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ABSTRACT

A conference of teacher center directors was held to explore the applications of computers to education. Three strands of the conference were presented: management, information systems and communications, and instruction. The papers given at the conference provide a primer for teachers and teacher center directors who are beginning to work with computers. The first four papers give a perspective on the computer in society today and in the future, with illustrations of specific uses of computers in educational settings. Other papers discuss how teacher center communications and management can be improved through the use of microcomputers and how computer-assisted or computer-managed instruction can be used in schools. Positive implications for teachers are also presented. Appendices provide a glossary and list educational computer resources and organizations. (FG)

USING COMPUTERS TO ENHANCE TEACHING AND IMPROVE TEACHER CENTERS

A Report of the

National Teacher Centers Computer Technology Conference

Using Computers To Enhance Teaching And Improve Teacher Centers

Edited by

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Preface

The material in this book grew out of a need felt by teacher center directors to try to improve the services provided to teachers from individual centers. This volume is not a conference report, although the papers grew from the Teacher Centers' Computer Technology Conference. Taken as a whole, the papers provide a primer for teachers and teacher center directors as they begin to work with computers. Because computers are used for managing and retrieving information whether the database is a list of instructional resources or student progress reports, the sections on computers and information management are relevant to both teachers and teacher center directors. Teachers who plan to use microcomputers as instructional tools and/or objects of instruction will find the section on computer literacy and instruction and computers to be helpful as background information before computer-enhanced instruction is implemented. The dictionary of computer terms and list of educational computing resources are included as a result of requests made by conference participants.

In this book the authors, from diverse backgrounds and computer experiences address different aspects of educational uses for computers. The first four authors provide a perspective on the computer in society today and in the future, along with specific uses of computers in educational settings. Papers on the structure of the conference along with a summary report of the issues and activities of conference participants in each strand are included. Finally, a section on the process of educational change provides a perspective for the future.

We are indebted to a number of persons:

Allen Schmieder for his help in planning the conference as well as his creativity and leadership in providing new directions for the Teacher Centers Program.

Sally Vogel, Jack Turner, Jinx Bohstedt, and Rick Krueger, who coordinated the conference strands, and to those listed in the Ap-

pendix who volunteered enormous amounts of time and effort to make the conference a success, we are grateful.

To Patricia Sturdivant, Lynn Hale, and Ronnie Veselka who arranged the field trips in Houston, thank you for your invaluable help.

W. Robert Houston provided invaluable advice and help with the direction and coordination of this volume as well as planning the conference in Houston. For his leadership and help, we are grateful.

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Finally, to the conference participants, without whose goodwill, interest, and commitment to this idea, the conference would never have happened.

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B.R.S.
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CHAPTER ONE

The Genesis and Evolution of the Program

Charles Lovett

The Beginning

The Teacher Centers Program, begun in 1978, presently has 99 grants operating some 140 Centers nationwide. The Program is part of a much larger movement which is international in scope, with many sources of funding, that takes as its basic tenets that (1) classroom teachers are the people who do the educating, (2) teachers want to educate better, and (3) teachers themselves are the least utilized source of practical knowledge and expertise, not only about teaching, but about their own and their students' needs, It is in this context that the Teacher Centers Program conference on computers and education was planned and held.

The genesis of the Teacher Centers Program conference on computers and education (held January 11-16, 1981, in Houston, Texas) was simultaneous with the genesis of the Teacher Centers Program itself. During the first year's application review process, a review team coordinator came to Allen Schmieder and said, "We have what looks like a good proposal, but it's heavily dependent on computers and no one on the panel knows enough about computers to determine whether or not the program planners could do what they proposed." As a result, we found someone who had worked extensively with computers who could advise the panel, the project was eventually funded, and this particular teacher center has gone on to become one of the best teacher centers in the nation.

A Burgeoning Interest

At that early stage we were aware that teacher centers around the world, in Japan in particular, were concentrating more and more on training teachers in the uses of technology, both in science and in engineering. Several years later, it had become clear that other nations were not only focusing on those important subjects, but by some criteria were pulling steadily ahead of efforts in this country.

The Teacher Centers Program continued to get indications from teachers that there was a burgeoning interest in computers and their applications to education. Newsletters from the individual teacher centers showed growing numbers of workshops on classroom uses of microcomputers, and numerous offerings of mini-awards to teachers to work on classroom applications of computers. Within the developing centers, plans to develop computerized resources files and other computer-related management tools became more common. The [illegible] terest of teacher center directors and teacher center policy [illegible] members in the potential for computers in education was accelerating. This interest in computer applications was so great that Teacher Centers Program staff in Washington and many project directors began to worry about the ability of Teacher Centers to respond adequately. This should have been no surprise, since teachers, like the public they serve, often find computers fearsome and mysterious and are largely unaware of how pervasive their uses are becoming.

The Teacher Center Approach

In February of 1980, nearly a year before the Houston workshop was held, a group of directors attending the Teacher Centers Annual Program meeting in Washington, D.C., formed an ad hoc planning committee to survey the other project directors to determine the degree of their interest in a national conference on computers and teacher centers. In typical centering fashion, the survey was put together and distributed immediately. The response from the centers was overwhelmingly in favor of holding such a meeting.

Several project directors working in the national office in Washington as interns during the spring and summer of 1980 laid the basic foundation for the conference, notably Sally Vogel, Director of the Mid-Coast Teacher Center in Camden, Maine, and Les Price, Director of the Norman, Oklahoma, Teacher Center. Since there was little resident expertise on the subject in the national office, a series of very fruitful sessions were set up by these directors with knowledgeable specialists from the National Diffusion Network, the Division of Educational Technology, and ERIC to explore possible resources, to recommend some desirable meeting sites, to outline an agenda (the three strands) and to set up planning teams (see Appendix p. 89).

On October 3, 1980, the Congress reauthorized the enabling teacher center legislation—The Higher Education Act of 1965. While the revisions to the law in terms of the administration of the program were largely in a minor key, language that encouraged increased attention to "technology and telecommunications" spurred our growing interest in the subjects.

In early October of 1980, a meeting attended by the author, Sally Vogel, and Jack Turner, Director of the B.E.S.T. Center in Bethel, Oregon, was held at the University of Houston College of Education for the purpose of looking over the conference site. College of Education faculty, representatives from the Houston Independent School District, and Region IV Education Service Center agreed to help coordinate the local arrangements for the conference and to make extensive arrangements for on-site visits to local schools where mini- and microcomputers are being used.

As a result of this planning meeting, in late October a mailing from Washington officially announced the meeting, generally described the planning to date, formalized the planning teams, and invited participation by interested and knowledgeable persons from teacher centers. Regional meetings (clusters) of directors and policy board members scheduled special sessions on the conference to get additional advice from virtually every teacher center.

Capping this typically extensive process of involvement, a detailed agenda was mailed to the field in early January. Its very contents accomplished one of our main objectives for the meeting, since topics and expertise relating to computers and their uses in education both within the Teacher Centers Program and without were identified.

Structure of the Conference

The conference, with a core of shared elements, became three workshops (called "strands") conducted simultaneously on (1) *management*, (2) *information systems and communications*, and (3) *instruction*. Everyone at the conference heard an opening address by Henry Olds of the Cognitive Research Group, Education Development Center, who outlined the kinds of uses of computers in educational settings. At the dinner on Monday evening, Dr. Joseph Carbonari, Associate Professor of Education, spoke to the group about some of the problems associated with the increased use of computers in education and future applications of educational computers. The text of Henry Old's address is in chapter 3, while Dr. Carbonari's speech is in chapter 4. In chapter 2, Allen Schmieder of the Teacher Centers Program steps back to provide a broader perspective on the role of computers and technology in education.

Site visits to schools in the Houston Independent School District and to Texas Region IV Education Center headquarters provided examples of the ways computers are already being used to improve the quality of education by enhancing instruction and assisting with the management of instruction. Participants found this real-world experience to be especially helpful in gaining a perspective on possible educational applications for the microcomputer.

Each strand had its own planning committee, with a different substantial focus and its own unique program strategy. The descriptions which follow were written to provide some common ground across these strands and to help in the planning and conducting of the meeting, not to represent a new and definitive taxonomy for computers and teacher centers.

The Management Strand

The emphasis in the *management strand* was on ways in which computers can be used to increase the effectiveness of the management of teacher centers and other kinds of educational administrative or program units (e.g., school districts, individual schools, special instructional programs). The strand highlighted methods of organizing and retrieving a variety of data needed in daily operations (e.g., for budget planning and monitoring, mailing lists, center usage profiles, instructional resource files) with an emphasis on how these data bases were actually developed and used by people engaged in teacher center management.

Management strand participants worked as a single group in a program which interlaced instruction, demonstration, and "hands-on" sessions. No previous experience was assumed, yet participants moved quickly from a general introduction to the machinery and its potential to devising and implementing their own trial data bases. Jack Turner, Director of the B.E.S.T. Center in Bethel, Oregon, was primarily responsible for coordinating the planning of this strand, and his paper (chapter 5) discusses the major developmental issues that were raised during the week.

The Information and Communications Strand

The *information and communications strand* focused on two major issues: (1) the potential uses and limitations of computers for using national data bases to help with local problems; and (2) on communications from center to center, center to teacher, center to state, and center to national. By the close of these sessions, participants had a basic knowledge of the principal existing educational information systems, and practical examples of how they have already been used in teacher centers, especially those relating to interpreting and adapting bibliographic references and materials for local classroom uses. Information strand participants also examined alternative approaches to building and sharing local data and experience bases (practice files). This included studying ways in which local information might be compiled and the limitations inherent in making local files compatible with related extra-local data bases by means of an array of communication network possibilities, e.g., telephone systems, computer linkages, cable television, microwave satellite, and the essentials of center-developed and commercially developed information and communication systems. Chuck Hoover, head of ERIC at the National Institute for Education, was especially helpful.

Sally Vogel, Director of the Mid-Coast Teacher Center, Camden, Maine, was primarily responsible for coordinating the planning of this strand (and the meeting as a whole) and her paper (chapter 6) accentuates the problems and potential of computers as part of an information management and dissemination network.

The Instructional Strand

The primary focus of the *instructional strand* was on the uses of computers by both teachers and students in classrooms. The purpose was to introduce participants to a wide array of instructional uses of computers and to examine approaches, resources, and possible problems for teachers and teacher centers in the selection and use of hardware and software related to this emerging technology.

The general format was to demonstrate the kinds of instructional computer programs that are currently available (both teachers and nonclassroom specialists conducted these) mixed with hands-on work with the microcomputer. Since the participants brought a broad range of experience with computers to the process—ranging from very knowledgeable to most neophyte—a great deal of learning took place during these "hands-on" sessions. Jinx Bohstedt, Director of the Oak Ridge Teacher Center in Tennessee, and Art Williams from the Southern New Jersey Consortium at Glassboro authored the paper (chapter 7) which reports the major issues raised by the sessions. Jinx, together with Rick Krueger and others, was largely responsible for coordinating the instructional strand.

