote the student to a more advanced lesson or provide appropriate remediation materials. The player's microprocessor can print out progress reports for self-review.[23]

<u>Videotex</u>. Another big development is Videotex for learning. Videotex is a system whereby a stream of digital data encodes alphanumeric and/or graphic images at a transmission rate television systems can handle. With a decoder attached to the television set buffered pages can be summoned by the viewer by a keypad. The Open University in Great Britain uses this system and already its 45,000 graduates comprise 1/12th of all UK alumni and have fully accredited world-recognized degrees. Similar systems operate in Canada, France, and other countries. In the U.S., Source and Compuserve provide related services. Videotex eqipment is used in electronic home banking, current flight information, E-mail, electronic news services, and a host of other applications.[24]

Availability of Courseware.

Using Moursund's breakdown of uses for personal computer systems as a guide, we can group various kinds of educational software (often called "courseware") to obtain a picture of what is presently available for home use.

Educational software can thuse be broken down into (1) computer as aide to learning (CAL: drill-and-practice,tutorials, instructional packages, etc.) (2) simulations and games (3) productivity tools (word processing, computer graphics, data base programs).

Canned software packages are now available that provide home learning modules, personal accounts payable systems, money management systems (logging checks,balancing checkbooks, inventment management, cash management, miscellaneous expenses, budgeting, monthly savings plans,stock buying and management,valuables inventories,etc.).

Other home applications involve time management programs (special date calendars,electronic diaries,home task scheduling, things-to-do lists etc.). Home data-base management programs are available for keeping electronic telephone directories, family dental and medical records and appointments, drug adminsitration records, symptoms/self-diagnosis material,jogging records, food cost records and analysis, tax record keeping, receipt inventory,menu planning, cost per serving/cost analysis, diet analysis, nutritional composition of foods, family clothing sizes, clothing inventory, fabric care records, energy audits, home utilities records and analysis, automobile records and analysis, etc.

Basic computer literacy (BCL) courseware has become available gradually. These self-instructional programs teach the rudiments of computer science and literacy (topics such as introduction to micros,history and evolution of computers, software development,and data processing techneques). Many of these programs teach varioius programming languages and designed for home-study situations. Much of the BCL type courseware is available through mail-order type sources (courses in digital electronics, computer repair, etc.)

If we add the idea of the home as cottege industry, studio, or workshop we can include all the accounting-type packages (General ledger, accounts receivable, payable, etc.) and other software packages associated with management of small-businesses such as Visicalc (electronic spread-sheet) and Profile (electronic filing systems).

The electronic filing systems can be used with word processing software to provide a powerful system for research and writing projects. The number of applications for such a system are too numerous to list but some possibilities are:

The Electronic Renaissance.
Computers In Creative Work.

I mentioned earlier in this paper the need for some sort of intellectual renaissance. The electronic model of matter is a revolutionary conception of matter in that it contradicts the traditional notion that matter consists of indestructible and unchanging autonomous atoms. The electrical nature of matter as understood by contemporary scientific thinking states that matter is made up of relationships, processes, and events rather than bits of substance and that fundamentally matter is relational, "much more like a delicate fabric than an ediface of hard-building blocks."

Modern mathematics has emphasized this relationality of matter in its concept of a relation as a set of ordered pairs revealing parent-child relationships. These same mathematical notions of fundamental order and pattern are of significant importance in combinatorics and computer science, especially in data base construction and management. It would seem to me that the renaissance we seek must build upon this electronic model of reality and the relationality of modern mathematics as a key or kernal concept.(25)

Life without entry into the world of ideas becomes nothing more than a repetitive baseness. Computers, as Papert stresses, are carriers of certain "cultural germs" or ideas. We must now begin to take a closer look at these "idea cells" and pull out of them what we can in the hope of finding a "philospher's stone" into the future.

One very key idea in this renaissance will be global communications, global consciousness. Another will be the key idea of problem solving and an enquiry-based consciousness instead of dogmatics and final answers. New global languages, based upon universal electrical communication systems, and the international telecommunications networks now in existence and growing may be the partial solution to the world paradox facing mankind of scientific progress and simultaneous threat of nuclear holocaust.

It is possible, just possible, that the methetical global communication languages of the Information Age, because they transcend local conditions and the inherent linguistic limitations of natural languages, can be used as the basis for a higher order of communications than is presently characteristic of the planet. This type of language, referred to as "Tao language" by Chinese philosopher Wei-Hsun Fu, could function to liberate us from the non-electric, mechanical-age type of communications that are currently hindering a new synthesis of global knowledge. As Wei-Hsun puts it:

To imitate Lao Tzu's Tao-utterance, we can indeed say that Tao-language is to all the linguistic forms what a great ocean is to the streams and brooks. What must be stressed...is that since the question of language, the question of thought, and the question of (the truth of) reality are ultimately one and the same question, man's linguistic expressional emancipation is ultimately none other than his ontological - or better, trans-onto-theo-logical-emancipation, and that means man's own emancipation onto new manhood, the manhood of Tao.[26]

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BEYOND DRILL AND PRACTICE

Joanne B. Rudnytsky

To participate in a conference entitled "The Computer: Extension of the Human Mind" is a pleasure. All too often computer-assisted instruction (CAI) seems aimed at making the student an extension of the machine. This conference title makes it clear that our model of the human mind will guide our view of the appropriate use of the computer in education.

Working with computers does illuminate our own mental processes. The words "input" and "interface" are so useful that they have passed into common speech. From time to time I realize that I am saying to myself something like "Hey, you didn't process that interrupt right!" But we must not try to turn people into imitation computers. A current model of the human mind, proposed by a leader in the field of artificial intelligence, Minsky (Bernstein, pp. 50-52), sees the mind as containing a very great many semi-autonomous information processing centers. For all their branching capacities, computer languages now used in CAI are essentially linear. They can represent only a tiny fragment of what the human mind does.

There is a view of education which is based on a linear theory. The Skinner box theory of learning maintains that behavior not only can be but should be learned as a linear set of tiny steps. There is no doubt that some parts of our behavior do and should follow this model. For example, tying shoe laces consists of a set of discretely learned but now automatic actions. The valid purpose of this linear approach, in mathematics and elsewhere, is to remove some sets of actions from the realm of that which requires any effort - to make those actions automatic.

No doubt it is handy to know automatically that seven times nine is sixty-three. I recommend it. I recommend much more mental arithmetic than is currently fashionable. But a child who knows number facts with no understanding of how or when to use them is a slow imitation of a four-function calculator. The jobs that require basic skills and nothing but basic skills are gone or going fast. Clerks seldom calculate change at the store. Some fast food chains have even made it unnecessary to punch in the price of a cheeseburger. The clerk presses a picture of one instead. Machines can perform automatic actions more rapidly and accurately than humans can.

There are two sets of circumstances in which we need to memorize without understanding. One occurs when we need the behavior before we are capable of understanding the organizing principle - we need to tie shoes before we learn any theory of knots. The second occurs when there is no accessible organizing principle - we learn our most commonly used phone number by rote.

But mathematics is a creation of the human mind and can be understood. There is no longer any "real world" need for or reward of performance without comprehension. Drill and practice is a part, a vital part, of mathematics learning. But it should be a practice upon and reinforcement of concepts. The child who without understanding learns the "invert and multiply" method of dividing fractions in the spring of one year remembers in the fall of the next that sometimes, under some mysterious circumstances, you turn one fraction upside down. I have met that child all too often. My experience is verified by a study by Peck and Jencks (p. 348):

> The difficulties children have with fractions are conceptual. . . . Children are going through the motions of operations with fractions but they have not been exposed to the kinds of experiences that could provide them with the necessary understandings. The study suggests mathematics educators and curriculum writers need to shift emphasis from the learning of rules for operations on fractions to the unveiling of a conceptual basis for fractions.

Although it may seem to take more time to teach concepts than mechanics, it is time well invested. I have often taught the same students in several grades, so if they did not remember something from last year or the year before there was no one else I could blame it on. Parenthetically let me remark that the student who remembers really vividly is the one who made the model. Organizing principles do pay off. If arithmetic is understood, algebra is easy. If algebra is comfortable, trigonometric and calculus manipulations are no problem. As Howard Fehr wrote (p. 3):

> In the teachings of mathematics it has been the custom to delay too long the introduction of certain fundamental concepts . . . that are necessary for a real and lasting understanding of the subject. The lack of emphasis on these fundamentals . . . may perhaps be explained but not justified by the fact that the mechanics . . . are easy to teach and easy to test, while it is more difficult to teach with real understanding the more abstract concepts, and to measure the degree to which a student has mastered these concepts is even more difficult. However, if we teach in this manner, we can in the long run cover more ground, since the mechanisms then become means to an end not ends in themselves, and, even more important, the students develop habits of thinking things out for themselves as well as attaining an increasing ability to do this.

The "Back-to-Basics" movement represents a legitimate desire on the part of parents that their children have substance in their education and not come out unprepared to enter an increasingly demanding marketplace. But the form the movement has taken is unfortunate. A student who learns that rote memory will be rewarded is learning a falsely optimistic picture of the world of work. We need to be able to use our information, not just have and regurgitate it. Concepts are not a frill!

Is it possible for a computer to aid in the formation of concepts? I submit that it is.