The instructional strand had the largest number of participants, with sessions which generated a great deal of lively discussion about widely held concerns. Thus, three papers of particular interest to teachers (chapters 8, 9, and 10) are included. These papers address the topics of computer-managed instruction, computer literacy, and the computer as an instructional tool. A glossary of terms (which was presented at the conference by Dave Garner of the Oak Ridge

Teacher Center) is included as well as a list of resources for additional materials on educational applications of the microcomputer. These lists are by no means exhaustive; it is the nature of technology and the limitations of the print medium to be out of date by the time you read these words. The best that can be hoped for is that these resources will provide some background and direction in the rapidly evolving area of computer-enhanced instruction.

The final chapter, by Dean Robert Houston, looks beyond the conference to the larger issues facing educators as they attempt to absorb this newest technology, a technology which once again holds the promise of revolutionizing education as we now know it.

The Real Summary

Back in Washington, after the excitement of the conference had abated somewhat and I had a good night's sleep, Allen Schmieder greeted me with "Sit down and tell me about the best two things that happened in Houston." Without hesitating, I said: "First, the people in Houston were very serious about learning. Often at conferences people's egos cause them to begin telling their own stories, and little that is new or positive is accomplished. There was none of that in Houston, since there was something or someone new for everyone. Each participant wanted to get as much out of the workshop as possible. Second, people moved very quickly from work with the machines and discussions about 'hardware' and 'software' to the pedagogical and social issues entailed by the educational uses of computers. The overwhelming concern for everyone was that computers be used as effectively as possible to improve the education now offered to students. The discussions were very serious about finding the best possible ways to integrate computers into the educational process. This is not a simple problem, since there is no single best way." The papers that follow elaborate on the issues that emerged in Houston, but the search really only begins this publication.

We hope that the Houston experience and this report of some of its more important outcomes will stimulate new ideas and activities in teacher centers across the country regarding how technology might be used to make strong centers even stronger. And we hope that, as much as possible, the "movers and shakers" will keep the Houston "90" and the Washington Teacher Centers Program Office fully informed and involved in the action.

CHAPTER TWO

Robots Universal Robots[1]

Allen Schmieder

For nearly a half-century, each time we entered a new decade many educational leaders boldly predicted that the real age of educational technology had finally arrived and that it would cause immediate and dramatic changes in the way we educate children.

Just as regularly, the ever present doomsayers warned that the machines were going to take over and their mad creators would find new ways to spindle and mutilate us and our precious educational processes—to say nothing of our innocent children. And there were always the cautious ones who gave comfort by assuring that these new mechanical wonders were meant only to be our servants and that they would not—as in the ingenious Capek play, R.U.R.—replace us. Each time they dragged out the good old dependable simplitude that machines can never be better than those who program them and become their keepers and husbanders. And so "technical know-how, the one element in our progressive civilization that seemed to get better and better in every way and which helped to make a better and better life for almost everyone, became one of the most sure-fire, predictable nontrends in American education. Donald Bigelow, a wise veteran of the Federal educational civil service best summed up the nonimportance of this highly important potential power, when he once lamented, "If we could only make the damn microphones work and find a long enough plug to make a connection for our overhanging projectors (let alone diminish the 'keystone effect'), we would be making real progress."

But risking the possibility that educators have become so hardened by the regularly recurring cries about the technological wolf that they will be unable to now respond with the necessary passion and preparedness, many of us in the Teacher Centers Program FIRMLY

BELIEVE THAT AMERICAN EDUCATION IS FINALLY ON THE THRESHOLD OF THE DECADE OF TECHNOLOGY, AND BECAUSE OF IT, SCHOOLING WILL CHANGE MORE DRAMATICALLY IN THE 1980s THAN IT HAS IN THE PREVIOUS CENTURY. It is not so much that computers and other gadgets have become so interesting and seductive as to take over or that our students now know them even better than we do, but that we have entered an area of societal and educational revolution that demands that we find better ways to access and process information.

Change is accelerating at an accelerating rate. The classroom is already an estimated two knowledge generations behind the cutting edges of science—and the gap is daily widening. In some technological fields, the body of knowledge and practice can change entirely in as few as *three* years. Ironically, I.B.M., which has been one of the major pioneers in the new technology, is now faced with the same problems that face us. At a recent meeting with some of the company's top staff developers it was reported that a decade ago their average "product life" was close to ten years and they had 10-14 months to prepare their personnel to market and service the products. Today, the viable life-span of many products is less than a year and the inservice training programmers have a week to ten days to accomplish what used to take over a year. The eminent authors of *Teachers for the Real World*[2] which was published 15 years ago, argued strongly for closer cooperation between training programs in business and industry and those in public education. Maybe the time has finally arrived when their rationale and sound recommendations should become reality.

One of the most visible reflections of this accelerating change is the growing list of new subjects and approaches that society and its governing agencies are asking schools to deal with, e.g., special education for the handicapped, the new vocational education, education for the gifted, career education, consumer education, bilingual education, energy education, nutrition education, metric education, environmental education, multicultural education, biomedical education, global education, the new old math, the new basic skills, and over the next ten years, at least 100 more fields that will be of "absolutely critical importance to all Americans." Many educational leaders dismiss these new thrusts as "bandwagons." They are badly mistaken. These new programs are for the most part true reflections of our rapidly changing world and each represents a serious educational challenge. Whether or not they are more a reflection of this accelerating revolution or of rising social expectations does not matter. They are of great importance to a large number of people and we have yet to establish an ongoing inservice educational system that can rapidly and effectively provide the kind of staff development that will be needed to ensure their effective implementation.

It will not be enough, however, just to establish an inservice education program that will provide "continuous retraining for all educational personnel." It will have to be the most modern, effective, technologically aú curant kind of staff development ever devised by persons. It is essential that we finally take full advantage of the awesome technological capacity that this nation has developed over the last several decades. It seems unthinkable that any educators still believe that we can "keep up" without it, or that without it, we can realistically reflect the kind of new world we are preparing our children to lead.

Two personal examples will show how technology can make a substantial difference in this time of human and educational googolplexity.[3] As a geography professor in the 1960's, I used 15,000 33mm slides to strengthen my teaching about the world. As I am sure you can imagine, the storing, cataloging, maintaining, effective mixing and utilizing of 150 carousels of delicate film and cardboard was quite a challenge. Every classroom hour of brilliant slide shows required 5-10 hours of outside preparation. With the new technology it is now possible for a teacher to place 7 *times* as many slides as I have in my large closet on a *single* video disc—one that can be held in the hand. Even more amazing, using this disc it is possible in a matter of minutes to array the separate entries into a desirable order—and an almost infinite number of combinations is possible. Example two: In preparing the foundation for a book about the Great Lakes, I spent *five years* analyzing data from sixteen decennial censuses. Today, with the help of computers, geographers are able in the course of *a few weeks* to analyze the same data in ways that are *1,000 times more complex* than in my original six-year study.

It is not just a matter of using technology to help keep up with rapid change. It is also necessary for teachers and their students to know how changing technology has caused us to substantially reform the way we think about the universe. If there were sufficient space in this short treatise I would elaborate at great length on this subject. It has been generally ignored by educational leaders for twenty years and, as a result, there are many serious consequences that have yet to be discovered and confronted. The serious scholars—the so-called creators of new knowledge—in most academic and scientific fields have been relying heavily on computers for more than a decade now. Because of that, the major disciplines in the university have become quite different from their curriculum counterparts in the schools that have, for the most part, yet to be impacted by this new emphasis. When you have machines that give access to what the "whole world" knows about a particular subject—machines that can help to organize and analyze millions of units of information, you begin to think about your field of knowledge in far different ways than in the past.

It is probably a less important issue than those already covered, but it should be pointed out that although the majority of jobs that school graduates will eventually compete for are computer-related, most schools still give very little attention to computers in their curricula. (It should be pointed out that some school systems are doing a remarkable job in this area.) Any significant increase in the use of computers in the staff development of educators should, of course, help to increase their relative importance in the curriculum.

And now to the inevitability of it all. Caleb Gattegna, the great teacher from Spain who now works his wonders in this country, has spent a lifetime trying to figure out why kids love games so much but find much of schooling to be quite dull. He is convinced that we can not only learn a whole lot about learning by watching children at play but that it is possible to design educational programs that will excite children as much as their play. I think that the children themselves and the new R.U.R.-like games that are pervading every aspect of our lives have joined in a conspiracy to make the conversion, whether we want it to happen or not. And what a wonderful condition! In the last several years, mechanized games for children have become as much a part of modern society as the magic of the Beatles. They have become the principal gifts for special occasions and game rooms are now major meeting places for youth in shopping centers, motels, and other public buildings. And their substance has escalated from colorful ways to simulate sporting events to playing at beating the stock market, reorganizing the federal government, or redistributing world resources. The young people not only love the intellectual challenges offered by their technical playmates but have become most comfortable with the knobs, the scratched screens, the rapidly moving images, and the funny sounds. It was curious to notice at an educational conference on energy that I attended, that the eight or ten different computerized educational programs on energy that were available for use by all the participants were swarmed over by the kids, whereas most of the adults in attendance stood in small groups, their coffee in hand, and exchanged wise views on matters much less closely related to the subject of their conference.

"The hearts of their human inventors were lifted—looking out the window, they noticed that the two young robots who were passing by were lovingly holding hands."[4]

Footnotes

[1]The full title of the 1939 play, *R.U.R.* by the Russian author, Capek.

[2]Smith, B. Othanel, Saul B. Cohen, and Arthur Pearl. *Teachers for the Real World*. Washington, D.C.: American Association of Colleges for Teacher Education, 1969.

[3]A googol is a mathematical term for 10^{100}. A googol-plex is a googol to a googol power.

[4]A summarizing of the finale in Capek's play in which the last humans on earth (the robots had destroyed the rest) ceased to fear for their lives, realizing that the robots who had been so perfected that they were like humans in every respect—with the exception that they lacked a soul and were incapable of loving or procreating—had discovered love and could now be totally human.

CHAPTER THREE

How to Think About Computers

Henry F. Olds, Jr.

THE CHALLENGE

Those of you here today, who have come from teacher centers around the country, have made the effort to be here because you sense there exists a predicament that you and your center need to think about in a new way. Every time I receive a letter from Jack Turner, one of the major organizers of this conference, I am reminded by the quote on the bottom of the letterhead that there was once a famous character who had a similar predicament:

> "Here is Edward Bear coming downstairs now, bump, bump on the back of his head . . .
> It is, as far as he knows, the only way of coming downstairs, but sometimes he feels that there is another way. . .
> If only he could stop bumping for a moment and think about it."
>
> Winnie-the-Pooh

We who have come this far must sense there is another way, and we have chosen to stop our day-to-day bumping along to come together to think about it. I would like to suggest at the outset that the predicament that we all face in education today is deeply serious and that we will have to be able to think in new ways to carry out effectively our responsibilities in the future.

The predicament is that the future development of our society depends upon a reconceptualization of the ways people can be educated. Twentieth Century education will not be adequate as our society prepares for the demands of the Twenty-First Century.