My experience with using the computer in mathematics classes goes back to 1968, when I started using a time-shared teletype terminal to teach beginning programming and numerical methods. At that time I saw no use for instruction by means of the computer. But in 1975, when I was fortunate enough to be introduced to computer graphics at the Oregon Museum of Science and Industry, I felt that I had met an educational tool with revolutionary potential. The ability it offered to make ideas visual and to allow experimentation would be exciting even to good students. But the possibility of making mathematics attractive to the students who had found it unattractive was what really excited me.

Since 1975 I have been involved, in various ways, in the development of CAI in mathematics. The remainder of this talk will be illustrated by examples from two series of programs, Factoring Whole Numbers (FWN) and Fractions (FR), and from one single disk, Arith-Magic (AM). The series are organized as follows. Each topic, six in Factoring Whole Numbers, and twelve in Fractions, is presented in two programs. The A program is made up of a highly-interactive, branching tutorial, an opportunity for the learner to give the computer problems, and then sets of problems given by the computer to the student. In almost all cases the student has a choice of level of difficulty in problem sets. The B program is a game or exploration which uses the skill in a creative way, or sets it in a wider context. Many of the B programs contain enrichment material. Many are usable by students of varying degrees of mathematical ability. A wide range of students will learn from them; more able students will learn more. Many of the programs suggest that the students use manipulatives while running the programs. Let me immediately concede that one needs to be able to read (at least at a fifth or sixth grade level) to use these programs.

The programs are carefully sequenced. In sampling it is important to realize that programs build on preceding ones.

Now let us look at some examples of ways in which we can use the computer in instruction. Perhaps the simplest level is the computer as electronic lecturer or textbook. At this level the advantages of the computer are that it can easily repeat last Wednesday's lesson for a student who was absent, is always consistent, never mumbles, and can present information in an attractive format. In a book "white space" is expensive. On the computer it is free. As an example of the display of information, let us look at "The Sieve of Eratosthenes" (FWN 3B).

A textbook cannot require the reader to interact, as a computer tutor can and should. Frequent questions verify that the student has understood. A branching program allows the student to skip unnecessary information and to get additional explanations and examples where needed. Let us look at the treatment of perimeter in "The Rectangle Game" (FWN 1B).

The dialogue will be as good as the programmer makes it. It is important to predict the categories of responses and handle them in a way that makes the user feel free to experiment. Running a computer program should never make the user feel stupid. (Programmers often feel stupid, but that is entirely different!)

On the other hand, if the questions are usually interesting, I see no need to use valuable machine memory space on being able to understand the word "yes" in fifty-seven languages. Let's look at the handling of input in, for example, "Pairs and Squares" (FWN 2A). The author must also predict and/or observe and then deal with other responses which differ from the expected. In "Pairs and Squares" we establish perfect squares as numbers which, as tiles, can be arranged in squares. In order to factor efficiently we need to have the concept of a square root, so we next try to find the side of a square with a given area. (That square root has any relationship to squares is a new idea to many adults as well as children.) We ask whether you can make a square with 8 tiles. The expected and desired answer is that you cannot. But what if the student builds a hollow square? That is the kind of reasonable error which needs special treatment.

Going back to "The Rectangle Game," let us look at an occasion where understanding grows in a quantum leap rather than a discrete step. Suppose that in the course of the game we want to find a rectangle with an area of 30 and a perimeter of 26 and have arranged 30 tiles (correct area) into a 5 by 6 rectangle (wrong perimeter). When the student physically breaks the 5 by 6 rectangle into two 5 by 3 pieces and slides one piece so as to make a 3 by 10 rectangle, the commutative property of multiplication springs into life. $5 \times (2 \times 3)$ really does equal $(5 \times 2) \times 3$, though the language the student probably (appropriately) uses is that if it's twice as long it has to be half as wide.

A picture is often worth the proverbial 1000 words, but even a picture is an abstraction. As Bruner says (Left Hand, p. 101), "Manipulation and representation . . . in continuing cycles are necessary conditions for discovery. They are the antithesis of passive, listener-like learning."

Students of all ages need a solid background with manipulatives before they deal with abstraction. Students of all ages also need to see mathematics problems as something a reasonable person (of that age) might want to solve. In her wise and helpful book, Children's Minds, Donaldson shows that children have more ability to conceptualize than they are often given credit for. As she says, (p. 17, emphasis is Donaldson's) if a task "makes human sense . . . it is not at all hard to convey to a child what he is supposed to do: he apprehends it instantly. It then turns out that neither is it hard for him to do it. In other words, . . . he shows none of the difficulty . . . [with certain Piagetian tasks] Piaget ascribes to him."

Sometimes the way to make human sense is through a human story. As an example, let us look at the story of Laura, Mary, the baby and the two cookies in "The Division Meaning" (FR 3A).

But as the popularity of Rubik's cube attests, solving good problems is inherently pleasurable. Small children love to learn. It is one of our responsibilities as educators to avoid destroying the child's pleasure in problem solving by substituting mechanistic rules for thought or by supplying inappropriate intrinsic rewards. It is sad to see how many children have become convinced that common sense has no place in the mathematics classroom. The individualization which is possible with the computer makes it possible for each child to have experience and success with problem solving. On the first page of his classic How to Solve It Polya suggests (the emphasis is Polya's):

> The student should acquire as much experience of independent work as possible. But if he is left alone with his problem without any help or with insufficient help, he may make no progress at all. If the teacher helps too much, nothing is left to the student. The teacher should help, but not too much and not too little, so that the student shall have a reasonable share of the work.

Helping not too much and not too little is not easy. As a rather mundane example of an attempt to provide help if and only if it is needed, let us look at "Adding Fractions" (FR 6A). More helpful, in the long run, is the stimulation of the student's ability to decide whether he or she is ready to move on. In the A programs, the computer does not give you problems until you have had a chance to give the computer problems. This gives the learner the opportunity to experiment, and to try out easy or difficult numbers. It is fun to watch people's ambitions soar. Let's make the computer find the answers in "Highest Common Factors" (FWN 5A). Polya's somewhat disconcerting advice to occasionally try to solve a problem by means of a related harder problem is often feasible on the computer.

I don't think that Polya would disparage adding fractions, but he of course has something else in mind when he speaks of problem solving. No computer can substitute for Dr. Polya. But one of my aims in writing these programs has been to provide some occasions for the richly suggestive freedom which encourages problem solving. Here I would like to demonstrate two programs which can be used by students at many levels of sophistication. Even weak students can play the games and begin to see some of the patterns. Even exceedingly stong students are unlikely to solve the second problem entirely.

In the "The Euclid Game" (FWN 5B) we use the Euclidean algorithm to find the highest common factor of two numbers. The object of the game is to find pairs of numbers which will take a maximum number of steps to find the highest common factor. In "Decimal Patterns" (FR 3B) the object is to predict the behavior of the decimal equivalent of a fraction, given the prime factorization of the denominator.

Mathematicians and scientists work by hunch and intuition, followed by testing and proof. In teaching mathematics we have tended to state the rule and than tell students to apply it. This makes mathematics alien to the student, and it is alien to mathematics. Improbable though it may seem, a computer program can make it possible to allow the student to go through the steps of dicovery and intuition which make an idea his or her own.

Computer programs are a powerful new teaching tool, but they are one tool among many. Teachers remain vital. Books, manipulative materials, other audio-visual materials, all have their place. The computer can only deal with the expected. Once in an algebra class a student asked how I knew that the way we had just factored an equation was the only possible way. This is a deep question, and we spent several fruitful days exploring it. No computer program has that kind of flexibility. At its best, teaching feels to me like what conducting a symphony must be like - a whole which is much more than the sum of its parts. I hope teachers will find these programs a valuable new instrument in their orchestra.

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TEACHING BEGINNERS TO PROGRAM: SOME COGNITIVE CONSIDERATIONS

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One interesting and important use of computers in schools is that of students learning to program. Many reasons are offered in favor of teaching students to program: programming puts a computer user clearly in charge of a machine; students who can program can write special purpose programs for use in their other classes; students can use programming to exercise their problem solving skills; becoming a professional programmer is one of today's best promises for future employment.

Many arguments are advanced against teaching students to program: a person must invest a great deal of time and energy to learn anything more than rudimentary programming skill; creating well written programs requires huge amounts of effort, even for skilled programmers; students usually code problems that someone else has solved rather than solving problems themselves; only a very small fraction of students will become professional programmers and those had best wait to learn until the can learn formally at a mature level. Regardless, programming is being taught, in a variety of forms, to students from preschool to senior citizen's classes.

Programming and Cognition

Programming is a complex task, consisting of many subtasks of varying levels of difficulty. A person can be said to be programming even though he or she is able to do only a subset of the tasks and is only using a part of the language. How large the minimum set must be if the total is to add up to "programming" is a question far from being settled. Effective use of any programming language, however, requires knowledge of quite a few different programming components. In designing instruction for students learning programming, one must consider the difficulty of these various programming subtasks, and must match the tasks to be taught to the cognitive developmental level of the students receiving the instruction.