Our public school system, which began in a one-room schoolhouse, has grown and proven amazingly adaptive in responding to society's changing educational needs. But in recent years its capacities for adaptation have been seriously tested. Growing societal expectations and demands have come into direct conflict with a system-wide inertia. This conflict has so strained the schools that significant, perhaps radical changes in the public educational system seem inevitable.

One must add to this perspective a fast-growing awareness that the educational enterprise will have to function within fairly severe limits, at least as compared with our relatively unlimited past. We will have to learn to live with fewer students, less financial support, and waning public confidence in the effectiveness of schools.

How might we think about our predicament? Albert Einstein once pointed out:

> The world that we have made, as a result of the level of thinking we have done thus far, creates problems that we cannot solve at the same level as the level we created them at.
>
> Albert Einstein

Last July, at a conference of the World Future Society in Toronto, there seemed to be consensus that we can only deal with the problems facing our world if there is a "paradigm shift" in our way of thinking about those problems. I take this to mean that it is not enough for us to think about our educational predicament; we must discover how to think about it in new ways.

The challenge to teacher centers seems clear: What is the role of the teacher center to be in helping teachers to learn to think differently about the future? How can the teacher center provide significant leadership so that teachers can educate children who will have to live in that future? This is a serious challenge, perhaps even a bit frightening.

Our coming together here provides us with an opportunity to begin to meet that challenge. It is, I think, a very special opportunity that we have.

OPPORTUNITY: A WINDOW TO CHANGE

The 1978 launching of the probes to Saturn were carefully planned to take advantage of a window in space—a fleeting moment during which conditions were optimal for the success of the mission. We too have a window—a brief moment in time during which a precedent will be set for the education of the next few generations.[1]

Innovations in high technology have produced microcomputers with amazing power at low cost. Soon they will be as common as typewriters and hand calculators in businesses, schools, and in homes. Many computers, already in homes, were purchased largely because of a promise of unique educational opportunities: a chance to augment schoolwork for children, or a chance to learn new skills for adults.

The microcomputer will replace the textbook as the main tool of education. It easily accomplishes tasks formerly assigned to the textbook; *and it can do far more.* It interacts in talk or in print or in graphics or in sound. It simulates, it gives endless examples, it makes music, it illustrates with graphs or designs or pictures or animations. *And it can always be taught to do new things.*

The microcomputer will drastically alter traditional learning patterns. Like the hand calculator or the typewriter it is not a school-specific tool. Advances in communications technology will link the computer with vast knowledge resources and information networks. Self-education — self-directed, self-paced, self-scheduled, self-monitored — in the home will become a dominant mode of learning and will be a major supplement to education in schools and/or work places.

But the development of appropriate educational software — programs that take advantage of the technology for learning—has lagged behind. Little has been offered to fulfill the promise of improved educational opportunities. There remains a desperate need for software that integrates the best of what is known about effective education with a comprehensive understanding of the potential of the technology. A brief moment in time now exists to explore uncharted territory and create a truly innovative response to that need.

The window is still open, but it may close soon. For the next few years it may be possible for creative educators to influence the development of high quality learning materials for microcomputers. Such materials would promote learning, be fit for humans, have solid content, be aesthetically attractive, and be grounded in good pedagogy. Creative educators may also assist their colleagues in gaining an understanding of appropriate and beneficial uses of this new technology.

So the question that must be asked here today is: How can we take advantage of this opportunity? How can we best make a beginning to move through the window? There are a number of possible first steps to consider.

FIRST STEPS

Some would argue that we ought to be teaching our students "computer literacy." Such literacy is frequently seen as consisting of a body of knowledge about the history of the computer, the nature of computers and their components, the languages of computers, the impact of computers on our lives, the ethical and legal issues raised by computers, etc. So courses in computer literacy begin to proliferate, and teachers and children begin to learn about computers, which is quite different than learning how to do something with computers.

I feel this is a very narrow academic view of the nature of true literacy and that it fails to comprehend the impact that computers are having on our lives.[2] Most of us achieve a reasonable level of functional literacy in technological domains that affect our daily lives without taking "literacy" courses. The literacy associated with automobiles, television sets, high-fidelity systems, microwave ovens, typewriters, and calculators grows out of experience with applications of these tools in our lives. So it will surely be with the microcomputer. In this sense, many children are already more computer literate than their parents because their experience with computer applications through toys and arcade games is more diverse.

I acknowledge that there are deeper levels of understanding computers — what I would prefer to call computer science. But if this is what is meant by computer literacy, then we must be very careful not to make the same mistake that has plagued the teaching of science for years; that is, confusing real understanding with capacity to name things. As David Hawkins has pointed out, when a child asks a question about some phenomenon in the world and is immediately given a name for an answer, a knot is tied in his head that effectively shuts off real inquiry and prevents understanding. Computer science that ties people's heads in knots with terminology and shuts off real inquiry into the nature and function of this new technology must be avoided.

Others would argue that we ought to be teaching our students how to program. For example, Harvard University has recently made it a requirement for graduation that all students demonstrate the ability to write a short computer program that will function properly on a computer. Teaching some form of programming has great merit as one aspect of understanding what makes a computer function. The question is how to do this. It is not at all obvious that a student needs a "course" in BASIC or FORTRAN or APL. The programming language called LOGO, which is soon to be publicly available on microcomputers, gives very young students the opportunity to write programs of their own within a few minutes of sitting down at the computer. My daughter recently learned some of the fundamentals of programming by playing with a commercially available toy called "Big Track" during her Christmas vacation. Marilyn Burns points out that there is much about the nature of programming that can be learned without having a computer at all.[3]

If we focus too intently on teaching our students any particular higher level computer language (e.g. BASIC), we also run a few risks. Some computer experts predict that most languages in use today will shortly be replaced by other languages that can be more easily used by most people and will be more effective in carrying out diverse functions. Secondly, since it is unlikely that most people will ever wish to spend time writing computer programs, too much focus on the learning of higher level languages could be both distracting and confusing. Instead, some time might well be spent becoming familiar with some of the low-level, functional "languages" or sets of commands required to use the computer as a word processor or as a data organizer or as a financial manager.

Finally, there are those who contend that the path to follow is to use the computer to teach the curriculum now being taught in the schools following the guidance of the textbooks that provide the foundation for that curriculum. It is argued that by learning one of the relatively simple authoring languages (e.g. PILOT or TUTOR) one can then easily create programs to teach large parts of the existing curriculum or to provide required drill and practice after any topic has been taught.

Such an approach can surely be taken. But the question that must be asked is: Why do we wish to limit this powerful technology to the doing of things that were perfectly well done (or not well done) without such expensive hardware? Hopefully, it is only for lack of knowing what else to do that so much attention is given to using the computer in this way. In an effort to improve this situation, I shall outline below the wide range of possibilities that lend themselves to the application of computer technology.

Finally, there are some who suggest that we should devote our energies and our minds to trying to understand how computers can (and undoubtedly will, whatever our intentions) expand the intellectual capabilities of learners. This more promising role of the computer as an intellectual amplifier depends, first of all, on a recognition that new technologies not only change old ways of doing things but also make possible the doing of new things. Technologies can change the character of human competence and culture, as McLuhan and others have observed. *The idea that computers can make all of us inventors and creators of our own intellectual tools is difficult to express and understand, but it is the central idea for educational progress.*

It is possible that educational applications of computers will incorporate the computer's potential as intellectual amplifier only when educators fully understand that potential. As a first step toward better understanding, I would like to present a theoretical framework for thinking about the educational uses of computers. This framework starts with known and relatively familiar uses and then moves beyond to unfamiliar and largely unexplored uses.

It is important to appreciate before reading and thinking about this framework that we are talking about a new technology that does things that are not yet experiences we all share. I can talk to you about the educational strengths and weaknesses of "Sesame Street" because everyone has a television set and most everyone has seen at least some programs. Most of you do not yet have computers, and your range of contacts with computers is limited, so we do not yet share the experiences that would make talking about the uses of computers easy. So you will have to imagine a bit and trust that this framework makes a little sense. Hopefully, you will soon have a chance to check it out against your own experiences with computers.

THEORETICAL FRAMEWORK: THE EDUCATIONAL USES OF COMPUTERS[4]

Many, if not all, present educational uses of computers fall into one or the other of two categories: the computer as a medium or the computer as a tool. By computer as medium is meant the use of the computer to convey to the user or to instruct the user in some body of knowledge. By computer as tool is meant the use of the computer to accomplish some task for the user, including the most significant task of creating new tools.

THE COMPUTER AS INSTRUCTIONAL MEDIUM

There are three broad categories of the use of computers as instructional medium: tutorials, games, and simulations.

TUTORIALS

There is a rather long history of attempts to use the computer to instruct students in a direct and explicit way (e.g. Computer Assisted Instruction). Implicit in the concept of a tutorial program is the assumption that the program can interact intelligently with the user; that is, that the program can be a good teacher. Tutorials using multiple choice answer formats generally assume that there is one intelligent answer to every question and pay little attention to what may have led a student to make a wrong response. On the other hand, tutorials which attempt to analyze and evaluate a student's constructed answer must do so with a theory of the nature of knowledge in the domain being taught and a cognitive-developmental theory of the learner. Rarely are these theories well developed or explicit.

It is quite obvious to any teacher that even good tutorials are merely effective at mimicking some attributes of a very limited model of good teaching.

Those who seek to design tutorial programs assume a heavy burden. However intelligent they may try to make the programs, it is unlikely that they will be able to cope with the nuance and the unpredictability of human thought, let alone its convolutedness. Furthermore, the cost of a computer's misunderstanding of a user is too great to be tolerated for long in educational settings. A teacher who misunderstands a student's behavior can always make amends in light of additional information. I have not yet seen a self-correcting computer program.

This immediate dilemma, however, for those of us who are searching for good instructional programs is that most currently available tutorials are merely textbooks transferred to computer disks where the computer is asked to function as a high-priced page turner. Not only do the programs attempt to be intelligent (in the most un-self-critical fashion), but the content presented doesn't even get a chance to pass through the often beneficial filtering process of a real teacher's intelligence ("Students, just do the odd numbered examples on page 34, and then skip to page 38.").

So we are faced with program after program of drill and practice. There seems to me to be a great irony that this very powerful tool should be used to drill students to perform the algorithm for long division when the technology itself has made the use of that algorithm all but obsolete.

All of which is not to say that computer programs cannot be effective tutors. They certainly can be. As a musician, I think the Music Theory tutorial programs by Linda Borry, available through the Minnesota Educational Computer Consortium, (MECC), are truly excellent. My colleagues and I discovered that a simple tutorial on fractions could provide the user with some real insights into the nature of fractions. Figure I shows a partial "run" of this program.