Cognitive development

The several different prominent theories of cognitive development agree on general characteristics of the growing mind (see Further Reading). The young child is primarily focused on concrete objects and relates to physical representations best. As the child gets older, he or she is able to deal comfortably with more and more abstract representations of objects and ideas. At the same time, the growing child comes to classify objects into groups, considering the groups as aggregates of elements, where the elements have common characteristics. Processes and ideas also become members of groups, and even problems eventually are recognized as belonging to classes.

With objects or ideas associated into groups that represent a single conceptual unit, a person can consider more ideas at one time. The size of a learner's "chunks" of knowledge has great effect on how readily he or she can understand a situation or solve a problem. Another characteristic of cognitive growth is the transition to more and more formal logical analysis of a situation or problem. This growth in formal logic, like other cognitive growth, may be due to experience with logical analysis or may be due to maturing of innate cognitive skills. In either case, it can be observed in students as they get older.

Research

Some researchers have looked at programming through a cognitive perspective (Brooks,1977; Floyd,1971; Sheil,1981; Sime,1973,77). Most of their work, however, is primarily focused on expert-level behavior and is based on observation of professional programmers who already had adult level cognitive abilities when they began programming. A few researchers have addressed the teaching of programming, to computer science students (Hoare,1976; Soloway,1981) and to novice, non-specialist groups (Cheney,1980; Mayer,1975,76,79,81). These studies have looked at the teaching of specific tasks and students' success with learning them.

In the next section of this paper, I suggest a hierarchical structure of the subtasks of programming as a whole. This will, I hope, provide some guidance to designers of programming instruction. I hasten to add that the tasks being discussed here are not all one needs to be a programmer. Rather I am addressing the specific constructs of programming languages that one learns while one learns to program.

Programming Constructs

A computer programmer writes a program to give direction to a computer. The program must specify the actions that are to be taken and provide a means of recording the effects of those actions. Learning to program computers involves learning the syntax of a language plus learning how to make effective use of the structures the language provides. Beginning programmers often are taught only syntax, with the expectation that the overall structures will be apparent. In the discussion below, the focus is on the structures of computer languages rather than the syntax.

The programming process follows a pattern like that of other structured problem solving processes. First the given problem must be analyzed and the initial state clearly understood. Next the final, desired state must be indentified and the specifics of that state defined. The remaining part of the problem solution consists of determining what processes are necessary to cause the transformation from the initial to the final state. A specific programming task often involves many cycles through these steps, as the problem definition becomes clearer.

Throughout this process, the programmer has two factors to keep in mind: the data to be manipulated and the control of operations on those data. In one sense the data are the nouns and the operations are the verbs of a computer language. In natural language the nouns and verbs cannot be dealt with entirely separately. The programmer similarly must keep the relationship between the data and the operations in mind. However, considering these two factors separately aids in the understanding of the programming process, both for the individual learning to program and for the teacher designing instruction.

In the following discussion, I have given examples of the control constructs through two language forms. One is an informal algorithmic language using English language expressions. The other is a language very much like BASIC, but with some extension to make the examples more understandable. For examples in the discussion of data, I have shown how the data structures would be used in the BASIC like environment.

Data

Data are the entities that a program is processing. Programmers think of these entities as objects to be moved about, changed and recorded. They are the things the program must keep track of. Data can be viewed in different categories, dependent on how abstract the representation of the data is. The first are literals and constants. For example, when a program says

```
10 PRINT 'HELLO'
```

the literal 'HELLO' is directly evident. Similarly, in

```
10 PRINT (4+5)
```

the value of the constant is very easily seen.

The next level of abstraction provides the simple variable, either entered into the program by a user

```
10 INPUT A
20 PRINT A
```

or assigned within the program.

```
10 A = 1
20 B = A + 1
30 PRINT B
```

Understanding the use of this kind of data requires the ability to see the variable as a name of an object which, in turn, has the value of the variable as its contents.

The next category of data contains structures through which the data are addressed less directly. Typical of these are records and arrays. The data in these structures are perceived as a unit. The units are aggregates of values that are accessed through the use of a variable value separate from the unit. For example, in a two dimensional array, a value is indexed through two variables.

```
10 X = 1
20 Y = 2
30 PRINT TABLE(X,Y)
```

This requires using one set of variable values to point to another set. Additonally, in some aggregate data structures, the position of the data in the set contains meaning. For example, in the record

```
ROGERS,JEAN,B,1982
```

the information is known to be a first name if it is in the second field of the record, while in a list of colors

```
COLOR(101) = 'black'
COLOR(102) = 'red'
COLOR(103) = 'blue'
```

the order of the values may have no meaning. Other complex data structures, such as a file made of records, add more dimensions to the complexity but do not involve further levels of abstraction.

The least concrete data structures are those in which the programmer creates images of structure over the data. To do this, the programmer builds data relationships using tools provided by the language rather than using a structure that is predefined in that language. Accessing the values in such structures often involves very indirect addressing, and the structures may be dynamic and ephemeral.

Control of Flow

The second facet of programming is control of flow of operations. Operations are the active parts, the verbs of programming languages. When a program is run, it executes the operations on the data.

The simplest flow of operations is a straight sequence, where each operation is done once, in sequential order according to the linear order in which the operations are written.

```
10 INPUT NAME                        Get value
20 PRINT 'HELLO, ',NAME              Print message and value
30 END
```

The next most easily understood and used is the infinite loop.

```
10 INPUT NAME                        Get value
20 PRINT 'HELLO, ',NAME              Print message and value
30 GOTO 10                           Start over
```

But rather than attempting infini., one wants control over the repetition of the loop. If the programmer knows how many times a loop should be executed, that structure can be written with a for loop.

```
10 FOR COUNT = 1 TO 10               Iterate 10 times
20 PRINT '*'                           Print message
30 NEXT COUNT
```

or using a variable limit rather than a constant

```
10 FOR COUNT = 1 TO N                Iterate N times
20 PRINT '*'                           Draw picture
30 NEXT COUNT
```

To use the for loop, one must think of the loop as a unit to be executed a discrete number of times. This is in contrast to thinking of the statements as a sequence of operations that are to be done and possibly repeated. The for loop thus requires a move to a different level of understanding and is a more difficult concept as a result.

Often the completion of a loop will depend on some condition rather than on a count of the iterations. The most common construct in natural language expression of such of process control is the do/test loop (Miller,1981). In a do/test loop, the process is done once, then the decision criterion is tested to see if execution should be repeated. The do/test loop assumes there is some other instruction to follow when the loop activity is completed.

```
10 INPUT VALUE                       Repeat
20 PRINT VALUE                         Get the paper
30 IF VALUE <> LAST  GOTO 10           Grade the paper
40 END                               Until the last one
                                               is done
```

or in a counting loop

```
10 COUNT = 0                         Repeat
20 PRINT '*'                           Print the message
30 COUNT = COUNT + 1                 Until 10 have been
40 IF COUNT < 10  GOTO 20                      printed
50 END
```

Another loop, the test/do construct, is even more difficult because one must see the loop as a unit with an additional complication. The decision about execution of the unit is made before each execution, as the test for a test/do loop is at the beginning of the loop. This allows for the loop not being executed at all under certain conditions. In these cases, or at the time when the looping is complete in the usual case, the activity of the program flows to some other instruction. This next action is assumed in the test/do loop structure as it is in the others, but takes a more confusing role because the test for the loop comes first in the structure. This loop seems to be the hardest of the loop constructs for learners to handle correctly, particularly as it often requires tests on negative situations.

```
10 IF A > 100 GOTO 50                While A not equal 100
20 PRINT A                             Print A
30 A = A + 1                           Increment A
40 GOTO 10
50 END
```

Another poorly handled construct is the conditional or branch structure, which allows for a fork in the flow of execution of operations (Sime,1973). This also requires the programmer to think of segments of operations as units, and to understand the criteria for executing one unit or another. In computer languages that do not provide the if/then/else directly, unskilled programmers write some very convoluted code to accomplish this structure.

```
10 IF A > 10 GOTO 30                 If A > 10
20 GOTO 50                             Then
30 PRINT 'GREATER THAN 10'              Print 'A greater
40 GOTO 70                                      than 10'
50 PRINT 'NOT GREATER THAN 10'       Else
60 GOTO 70                              Print 'A not greater
70 END                                          than 10'
```

Implications

These data structures and control constructs are the building blocks which programmers combine to create programs. The methods and styles of combination are another important area, one which I will not address here. Tasks within the hierarchy given above, however, demand a wide range of levels of cognitive abilities.

Observing and considering this hierarchy can help the designer of instruction in two ways.

The first is identifying the developmental level at which students will be able to understand particular concepts (Kossan,1981; Mowe,1982). It should be noted, however, that people do use constructs they do not clearly understand, often using them quite effectively. Some researchers (Papert,1980) have argued that given experience with more complex cognitive tasks, particularly control of flow of operations, younger children can learn to accomplish these tasks independently.

Additionally, by considering the levels of difficulty of specific tasks, the instructional designer can adapt the delivery method to the specific task (Lawson,1975; Merrill,1966). Knowing the developmental level of the students and the difficulty of the task, the designer will have guidance on the best teaching tools to use.

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EA 014 932

ELEMENTARY CLASSROOM COMPUTING

Joshua Reckord

We would like to share with you our observations as teachers about the classroom in general and as a site for the placement of micro computers. We would also like to share some thoughts about our profession with a specific look at its relationship to classroom computing and curriculum decisions.