FIGURE I

FRACTION SEARCH

```
Your mission is to find a fraction between 0 and 1.
The denominator of your fraction should not be greater than 16.

               0 ____________________________________________ 1
Trial # 1 ?    1/2
               1/2 is too big

               0 ___________________________________________ 1/2
Trial # 2 ?    1/4
               1/4 is too small

             1/4 ___________________________________________ 1/2
Trial # 3 ?    3/8
               3/8 is too small

             3/8 ___________________________________________ 1/2
Trial # 4 ?    7/16
               7/16 is too big

             3/8 __________________________________________ 7/16
Trial # 5 ?    6/16
               6/16 is too small

            6/16 __________________________________________ 7/16
Trial # 6 ?
```

At "Trial # 6" most users (adult and child) stop and scratch their heads. "How can there be a fraction between 6/16 and 7/16 that has a denominator of 16 or less?" What seems to happen in many cases is that the person's search strategy, which suggests that the next approximation would be 13/32, gets in the way of their finding a solution. Many persons can't pass this point without "inventing" the decimal system and discovering that 4/10 (or 2/5) is possible — but, in this case, wrong. It takes a little more perseverance to find that the answer in this case is actually 6/15. Almost all persons are astounded to discover (or rediscover) that all of the following fractions lie between 6/16 and 7/16:

4/10 (2/5)
5/12
5/13
6/14 (3/7)
6/15

The point is that it is possible to create reasonable and effective tutorial programs for computers. But, so far the focus of program creation has been almost exclusively on tutorial use, which may be at best limited and at worst, if carried too far, downright dangerous.

GAMES

One can distinguish two categories of games: those which attempt to convey some portion of the content of some discipline (content games) and those which attempt to sharpen the use of a cognitive strategy that may be applicable to a variety of disciplinary contexts (process games).

Content games generally appear to be more instructive because it is frequently easier to grasp what is being taught, but they often lack the playful appeal of process games. With many content games, once the content is learned, there is little reason to continue to play.

Process games tend to be more successful and long-lived. But it is not easy in some cases to describe the process being learned. Furthermore, it has often been noted how people can play process games without learning seeming to occur at all. Mere repetition of a process does not of itself guarantee improvement in that process.

There are not a large number of successful educational games of either content or process types. Furthermore, in all too many classrooms the use of any games is discouraged because it seems that playful learning is not considered significant learning. Perhaps the increasing availability of computers may stimulate the invention of a new generation of worthwhile educational games, and perhaps playful learning will be more acceptable when masquerading as computerized instruction.

SIMULATIONS

Two categories of computer simulation can be distinguished: those that are executed in parallel with the operation of a system they are simulating and are more or less verifiable by direct comparison with the system itself (easily verifiable simulations), and those that cannot be easily compared with the real system they are simulating (non-easily verifiable simulations).

EASILY VERIFIABLE SIMULATIONS. If a mechanical experiment (e.g., a pair of coupled pendula) in a laboratory is set into motion at the same time as a computer simulation of the experiment is started, and if the time constants are scaled properly, the two systems can be directly compared instant by instant. More importantly, as the behavior of the systems become discrepant, because of dissipative effects in the real pendula that might not have been incorporated into the model, the student has the opportunity to explore the limits of validity of the model. Exploration of the range of applicability of models of the real world is among the most productive educational uses of simulation and should precede the use of the simulation for its time-honored role of developing insight into the behavior of the system. Insights developed via a simulation whose limits of validity have not been explored are like as not to be faulty.

NON-EASILY VERIFIABLE SIMULATIONS. Most of the physical or social phenomena we wish to explore have spatial and/or temporal scales such that it is impossible, or highly inconvenient, to compare directly the real system with the simulation. For example, consider a planetary motion simulation. Such a program might show the behavior of two masses interacting via a gravitational potential. Using the program, one may explore the effects of varying the mass ratio as well as the initial conditions of the system. The simulation thus offers a degree of control not present in the system being simulated. On the other hand, the output of the simulation — planar orbits evolving in time — is a more or less directly scaled translation of the observables of the real system.

Many simulations are quite remote from reality because they are simulations of model systems that have been simplified in order to increase insight into the structure and function of the system being studied. It is generally the case that as one studies more and more complex systems, one is obliged to make increasingly greater use of over-simplified models.

Because such simulations over-simplify reality, they need to be considered critically and used with caution. It is clear that the microcomputer lends itself to the presentation of simulations and that a well-constructed simulation can be highly instructive. But uncritical acceptance of the simulation (and its simplified underlying model) can create misunderstanding rather than insight. As any scientist will point out, the ultimate resolution of a discrepancy between a model of nature and nature itself must always be made in favor of nature.

So even if we had an abundance of superbly designed educational simulations (which is far from the case), we would be well advised to help our students develop a finely tuned critical capacity that is well grounded in experiences with reality.

For example, I do not know how to fly a plane, but I have recently been learning something about flying through using a flight simulation program which models in simplified form the experience of flying. I think I have learned a lot, but it would be both foolish, and possibly dangerous for me, to confuse what I think I know with actually knowing how to fly.

One final caution about simulations. I have frequently found that what students learn from simulations is not at all what the simulation was designed to teach. A student's fascination with a simulation, as often with a process game, can often derive from pleasurable repetition of habitual response (e.g., note children's fascination with arcade game simulations). There is one educational simulation program I have worked with many times, but I still have not learned what the program was designed to teach. I enjoy using it because the graphics are clever and funny. Could it be, I wonder, that the clever graphics are interfering with my learning?

THE COMPUTER AS TOOL

SPECIAL PURPOSE TOOL

There are many computer programs available that are designed to carry out a specific task and require no programming on the part of the user. Such special purpose programs are common in the business world. They can handle such problems as inventory control, accounts receivable, mailing lists, and telephone directories.

In education, such systems, designed to help the user solve a particular type of problem, can be very useful, particularly if the problem is important and has some generality. For example, a program designed to provide a graphic representation of data provided from a particular experimental situation would be a valuable special purpose tool for science education.[5] There will be many opportunities for the use of such limited function "tool" programs in many disciplines.

GENERAL PURPOSE TOOL

There are two general purpose, symbol-manipulating tools that the micro-miniaturization of digital electronics has made widespread. The hand calculator is everywhere, and its utility is well accepted. Even public educational institutions have grudgingly admitted its value. Not common in education as yet, but quickly displacing the typewriter in many business offices, is the word processor, a general purpose tool with equal or greater potential for influencing our lives than the hand calculator.

The microcomputer makes these general purpose tools and a good many others (e.g., financial management programs, data management programs, etc.) available to the user through a single form of technology with appropriate peripheral equipment. For example, to function as a word processor, the computer must have an appropriate word processor program, a mass storage medium, and a printer (which can be a modification of an electric typewriter).

General purpose tools frequently amplify human capacities well beyond their obvious pragmatic advantages. The word processor provides the user with the ability to modify and rearrange a body of text with ease. Insertions and deletions no longer require the writer to cut and paste scraps of paper. Beyond these advantages, every regular user of a word processor that we know has found a new measure of freedom with words since using such a system. Several pilot experiments carried out at MIT using a word processor with young children indicate that the potential impact of word processors on the education of the young is likely to be profound. A recent report from the National Institute of Education Study Committee[6] on the projected impact of word processors and automated dictionaries shares our optimistic view of the important future roles this tool will play.

Because educators have so far been preoccupied with using the computer as a tutorial medium, few are even aware of the range of general purpose tools that are available and therefore have not considered their educational potential. Nor have they considered how the general availability of such powerful tools in the near future will alter the world of the students they are educating.

I have recently had the opportunity to observe junior high school students working with a general purpose tool we have designed for the computer.[7] It is called the "Semantic Calculator," and it allows the student to use the computer to carry out calculations involving both numbers and the units to which the numbers refer. We are exploring whether the availability of such a tool will help the students solve mathematical "word problems." Though our research is still in its early stages, it is already obvious to me that once the student realizes how this tool makes it possible to explore fully the relationship of the quantities involved in a problem, his or her approach to the task of problem solving becomes an act of discovery rather than an effort to remember the "right" formula. What delight a student experiences when she or he finds that an intuitive hunch about how to solve a problem is correct.

If the discussion of the educational uses of the computer were limited to the relatively familiar uses discussed so far, then there would be little reason to expect that the effects of this technology will be very different from those that followed the introduction into education of other technologies, such as the textbook, the audio recording, or television, each of which has uses both as medium and tool. The feature of the computer that makes it different in kind is that it immensely extends each individual's capacity (as well as the capacity of any collection of individuals) to create new tools. Each of us now has, or will soon have, the opportunity to use the computer to design a tool to fit our own perception of a task we want to perform or a problem we wish to solve. As noted earlier, among the many things we can ask the computer to do, we can always have the option of asking it to do something totally new and just for us. It is not surprising that we may all have some difficulty in imagining how we can use such a tool or what it will mean for our lives. None of us has ever had such an opportunity.

But for our children such experiences may soon be commonplace, and a generation from now every functioning educated person will consider a procedural approach to problem solving of all sorts natural and commonplace, will be comfortable with many strategies for structuring data and representing knowledge, and will regularly create unique tools for applying these strategies. Or, to put it another way, while we may be concerned about how to use the computer to teach students, students will probably be learning how to teach the computer.

For example, young students who have had the opportunity to use the LOGO language developed at MIT have learned in a short time to teach the computer to make tools that they can then manipulate to carry out their own routines.[8] Such easily accessible toolmaking languages are likely to be more prevalent in the future. In fact, to some degree, most general purpose tools can also be employed as tool makers once the user is fully familiar with what the tool makes possible.

THE SOFTWARE DILEMMA

We are all looking for good educational software, but the sad truth is that very, very little exists, and what is likely to be available in the near future won't change this situation much. Part of the dilemma is a function of economic realities. The creation of quality software of any kind takes large amounts of time and money. Software developers are not sure the educational market warrants the investment required. Meanwhile, there are substantial profits to be made in the business market.

But those software developers who have turned their attention to education are clearly skeptical about whether teachers would appreciate quality if they could have it. They believe that teachers will always opt for familiar and traditional educational materials, even if offered a choice that includes far better products.

This, "They wouldn't know a good one if they saw one," attitude was proven to be false by a small study we recently conducted with eighteen teachers from various parts of the country (including some teacher centers represented here).[9] Our investigation showed great insight and sensitivity among teachers. They know as well as anyone the failures of many traditional educational curricula and methods, and they understand the subtlety and variety of human learning. They *do* sense the power of computers to make feasible intellectual activities heretofore unwieldy, if not impossible. They *can* recognize quality software and make good choices if those choices are available.

I think that one of the major goals of teacher centers ought to be to make available to teachers as full a range as possible of educational software (and the computers required to try out the software). In particular, there should be good examples of all the uses outlined above so that teachers can know the range of possibilities. If these uses can't be illustrated right now with "educational" software, then illustrations should be drawn from other domains.

EDUCATIONAL SOFTWARE – SOME QUALITY STANDARDS

The creation of quality education software requires extensive and sophisticated understanding of every area of the endeavor. If it is not to incorporate the weaknesses of past materials then knowledge of educational theory, educational practice, curriculum design and computers must be carefully integrated. And this knowledge must be blended with a sensitivity to learning and to learners, children and adults.

A) Content

Effective instruction must be built upon a well-conceived intellectual model of the nature of the discipline. The key ideas in each discipline are simple and elegant. These must be communicated to students in such a way that they can feel their simplicity and appreciate their elegance.