Much discussion about computers and their relationship to future classrooms is being suggested at this conference. When we, as classroom teachers, consider the future we are struck by the potential variety of outcomes. Hopefully, as we consider the importance of classroom computing on future classrooms, we will consider computing within a broad possible horizon, realizing that decisions about classroom computing will affect the total make-up of our schooling experience.

Daily schooling, especially at the elementary level, is experienced within a classroom, most often a space roughly 30 feet by 40 feet by 10 feet high (12,000 cubic feet) with permanent or sliding walls shared by 20 to 25 children with one or more adults. This experience lasts six hours a day, 180 days a year, totalling 1,080 hours annually. This space is shared by desks, chairs, tables, books, maps, brooms, tape recorders, drinking fountains, a pencil sharpener that might or might not work, and, in a growing number of classrooms, micro computers. We call this rich environment "class scape." There is a relationship of each component to each of the other components. We have chosen to look at "class scape" through the following five perspectives.

Different levels of citizenship: the relationship of adults to children as groups, sub-groups, and individuals, as well as the relationship of individuals and groups of children to other groups of children.

Space arrangement and territory: the physical layout of the room, the arrangement of equipment, and the access and availability of materials and equipment.

Information circulation: the use of books, bulletin boards, circulation of assignments, the use of dittos vs. workbooks, and the availability and access to record-keeping and evaluation.

Sound level: the relationship of noise, or the lack of it, to the environment.

Time: the elements of instructional time vs. free time, passing time, and the opportunity for individuals to choose activities appropriate to their own interest.

Each of these various elements found in the classroom have a relationship to each other as we interpret or look at the classroom. We would like to quickly raise some questions and observations about these five perceptions in relationship to micro computing.

Citizenship: Who decides which student should use the computer? Is computer access on a regular sequential basis according to a class list, the first student finished with his or her work, students assigned by the teacher, or a sign up by interest? Is there a relationship of computer access to a behavioral reward system?

Space arrangement: Is the micro computer movable or stationary? Is it used only on one level in the room, i.e., on a desk?

Information circulation: Who teaches whom how to operate, load, and use the micro computer? Who is responsible for software purchases and use decisions? What is the level of privacy in regard to children's computing, especially as it is used as a word processor?

Sound level: Is there an expectation that the computer is an electronic teacher's aid and that children, individually or in small groups, will be working with a computer doing drill and practice that reinforces classroom instruction?

Time: Are decisions about control based on teacher availability for supervision? Is access available before and after school but limited during other instructional times, i.e., reading or social studies?

As we analyze the various perspectives, numerous anecdotes from our day-to-day experience illustrate for us the relative importance or unimportance that micro computers in the classroom play for individual students. Many students have other strong interests yet their lives, because of our choice to include computers in our "class scape," are affected. The computer is singularly important to other students for reasons that exceed their instructional value. For these students decisions about access and physical placement of the computer within the classroom are crucial. Our consciousness as teachers needs to be sensitive to all the members of our classroom. We need to be respectful of those who have no interest in classroom computing and encourage their interest in other areas, as well as to be aware of and respect those who have a strong interest in computers.

This light brushing of the surface of the "class scape" hopefully will suggest for you similar anecdotes from your own experience which, upon examination, will have explanatory power and give some insights into your decision to include micro computing in your classroom. It is important to remember that computers in the elementary school, in any school, are not experienced in isolation, nor are they necessarily the most important component found in your classroom. For some children the crucial educational issue of the eighties is, "Who gets to take out the dodgeball?"

It is important to our self-interest to view the position of teachers as an important element of the "class scape." We are interested in the relationship of classroom teachers as decision-makers to the choices of material, equipment, and curriculum, particularly as they relate to classroom computing. It is safe to say that our individual understanding of our responsibilities and conduct as teachers is tied to the personal system of values, experiences, and opinions that we each bring to school and into the "class scape."

Teachers and students have in school a different relationship to knowledge and information. Teachers are trained and reinforced in their belief that they have knowledge to impart and the responsibility to control knowledge within the formal learning environment. (Whether the teacher sees him or herself as a learner is another matter.) The student, a teacher through large parts of his or her world (BMX bike maintenance, video game operation, TV show plots, etc.) is primarily the receiver of knowledge in school. Our success as teachers is often not measured by the richness of our environment or the interactions of our students, but by the progress we make through a planned, sequential curriculum. <u>Who controls the information</u> has been, is, and will be a fundamental issue of our profession. The decisions that we make in regard to curriculum have a political and economic component. Decisions that on the surface are justified as educational have a much deeper element which protect our vocational and emotional self-interests as we continue to work with children who will be using the information, tools, and knowledge in 1990: we need to feel needed. We would contend that the subjectiveness of our decision-making is far more powerful than the professed objects of our profession. Specifically, the most pressing issues for teachers as curriculum and material decision-makers in relation to our classroom responsibilities and the placement of micro computers in our classroom are the following: who has and controls knowledge, our relationship to strong and vested economic interests, and the emotionalism (subjective reality) of alternative futures.