B) Cognitive Development

A "Constructivist" approach to the nature of human learning, which is based on the assumption that the learner constructs knowledge, should be taken. In this approach, the child's understanding of reality forms a basis on which to build the tools that will further that understanding. Learning occurs when the child has the opportunity to construct new knowledge for him or herself. Educational software should provide carefully designed opportunities for such constructions to occur. It should give the student the chance to invent ideas and to play with them. At the same time it can also help the student develop concepts and skills that fall within the traditional definitions of the disciplines they are learning. Creating such software requires both the formal knowledge of research on children and learning, and the informal knowledge that comes from contact with kids.

C) Pedagogy

The construction of new knowledge, as Piaget has noted, is an interactive process, a dialogue carried on by the learner with both the physical and social worlds around him. Pedagogy is concerned with the nature of the interaction that takes place and seeks to create the conditions that enhance communication with the learner. Since the computer is fundamentally an "environment" for interaction, knowledge of effective pedagogy can insure that its use supports the process of learning.

D) Technology

To take advantage of the possibilities of microcomputer technology requires a thorough understanding of the full range of uses to which this technology can be put, both as medium and as tool. It also requires recognizing that this technology is significantly different from almost all former technological "advances" that have had so very little impact upon education.

And, since we are probably still in the "Model T" stage of the development of this technology, a vision of how the technology is changing should inform the creation of software. Software too rigidly designed to operate within the constraints of existing hardware will quickly become obsolete. Software that can easily be adapted to evolving capabilities is more likely to endure.

E) Software Design

The nature of the computer is that it is fundamentally interactive and therefore fundamentally educational. Good educational software will grow quite easily out of an understanding of this nature. When the design of the software is in conflict with the nature of the computer (as is always the case, for example, when print materials are turned into software), then the product reflects all the tensions of the forced marriage.

We must learn to think about curriculum and learning in new ways — ways that are compatible with a technology that by its very nature lends itself to our efforts. We must not simply try to overlay our old ideas of curriculum and learning on this new technology.

RESPONSIBILITY AND DIRECTION

Just like the "good news - bad news" stories, every opportunity has its associated dangers. The widespread availability of microcomputers at prices that many can afford, but that many can't, signals the possibility of yet another way of separating the "haves" from the "have-nots," and building, rather than easing the painful tensions that exist in our culture.

For the many who will not have computers in their homes, at least for awhile, schools have a responsibility to assure some measure of equitable access to this technology. Fulfilling this responsibility may be the greatest challenge for schools in this decade.

Teacher centers are, I believe, in a unique position to exert strong leadership in helping schools meet this challenge. They can also seize the opportunity to help teachers and parents become familiar and comfortable with, not to mention excited about, this new technology. Teachers are and will continue to be critical to the effective use of computers in schools. They must have opportunities to interact with computers under conditions that allow them to learn, not to be trained. Teacher centers provide regular opportunities for teachers to engage in professional development in a mode that is responsive and generally closely tuned to teachers' needs. Teachers encountering computers in teacher centers are likely to be positively disposed to learning about them and to considering their potential.

Jim Edlin, one of the more perceptive contemporary writers on microcomputers, has pointed out: "in microcomputers lies the seed of an invention with the power to catalyze major beneficial changes in our lives; this invention doesn't stand a chance of reaching fruition until it is wrested from the hands of 'computer people.'"[10] I would add that in education it stands its best chance of reaching fruition if it is put in the hands of teachers. Teacher centers can bring this about.

Footnotes

[1]I am indebted here and elsewhere in this paper to my colleagues, Art Bardige and John Richards, with whom I have been preparing a more extended discussion of some of these ideas.

[2]For an excellent discussion of this topic see Daniel H. Watt, Computer literacy:

What should schools be doing about it? *Classroom Computer News*, Vol. 1, No. 2, Nov.-Dec., 1980, p. 1.

[3]Marilyn Burns, Getting kids ready for computer thinking: Thoughts for teachers, Grades 4-8, *The Computing Teacher*, Vol. 8, No. 1, p. 28.

[4]This framework is adapted from Henry F. Olds, Jr., Judah L. Schwartz, and Nancy A. Willie, "People and computers: Who teaches whom?" Education Development Center, Inc., September 1980. In particular, I am indebted to Judah Schwartz for the formulation of this framework. (Note: Copies of the report are available from Cognitive Research Group, EDC, 55 Chapel St., Newton, MN 02160. Send $3.25 to cover cost of printing and postage.)

[5]For example, a computer thermometer, designed by Robert Tinker of Technological Educational Resource Centers (TERC) of Cambridge, MA, provides a continuous reading of temperature as a function of time.

[6]*Automated Dictionaries & Word Processors*. The report of an NIE study committee chaired by George A. Miller, NIE, Washington, DC, 1980.

[7]Dimensional Analysis Project, Cognitive Research Group, Education Development Center, 55 Chapel Street, Newton, MA 02160. This project is supported with funds from the National Science Foundation.

[8]Daniel H. Watt, A comparison of the problem solving styles of two students learning LOGO: A computer language for children, *Creative Computing*, Dec., 1979, p. 86.

[9]Olds, Schwartz, & Willie, People & computers: Who teaches whom, *op. cit.*

[10]Jim Edlin, The mass market micro: The demise of documentation, *InfoWorld*, Vol. 3, No. 2, Feb. 21, 1981, p. 9.

CHAPTER FOUR

Are Humans Necessary?

Joseph P. Carbonari

When I was in graduate school, one of my professors was a very popular speaker on the P.T.A. circuit. A title of one of the speeches he often made was "How can we best use husbands or are they really necessary?" I thought as I was preparing this speech that paraphrasing his title would give me an equally good title. "How can we best use computers or are they really necessary?" Then as I thought about the advances in this field and of the almost unbelievable growth in the capabilities, capacities and power of computers within the last few years, an absurd (I hope) scene flashed across my mind. That of a computer standing here addressing other computers and titling its speech "How can we best use human beings or are they really necessary?"

There is a computer revolution, and the question now is not how can we best use computers, but how can we best live with them. We in education, we teachers are going to have to live side by side with the computer. We will have a new kind of teaching team. The electronic teacher and the human teacher will share the task of teaching and neither will be subservient to the other.

As ordinary people, we are already living with computers, our bank accounts, telephones, cars are computerized. Even the french fries at McDonalds are cooked under computer control. Although we love to tell and retell the horror stories of monumental goofs made by computers, we are already experiencing frustration over services not under computer control. Most of us have had the experience of waiting for an elevator in a building where they were not controlled by a computer. First an interminable wait, then all the elevators come at one time, and then they are all going in the wrong direction.

The things you and I will see and hear about during this week will amaze and astound you, bits, bytes, megabytes, nybles (which are halfway between a bit and a byte) speeds in thousandths or millionths of a second, fantastic color graphics, synthesized voice, voice recognition, word processing with instant rearrangement of whole paragraphs and on and on. The growth of this industry and its impact on society is probably unparalleled by any other invention in history.

In preparing for this talk, I went to the University of Houston library and found that we subscribe to 59 journals that have the word "computer" as the first word in their titles. I found this easily because it was listed that way on a computer printout. I am sure this number is at least doubled when the search would include related journals not using computer as the first word.

There has been exponential growth in the power of computers. For a fixed price, the computational power and memory of computers has doubled every two years since World War II. This means that the cost effectiveness of a computer has increased by a factor of more than one million since that time and it seems very likely that this doubling will continue at least through the 1980s and 1990s.[1]

Let me give you an example of what this kind of exponential growth means. Imagine taking a large single sheet of newspaper, which is approximately three thousandths of an inch thick and folding it in half (or doubling it) over and over. After doing this forty-four times, how thick would the folded paper be? A foot, a yard, a mile? The answer is that the stack would reach to the moon and back, almost five hundred thousand miles. This is the kind of growth the computer industry is experiencing.

If the auto industry had kept pace with the computer industry over the last 40 years, today a Rolls Royce would cost about $2.75, get 2 million miles on a gallon of gas and have enough power to run the Queen Mary.[2] The 2 million miles per gallon is a very compelling analogy. Computers do not use much power, nor do they use much in raw materials and this is a major part of the reason the industry will continue to grow at such a rapid rate.

I could easily fill this speech with astounding facts and my guesses as to what the computers of the future will look like and how they will change our lives, but I won't. I want to focus instead on the problems the computers will bring to us as educators.

Before going on however, I want to define a problem as an opportunity to make quantitative and qualitative leaps in enhancing and extending the intellectual growth and development of those who are to be educated, and that includes all of us.

Not too long ago, I heard another speaker talking about the future of technology and education. A member of the audience asked about the role of the teacher in the coming computerized society. The speaker's response was that technology will take the drudgery out of teaching. The computer will teach the facts and take care of the drill and practice, thus enabling the teacher to participate in all those higher order interactions with the students. This was just the answer that I as a teacher wanted to hear; I could just see myself engrossed in high level conversations with students about abstract ideas and their implications for the meaning of life. Unfortunately, this image and that speaker's answer are probably wrong.

What is probably right is that most of us do not have the formal operational skills and abilities needed to function in that world of higher order interactions. Perhaps no more than 40 to 50 percent of the teachers today have the cognitive abilities needed for formal operational thought while the rest of us are at the concrete operational level or below. It may very well be that computers, armed with programs developed by formal operational people, will be engaging the students in those high level conversations while the human teacher takes care of the drill and practice.

I used to teach a course in FORTRAN programming here in the graduate school. The first two or three times I taught the course, I did it in a conventional way. Lectures, text, practice and tests. The results seemed good. The students learned something and were satisfied. One semester I decided to use a discovery approach to learning with the computer as my partner. On the opening day of class I gave a half hour lecture, a few basic directions for getting on and off the computer and a series of statistical analyses to be programmed. The students were then told that by the end of the semester, they were to have running programs of these analyses and that from this point on, I would serve only as a consultant. A one half hour per week meeting was scheduled so that we could come together and discuss common problems. (I couldn't let go completely.) About a quarter of the way through the course, the students asked if we could do away with our scheduled meetings, they were getting in the way. These students interacting with the computer learned far more than anything I could have anticipated, they consulted with each other and I sat in the corner, in the fetal position sucking my thumb. The course was a huge success, I never taught it again.

This, then, is the first problem. Can we live with the computer as a teaching equal and in some cases our superior? Can our egos stand it? How do we help teachers overcome their fears and prejudices and gain the attitudes and skill needed to maximize the effectiveness of the new teaching team?

A second problem: With the development of the new smaller and more powerful computers, the students may well lose, what we call today, basic cognitive skills. Already calculators have made the need to know number facts relatively unnecessary. Arguments are going on now about their use in the classroom, but whether or not we allow them in the classroom is unimportant. They already exist in the students' lives. They are fast becoming an everyday tool for all people. Being used for such tasks as shopping in the supermarket, planning trips, converting recipes and everyday arithmetic. Those number facts that we so carefully forced into children's heads will be forgotten if they are rarely used.

While the mathematics teachers have had at each other over the teaching of basic skills, the language teachers have been sitting smugly by, but their turn is coming. Now computers using word processing programs are starting to be able to spell and correct the spelling of the user. Imagine term papers with no spelling errors! Soon the computers will correct syntax and punctuation errors. People like e.e. cummings will have some problem getting their material into the memory banks. Or can you imagine Gertrude Stein being told by a computer that "A rose is a rose is a rose . . ." is incorrect English.

Let's not forget the reading teachers. We are being told that books, as we know them, may well disappear and we will have electronic books. Left to right reading (or right to left, depending on the language) may also go. Some research is being done now on the effect of flashing of one word at a time, very rapidly, in the same place on a video screen instead of a line of words. This may produce very high reading speeds and a higher level of comprehension. The very nature of reading may change. It seems that only the physical education teachers are safe at this time. So far computers cannot exercise for you.

Is it bad to lose skills that would rarely be used? A great little book entitled "Saber-tooth Curriculum"[3] illustrates the absurdity of teaching now useless skills. The real problem is to make sure we replace the loss in "basics" with gains in the "new basics." Gains such as those in higher level abilities such as logic, probabilistic thinking, hypothesis generation and mental manipulation of alternative solutions to problems.

A third problem: The computer will cause a separation of the functions of school. Schools have at least three major functions. One, to convey information and teach skills; second, to enculturate students and third to babysit. These functions may not be complementary. Even if computers could teach the cognitive part of schooling at a very accelerated pace, the schools still would have to serve as a holding tank in order to keep these students out of the workforce and to allow both parents to be in that workforce.

How, with our present perception of students working individually, each with a computer terminal, all at their own pace, are we going to teach them the hidden curriculum. That only one person at a time talks, and that all the others must at least pretend to listen. That promptness is crucial. That gym uniforms should always be clean and most importantly, that certain bodily functions cannot function unless you raise your hand and get permission for them to function.

Society and schools must deal with this problem. The problem is that schools presently play different and possibly conflicting roles and that these roles may well be better served in different ways and in different places.

Problem number four: The correct use of computers in education will maximize individual differences, and yet society is calling for closer and closer cooperation. Students presented with high quality computer interaction opportunities will develop their abilities in those areas for which they have aptitude to a far greater degree than we have ever seen before.

At the same time, with instant communication networks of computers, radio, and television, we are being brought closer and closer together in ever more complex ways. World wide cooperation is even now a necessary part of survival and the future will give us no other choice. How do we educate people of all levels and abilities with ever greater disparities to function and grow in the "global village?"

Yet another and even more urgent problem. Who gets the good stuff? The accelerated classes? those with learning problems? the poor? the rich? maybe even the middle class, average student? Although the cost of computers and their related equipment is decreasing very rapidly, the cost of producing quality software is rising. In a recent article in a journal named *Computer,* the author, an educational software development manager, estimated that the cost of developing the instructional software needed to provide a student with 15 minutes of daily interaction with a computer for an academic year is $157,000.[4] Who gets the good stuff? The challenge is obviously to provide for the equitable distribution of this expensive resource. I am sure there are many more problems, but perhaps these are enough to help estimate the magnitude of the impact computers will have on education and on each of us.

As I read and wrote in preparation for this opportunity to speak, my mind returned to the opening scenario in which the computer is standing before an audience of computers wondering if there is any use for humans. And I wondered, what is it that we humans can contribute that computers can't. Are we necessary?

Computers can write original music. They can paint pictures. Computers can be moral. Highly moral decisions are often made using probability models with built-in premises such as "The greatest good for the greatest number." Computers could easily make such moral decisions.

They can be fair and just, maybe even more so than human judges. They could arbitrate, run factories, beat us at chess and even ponder philosophic questions of ontology, axiology and epistimology. Are we necessary? Yes we are. Computers can't be curious. They can't ask valid original questions. They don't want to know. They seek homostasis. We, the curious, seek dilemmas. In this way we differ. The computer answers but does not ask.

If this is true, then it follows that the real problem for education in the computer age is to teach people to be curious. To teach them to interrogate computers. To ask real questions and to learn enough from the answers to ask the next question. To force, through questioning, the exploration of alternative solutions to our problems. This we must learn to do. This is our challenge and our gift from the computer revolution.

Footnotes

[1]J. I. Lipson, Technology in science education: The next 10 years, *Computer*, July 1980.

[2]C. Evans. *The micro millenium*. New York: Viking Press, 1980.

[3]J. A. Peddiwell. *Saber-tooth curriculum*. Manchester, Mo.: McGraw-Hill, Inc., 1939.

[4]J. M. Heines. Courseware development and the NSF, *Computer*, July 1980.

CHAPTER FIVE

Communication and Microcomputers

Sally Vogel

The major issues raised by participants in the communications and information strand of the Houston conference were the following: (1) Can computer technology be used to help teacher centers solve their communications problems? (2) What factors do teacher centers need to consider in making the decision to apply this technology to their communications tasks?

Defining the Problem

In order to answer the first question, we need to understand the components of the communications process and define the term communications problem. The components of the communications process may be thought of as (1) a motivation to send a message, (2) a sender/receiver that has a store of information (database), (3) channel(s) through which the message is sent or received, (4) other reecivers/senders that also have databases, (5) the outcome or effect of the message.

A problem is anything that gets in the way of a person or organization accomplishing an objective. If such an obstacle occurs in the communications process, it can be considered a communications problem. With regard to centers (sender/receivers) and their audiences (sender/receivers), computer technology probably has little relevance to the desire to send a message (motivation) or to the effect of the message once it is received. Obstacles in these areas of the communication process are likely to reside in the people who send or receive the message.

Blocks in the communications process may occur because (1) we do not have certain information (inadequate database), (2) we cannot find or recall the information (organization of the database or the sender/receiver), (3) the message does not get to the person(s) who can do something about it (sender/receiver or channel). Computer technology can be applied to help overcome some problems in these areas of the communication process but some questions need to be considered by teacher center personnel as decisions are made about utilizing this technology.

Questions To Be Considered

Will the application of computer technology help teacher centers reach their objectives? Providing resources of some kind for their participants is one of the objectives of most teacher centers. In fact, the Teacher Centers' Documentation Project has evidence that the greatest amount of participation in teacher centers comes from the use of center services and resources. Each center needs to determine whether it wants or needs to increase the number of resources it will make available to participants.

For instance, one of the requirements of the Teacher Centers' legislation is that teacher centers provide research information to teachers. If a center is located in an area where such information is readily available through university libraries or an education service agency, the center would not need to provide such information; it could simply refer participants to these places. On the other hand, a center in an isolated area might want to consider contracting with a bibliographic retrieval service and have a staff member do computer searches of research literature in order to provide this service to teachers.

In what form do center users want to get the information and how they will use it are other questions that need answers. Do users get an annotated bibliography from which they select those references they want to explore or will center staff select and review references to prepare reports for participants? Will participants use research studies to prepare papers for course work or will they use the information for curriculum development? These are a few of the questions that need to be considered before making a decision about the viability of using a computer for retrieval of research information.

One objective for some teacher centers includes making an abundance of resources easily available in response to participant requests. In making the decision to apply computer technology in such a case, the center will need to determine how it wants to file these resources. Will the file include the actual resources (such as a vertical file of pamphlets) or records referring to the resources (such as a card catalog)? What will be the ultimate size of the file? How frequently will new entries be made or old entries deleted? How will users access the information? Will the center take call-in requests and then locate the resource or will people look for the resource themselves, or will both procedures be used? After these decisions have been made, the center can consider the value of developing a computer file to aid in the accessing of this information and the type of hardware (micro, mini, main-frame) and software (computer programs) best suited to meet the center's objective.

Perhaps a teacher center has a large card file with the names of people who have expertise in a variety of areas. The center wants to be able to refer center participants to these people. At present the center staff has to (1) take requests over the phone, (2) prepare multiple cards for each expert, (3) file the cards under a variety of possible headings, (4) hand search the cards in response to requests, (5) prepare a list of experts appropriate to the request, and (6) send the list or call the participant back. In addition, center staff has to update the card file frequently as people move, decide they don't want to be involved, etc.

If the number of people indexed in the file is, let's say, larger than two hundred, this entire process can be very time consuming. A small file developed with a microcomputer database program would cut down the time needed to make multiple file entries and the time needed to search the file for relevant information. If the center had a printer connected to the microcomputer, the lists of experts could be machine printed. Updating records could be done more frequently and probably more quickly, particularly if the file was stored on a computer disk. It might be possible to use a telephone answering device to record requests. Initially, time would still be needed to computerize the file, to search it, and to update it. The equipment alone would cost about $3,000. Obviously, a center which has a hundred names in its resource file would not want to purchase such equipment if its use were limited to this problem alone.

Other objectives of centers may require a center to document such things as the number of participants in various center activities, evaluations of center's services, or number of participant requests and actions taken. Answers to some of the following questions will help centers develop documentation plans. What information is to be documented? What kinds of documentation are desired (pictures, charts, case histories, etc.)? How much staff time will documentation take? How frequently will data be collected and summarized?

Computer technology makes it possible to rapidly aggregate numerical data in a variety of formats but, as yet, it is not possible for it to provide a photographic record and it cannot write a subjective narrative although computer word processing can be used by a writer to speed up editing.

Will computer technology help teacher centers to communicate more effectively with their audiences? When should a center or centers use the computer communications channel? The choice depends on the audience which is to receive the message and the type of message. Each center sends and receives messages from a variety of audiences. These include different groups of teachers; administrators; university faculties; local, state, and national politicians; state departments of education; other teacher centers; community members; the Department of Education. Some audiences have access to computer equipment. Others do not. Some messages require many people in disperse locations to respond. Others are intended only for one or two individuals.

If, for example, every teacher center had a microcomputer or a computer terminal and a modem (which permits messages typed on terminals to be sent and received over telephone lines), a center in California could send a message to all the other centers in the country at the same time or the Program Office at the Department of Education could send a single message to all centers. Such a message might be: Do you have a TRS-80 program designed for instructional use with fourth and fifth graders on energy saving in the home? Or, will you estimate your year-end balance of funds? If a teacher center had such a TRS-80 program, it would respond. If the requesting center had a TRS-80, arrangements could be made to send the program by mail or the computer at one end of the line could receive the program from the other. In response to the question from the Department of Education, centers could simply enter the figures online for transmission to the Program Office. Another application might be communicating with national senators and representatives, since most of the Congressional offices have computer terminals.

A center probably could not justify the expense of the hardware staff time to send or receive infrequent messages. But, if the schools in the center's service area had terminals and receiver modems, a center could prepare a daily bulletin of center news and upcoming events which would reach all its schools.

Centers should explore the possibility of using computer hardware to accomplish multiple tasks such as accessing outside information sources, organizing center resources, documenting center activities, training teachers, and communicating with center audiences. The cost may not be justified for one purpose but if used for several jobs the expense may be warranted.