THE EXPERT

There is a tendency in any profession to protect ones job and make decisions based on ones self-interests. Thus, while many of us have become hooked by the electronic excitement that micro computing offers, two things seem to have occurred. First, available software seems to duplicate the authority model of traditional classroom instruction. The program asks questions and rewards correct answers. Second, because of the availability of funds and the perception that "computers are where kids are," micro computers are purchased without a careful pre-computing foundation or a commitment to make full use of computers and allow access on a broader scale in order to justify the expenditure. The tendency at the elementary level seems to be the emergence of the "specialist:" classroom teachers who have special interest in computing. What emerges within each building is a technological folklore and language which limits access and reinforces the perception among children and adults that computers are mysterious and scientific.

ECONOMIC PROBLEMS OF MATERIAL DECISION-MAKING

It is a fact that schooling is a big business. One need only walk through conference display areas in any subject area to realize the impact and growing importance that micro computers play. We are cynical about the use of hardware as bait for school districts to become entwined in long-range software commitments. The powerful sales pitch to sell all PETS or all Apples to a school district, just as we buy uniform texts, is a current issue in education. Of growing importance to us as classroom teachers, though, is our role and responsibilities in putting pressure on families to purchase small computers for home use to allow for continued and expanded opportunities outside of school. The speed at which the market is changing and the extent of its growth is remarkable. Temptation is great, and with the declining availability of funds crucial long-range decisions are being made. This pressure, however, is not new or different than the pressure for standardized classroom furniture at the turn of the century or the adoption of uniform texts and the lobbying by publishing companies over the last eighty years.

THE EMOTIONALISM OF ALTERNATIVE FUTURES

We are told, "The computer is here to stay." The full meaning of this statement and our understanding of it gives us insights about our view of the future. The future is viewed by teachers, both as adults and educators, with a vested interest in the continuum of the past through the present to a future: changing but not changed yet predictable, which justifies not only our curriculum decisions as teachers but our behavior as adults. Our day-to-day actions need the support of a predictable future. History has not only a past but a future component as well. The acceleration of change condenses the past into the present, making our children not poor historians but historians having a different historiography. In the application of decisions about schooling, we teach about our view of history and a future through curriculum organization, classroom structure, and equipment and material choice. We would suggest in our choice and use of computers that we are attempting to reinforce our understanding as adults about the future. Computers have become, for too many classrooms, "deus ex machina," saving the classroom from its inability to be useful. Kids, on the other hand, because they have a different view of the future through a different historiography, use and understand computers in a different way.

WHAT WOULD YOU DO?

In our conversations with children we have discussed and shared ideas about computer use in public schooling. These conversations are revealing to the extent that their ideas vary from our current classroom computing activities. Here are some suggestions for computer use as a result of discussions with elementary students.

1. Computers ought to be in plastic bubbles like phone booths so kids could play or use the computers at recess and after lunch breaks.

2. School districts should creatively arrange the working hours of all staff so that someone would be available to supervise students' use of the computer a maximum number of hours each day. For example, the custodian might supervise in the morning before teachers report for duty.

3. Schools should not purchase all of one type of computer. Kids should have experience with all different kinds, and families should be able to check out computers for the weekend.

4. We should fight the curriculum connection by having all games, learning activities, and software developed by students within the school district. Older students would help younger students by means of a ladder system working from high school to first grade.

5. We should make a commitment to spend time discussing pre-computing activities. More time should be spent talking about computers in a technological context, discussing historical, social, and moral issues.

6. We should work to de-mythologize the emerging folklore (computers are scientific, difficult, only for "bright" people, etc.) and broaden the access to computers so it is not based on some mystical heirarchy.

By far the most important point is that everyone does not need to know or love a computer. There are many ways to get through life as children and as adults. We must teach by our example to respect each person's choice.

As classroom teachers who are concerned about computers and children who will grow up in the "computer age," we are mindful of Joseph Weizenbaum's advice in his book, Computer Power and Human Reason:

> "I want them to have heard me affirm that the computer is a powerful new metaphor for helping us to understand many aspects of the world, but that it enslaves the mind that has no other metaphors and few other resources to call on. The world is many things, and no single framework is large enough to contain them all, neigher that of man's science nor that of his poetry, neither that of calculating reason nor that of pure intuition."