Centers should examine the effect the use of computer technology will have on the organization of the Center itself. Can certain staff functions be done by computer, thus allowing more time for staff to do other tasks or permitting the center to do more without additional staff? How much staff time will be allocated to entering data, accessing information, sending messages, etc.? Will participants be more likely to find the resources they need quickly and to communicate with the center more readily? Or, will they get too much to choose from and lose the opportunity for personal face-to-face contact with center staff members?

In making decisions as to whether or not to apply computer technology to the solution of one or more communications problems, a center needs to look at whether computer technology will increase the center's ability to meet its objectives and whether the use of the computer as a communications channel will increase the chances that center messages will reach their target audiences in the most efficient manner.

CHAPTER SIX

Management and Microcomputers

Jack Turner

A useful definition of computer literacy[1] says that one must be able to define, demonstrate, and/or discuss:

- how computers are used
- how computers do their work
- how computers are programmed
- how to use a computer
- how computers affect our society

The overall goal for participants in the MANAGEMENT strand at the Houston conference was to become computer literate, but with a special qualification to the unbounded scope of the definition above. Each of the five elements in the definition would be focused at management, particularly with reference to microcomputers and small administrative units, like teacher centers. Within the span of one week could participants be guided from diverse entry points into at least a basic comprehension of the prospects and problems which are central to computing?

The basic framework for the MANAGEMENT strand had been developed by Teacher Center directors from Massachusetts, Nebraska, Texas, California and Oregon,[2] with most of the specific content prepared by Bill Crouch and Jack Turner of Eugene, Oregon. Crouch, an independent small business microcomputer consultant, was chosen because of his technical skills, his broad experience with management applications for micros, and his ability to communicate effectively with those who have no computing experience. Turner, as a Teacher Center director working to incorporate a microcomputer into his Center's operation, provided a foil to Crouch's technical competence. Crouch's multiple presentations showed the diverse possibilities for using microcomputers as a small-unit management tool; Turner's focus was on the specific uses being implemented at his Center and some of the "real life" implications which accompany the innovation.

By mid week one of the participants revealed that he had been reluctant to join the MANAGEMENT strand because he believed its import would consist largely of high technology and zealous advocacy. The commenter was relieved to learn that our intent was more cautious than zealous.

In the remainder of this section we will focus on core issues, ideas and implications which grew out of the MANAGEMENT strand training design and the reaction of approximately 35 participants.

THE QUEST FOR CLOSURE

Among the more vivid frustrations confronting educators new to microcomputing is the question of which machine to buy. Preceding that dilemma is the preliminary issue of whether to buy a microcomputer at all; i.e., do the management tasks we would assign to the computer justify the whole series of "prices" to be paid, only the first of which is the acquisition cost?

Setting aside those entry level closure questions for the moment we come next to which software choices offer the most appropriate capability for the cost involved and related software issues, almost none of which have broadly generalizable answers. There is such rapid development in software choices and capabilities that the impressive offerings from last year now pale by comparison to the sophistication of more recently developed software. It was no surprise that participants in the MANAGEMENT strand came in with these kinds of technical questions and confusions. When one is unfamiliar with a set of concepts and possibilities - and in the case of computing, uncomfortable not only with the lack of information, but with the subject at hand - it is likely that the search for closure will be intense if not impatient.

The wisdom in originally planning this conference for five days became apparent when we left the hardware issue and began to focus on *substantive* issues which will be explicated in the next section. The point to be made here is that it would probably be impossible in less than a five-day training design to generate anything other than cognitive overload, confusion, and anger among participants to simply raise all the issues inherent in computing, even within a restricted focus as we had, in a training design shorter than five days.

Our main premises for the flow of the training design were several:

1) That participants could indeed learn to comprehend enough about the operation and characteristics of microcomputers to overcome any prior doubts.

2) That there are very few "answers" so true and generalizable for all settings that persons in decisionmaking roles can embrace them as reliable.

3) That careful consideration of how a microcomputer would be used in a Center might well lead to the conclusion that its cost cannot be objectively justified.

4) That microcomputers are so versatile in terms of potential applications that, while no single task might warrant purchasing one, the aggregate value of all tasks might make the purchase worthwhile.

5) That participants should rediscover ignorance as a valuable part of the week's training: contend with it, share with and support others in the group, and begin the process of replacing ignorance (lack of information or insight) with tempered experiences.

APPLICATION ISSUES

By the mid-point of the week participants' questions began shifting away from the technical/mechanical to what we characterized as the substantive/application questions. Restated, this shift amounts to: "I now recognize that we *can* do these computerized things, but *should* we?"

Given the computer's unparalleled ability to sift and compare data fed into it, there exist new opportunities to manage and interpret teaching behaviors, for example. One participant exemplified the possibility nicely in relating an inferred connection between "good teaching" and frequency of use of A-V materials. Thanks to their use of a computer to organize audio-visual materials requests this center had data available on which teachers called most frequently for films to use in their classrooms. If such data becomes available to administrators who have evaluation responsibilities for the teachers on file it would be easy to infer from the A-V data some judgments about teacher efficacy. Whether or not the frequency of film usage correlates with good teaching practice is not the issue here. It is, rather, the appropriate and considered use of computer data gathered for one purpose, but realized to be applicable in unintended contexts. These kinds of problems are increasingly likely as computer data is shared with others who were not a party to the original and intended purpose.

Perhaps this set of issues is merely a more subtle variant on the Quest for Closure phenomenon discussed above. In educational systems where there is not universal agreement on which practices constitute good instruction yet where evaluators are being increasingly asked to document and be accountable, it is a strong temptation to let the computer provide closure on which teachers are good and which are not. It might ultimately be possible for a computer to make those discriminations, but we must be sure to feed it relevant data, derived specifically for that purpose.

URGENT PATIENCE

We find ourselves, in both teacher centers as well as in education generally, in a Hobson's Choice situation with regard to computing. Simultaneously we should have "been there" not later than yesterday, but would be well advised to wait until tomorrow. Educators are bewildered and apologetic in the face of demands from employers accompanied by futurists who decry the school's present inattention to computer facility. We are criticized because schools (and teacher centers) should have "been there yesterday" teaching students (and teachers) about computers, preparing for a computer-filled tomorrow.

From the other side comes a jaded chorus of conservative patience, microcomputers, they insist, are merely an expensive fad, more suited to the arcade or small business than to school. And besides they will be cheaper next year, probably simpler to operate too, so what's the rush to this most recent of educational boomlets?

What should be the role of teacher centers in this debate? One speaker suggested that "if it plugs into a wall teachers won't use it" as explanation for the demise of other technology in schooling. Consequently the explanation for the demise of other technology in schooling. Consequently the experience of tradition implies that we should confine attention to the real stuff of schooling, and this most recent fad - the microcomputer - will pass. Others paint a future which includes a notebook-sized portable micro for every student, who no longer need pencils, books or computation skills. Our conclusion lies in the temperate middle, neither denying the present reality of microcomputers nor anticipating a radical shift away from tradition. There is an undeniable urgency to master the rudiments of computing - at least as urgent for teachers as for pupil. But that urgency must be bonded with a patience which will accommodate people who take slowly to computing and situations which are not appropriate to the limits of a computer. This infant in our midst cannot be denied, but will take some considerable getting used to.

There is a great deal of professional responsibility implied in any bargain struck between educators and microcomputers, but as one of the conference presentors asked, "If not us, who? And if not now, when?" We need to move rapidly away from ignorance (with special emphasis on the root of that word: ignore). But that is not to say we should proceed next to wholesale embrace of computer as the salvation of public education. Those who insist on closure will have to wait.

THE COMPUTER'S LIMITS

As participants in the MANAGEMENT strand became more comfortable with using the micros available, there was both relief and occasional frustration with how literal and mechanistic a computer often acts. One presentor captured it perfectly in stating, "A computer never does what you *want* it to do, only what you *tell* it to do." Dr. Joseph Carbonari in the keynote address had pointed out that a critical distinction between the artificial intelligence of a computer compared to human intellect is that only the latter exhibits the quality of curiosity. Early in our week together the participants' curiosity was inhibited by fear and tainted by computer myths. By week's end participants had developed new constructs within which to think about computers; constructs which were limited yet freeing.

Perhaps the most revealing evaluation of the week's experience was evident when people began to realize that colleagues back home would now be quick to judge them as computer experts. After all, these folks had spent a week focusing exclusively on the young topic. They would soon be called on by policy boards or school officials to pronounce knowing judgments on which programs are best or which brand of micros to purchase for the schools. As the group anticipated these sobering future requests for closure, one participant confessed, "I'm not looking forward to being granted that kind of responsibility. Now I realize what the MANAGEMENT strand planners were up against at the beginning. But you had a whole week to answer."

Footnotes

[1]From "Computer Literacy - 1985" by Kenneth Brumbaugh in *The Computing Teacher*, Vol. 8, No. 4.

[2]Rob Richardson, French River Teacher Center, N. Oxford, Massachusetts; Marge Curtis, W. Nebraska Rural Teacher Center, Sidney, Nebraska; Dennis Spuck, College of Education, University of Houston, Houston, Texas; Ricki Nicholson, School Resource Network, Ventura, California; Jack Turner, B.E.S.T. Center, Eugene, Oregon.

CHAPTER SEVEN

Instruction and Microcomputers

Arthur Williams

Educators in general have long recognized a myriad of general applications and uses for computers in education. In the past, however, this potential went largely undeveloped due to cost factors which made the computer a prohibitively expensive resource for most schools. Understandably, few educators saw the need to become computer literate or to consider specific uses of the computer in instruction.

The technological developments of the last few years that resulted in the availability of low cost, transportable microcomputers have caused educators to reassess the place of computers in education. Despite the increasing number of educators who advocate a microcomputer in every classroom, it behooves us to remain rational while carefully considering our options. Because of the rapid technological advances in microcomputers, many educators may feel a sense of urgency to jump on the bandwagon for this newest piece of modern technology. In the haste to adopt computer-assisted instruction (CAI), educators may fail to take note of the experiences of those who acted without caution. We would be wise, then, to look before leaping, and proceed with cautious urgency.

There is need to temper the awe and infatuation associated with microcomputers with sound educational considerations which will enable us to make wise decisions. Even so, there is justification for proceeding with haste. According to a recent estimate, 80% of the jobs facing our elementary students do not even exist today. By 1985, seven out of ten adults will need to use a computer in their jobs.

Children and their parents are rapidly becoming computer literate and aware of ever-increasing applications of the microcomputer, Educators who fail to at least maintain pace may find their credibility under attack. Decisions related to computer-assisted instruction should be made by those trained and skilled in teaching. If educators fail to make these decisions, others will be only too willing to do so. The question, then, is not whether microcomputers have a place in our schools, but how computer-assisted instruction can be used most effectively.

It might be helpful to consider the microcomputer as a tool. This analogy allows us to assess the value of the tool in relation to how well suited it is to perform certain tasks in the classroom. It also allows us to focus on two primary considerations when attempting to decide if the microcomputer is the most appropriate tool for the task at hand. We must be aware of what a computer can do and also what it cannot do (a simplistic example of computer literacy).

Teachers need to examine their strategies, goals, and objectives, since these will be more visible in computer-assisted instruction. The closed door isolationism of the traditional classroom will decrease at an accelerated rate. Microcomputers will not camouflage poor teaching but will facilitate learning when used as a tool by competent teachers. A teacher who refuses to recognize and accept the computer as an instructional tool may be unemployable in the near future.

COMPUTER-ASSISTED INSTRUCTION

There are currently several classifications of computer-assisted instruction which include:

Drill and Practice. This type of CAI operates on the assumption that the subject matter of the lesson has previously been introduced to the student. It provides opportunities for the student to practice skills, frequently allowing more than one chance to do a problem, giving feedback or both correct and incorrect responses and usually provides information about how many problems were correct/incorrect at the conclusion of the lesson. Sometimes a game-like format is used to provide the drill-and-practice.

Tutorial. This mode of CAI most closely resembles the teaching of a specific topic. An attempt is made to anticipate possible student errors so that the student can be recycled through specific parts of the tutorial. Tutorials usually involve a great deal of reading as the printed instructions appear on the screen. Sometimes a diagnostic test for prerequisite skills is included at the beginning of a tutorial, so that a student must pass a minimum skill level before the tutorial begins.

Simulation. In this type of CAI, the computer attempts to simulate a real life situation. The student is told which conditions will change in the simulation and what the goal of the simulation is. Several options are then presented to the student and a decision about each one is made. The computer then determines how each of these decisions modify conditions and affect the total situation. The student is then presented with the results of his/her decisions and again is asked to make further decisions to reach a goal.

Problem Solving. The exploration, investigation and/or classification of problems is the focus of this type of CAI. The computer is used as a tool to do many long calculations quickly so that patterns emerge and students are free to ask other questions which follow from the computer results. Some teachers see the analysis of problems and de-bugging of programs as a form of problem solving.

In addition to computer-assisted instruction, the microcomputer can be used for computer-managed instruction (CMI). Computer-managed instruction generally refers to the use of the computer to support the teacher in the instructional process. Such uses as test generation and scoring, student record-keeping for grading, progress reports, etc., are included as part of computer-managed instruction.

The rapidly increasing procurement of hardware by schools and the resulting demand for compatible programs (software) has caused the demand for quality educational software to far exceed the supply. Although there are many programs available for computer-assisted instruction, the quality of many commercially available programs is extremely poor. In many cases the teacher would be better advised to use traditional methods of instruction which are effective rather than use a computer-assisted instruction program that impedes learning. Many entrepreneurs with little or no educational backgrounds are turning out instructional programs with little regard for or knowledge about how children learn.

These programmers often understand what can be done with a microcomputer and assume that anyone can write instructional programs for children. Thus, a program for teaching children how to button buttons and tie shoelaces is written with text requiring third-grade reading skills! Any educator who has attempted to purchase quality educational software is aware that the programs often do not live up to their advertising promises and frequently employ sound and color in ways which detract from sound teaching principles. Since most software is not available for preview before purchasing, the process of locating quality educational software can be very costly.

The question then is how does one sift through the bad programs and select the good ones without an expensive and wasteful trial and error method? Fortunately there is help on the way. One of the early pioneers in the area of testing, evaluating and documenting microcomputer K-12 instructional software and information is MicroSIFT.

Development of the Microcomputer Software and Information For Teachers (MicroSIFT) Clearinghouse began in December of 1979 with the support of the National Institute of Education. It is a major project of the Computer Technology Program directed by Dr. Judy Edwards at the Northwest Regional Educational Laboratory (NWREL). Donald Holznagel, Coordinator of MicroSIFT, has been working closely with Dr. Edwards in designing the clearinghouse which is now moving into its operational phase. The major focus of the project is on establishing effective procedures for the collection, evaluation, and dissemination of materials and information, and incorporating a flexible user support and technical assistance component.

COURSEWARE EVALUATION

In response to the need to identify quality software (well documented and tested packages), MicroSIFT staff are designing an evaluation process. Instruments are currently being devised and procedures being tested for the evaluation of microcomputer-based instructional software and courseware.

Development of this evaluation has been a joint project of MicroSIFT and the NWREL Research on Evaluation Program. Resources such as checklists, questionnaires and guidelines were collected from school districts and consortia to use in the development process. CONDUIT (the higher education clearinghouse for microcomputer-based education materials, located at the University of Iowa) has extensive experience in this field; their advice and input have been instrumental in the formation of the MicroSIFT evaluation package. Pilot tests of the evaluation forms were held with Portland and Beaverton school district teachers in Oregon. A field test version of the evaluation instruments has been developed for use during the 1980-81 school year.

The evaluation procedure involves four stages:

1. *Sifting.* An initial judgment is made whether a program or package is suitable for microcomputer use in grades K-12 and is ready for evaluation. Certain fundamental criteria must be met: does it have instructional value (as opposed to strictly recreational), can it be run on a microcomputer with little or no adaptation, etc.

2. *Description.* Factual information about the program and

materials is reviewed; i.e., instructional purpose, technique, package form, documentation available, and so forth.

3. *Evaluation.* Professional teachers with experience in the program's subject area and stated grade level review the material, test the program, and make judgments concerning its value as an instructional package.

4. *In-Depth Evaluation.* When a package successfully passes the first three stages and is rated high enough to warrant further evaluation, instructional effectiveness will be assessed through pretesting and posttesting, student observation, or other means. An expert in the package's field of study will supervise the In-Depth Evaluation and make a recommendation and/or judgment to MicroSIFT regarding the usefulness of the program.

The evaluation process will be supplemented by an Evaluator's Guide, now in development. It will be used in training and as a reference for evaluators to help them achieve accuracy and consistency of procedures and judgments.

During the 1980-81 school year this evaluation process will be field tested by Network members using educational packages submitted to MicroSIFT.

PACKAGE DISTRIBUTION

MicroSIFT will facilitate dissemination and distribution of evaluated instructional packages in a variety of ways. Services available through NWREL MicroSIFT include:

- Developing and publishing guidelines for authors and exemplary instructional packages.
- "Product finishing" to bring packages up to publishable standards.
- Conducting a publisher's search.
- Establishing criteria for publisher selection.
- Reviewing publisher's proposals and making recommendations.

The first set of completed package reviews is projected for spring 1981.

MicroSIFT and other similar programs may well become the Consumer Guides of instructional software. Producers of software will also be more likely to deliver a quality program when faced with such in-depth evaluation.

OTHER INSTRUCTIONAL ISSUES

Aside from the many decisions educators must make regarding hardware and software, there are other considerations and issues we must face. Some of these include:

- A need exists for computer literacy among educators—not that they need to become technicians, but they should be made aware of the potential and limitations of the microcomputer as an instructional tool. Computer literacy must become a part of preservice and inservice teacher training.
- The computer should not be perceived as a threat to educators. Computers can only respond and must rely on trained, competent educators to ask the questions. There will be even greater demand placed on teachers to develop and improve their questioning skills, especially for higher level processes.
- Rather than overburdening the teacher, the computer, when used most effectively, will free the teacher to perform more important tasks involving personal interaction.
- Educators using computer-assisted instruction will require continual support and updating to keep pace with changes in the field. This could be accomplished via conferences, workshops, networks and publications.
- Problem-solving skills will become an integral part of the curriculum for all students and not merely restricted to Gifted and Talented programs.
- Computer-assisted instruction must not be restricted to computer science and math.
- Care and planning should be exercised by change agents in bringing about computer-assisted instruction in the classroom. The first experience of teachers and students with computers should be positive and non-threatening.
- Great rifts will occur in our society if the issue of equity in computer access and experience is not solved.

Can education survive if educators resist the advent of microcomputers? Probably not. Isaac Asimov, quoted in *Time*, February 20, 1978, summed up the issue: "We are reaching the stage where the problems that we must solve are going to be unsolvable without computers. I do not fear computers. I fear the lack of them."

CHAPTER EIGHT

A Teacher's Guide To Computer-Managed Instruction (CMI)

William C. Bozeman and Dennis Spuck

The confusing initials CMI and CAI are frequently encountered by the teacher or administrator who is learning how microcomputers can be used in schools. To help clarify what is meant by CMI, the following article was excerpted from two articles written by Dr. Bozeman and Dr. Spuck. (Bozeman, 1979; Spuck and Bozeman, 1978.)

A DEFINITION OF CMI

CMI systems are generally considered management information systems designed to support the management process or functions associated with programs of individualized education. Of particular importance is the support of decision making in individualized educational programs. Decisions involved in the identification of the instructional needs of students and in the selection of the most appropriate instructional activities to meet these needs are emphasized (Spuck, Hunter, Owen and Belt, 1975). CMI systems seek to facilitate the processing of information and to supply this information at appropriate times and places so that it can be applied directly to instructional decision making (Spuck, Bozeman, & Lawrence, 1977).

Baker (1978) cited three themes in American education which have contributed to the development of CMI:

1. Individualization—Educators have demonstrated an intuitive feeling about the existence of means to meet the instructional needs of individual students. Individualization of schooling has been a primary motivation in most CMI development.

2. Behavioral objectives—Student behavior or performance (typ-

ically in the cognitive domain) is specified in precise terms as part of the curricular structure. This is usually accompanied by some specification of time, means, and evaluative measures.

3. Educational technology—The impact and progress of technology has been closely scrutinized by educators for instructional potential. The primary focus of attention in recent years has been on computer utilization.

CMI is an excellent device for incorporating the needs educators have expressed with regard to individualization of instruction. One of the most obvious applications is computerized record-keeping systems to handle the increased data generally associated with individualized instruction. The potentials of CMI can extend far beyond this mode of application.

The basic structure of programs of individualized instruction (e.g., Individually Guided Education or IGE) leads to the following assumptions concerning instructional programs which may be supported by a sophisticated CMI system:

1. There exist instructional missions and goals which are reduced to sets of measurable instructional objectives.

2. Testing instruments and/or procedures which may be used to assess mastery of the instructional objectives are available.

3. Level(s) of mastery or performance standards are specified for each child and for each instructional objective (full mastery-variable attainment).

4. Objectives which are to form a part of each student's instructional program are delineated (common objectives-variable objectives).

5. Dependencies existing between objectives are specified (sequence objectives-nonsequenced objectives).

6. Normative information exists for input into the specifying of long-range performance expectations.

7. Educational activities and materials exist which provide individualized instructional experiences toward the accomplishment of the specified instructional objectives.

8. It is possible quantitatively and/or qualitatively to assess the individual characteristics of students essential to individualizing instructional activities.

9. It is possible quantitatively and/or qualitatively to assess the

resources implications of alternative educational experiences. (Spuck, Hunter, Owen, & Belt, 1975, p. 22.)

A distinguishing factor between CAI and CMI systems is the degree of direct interaction that the student has with computer programs (Fromer, 1972). Computer-assisted instruction is a curricular program wherein an interface exists between the student and computer for the purpose of instruction. Typically in CAI systems the student communicates with the computer via a television-type display or teletype terminal. Instructional material is presented to the student, student responses are accepted, feedback is provided, and records may be maintained. These functions, including sequencing of materials to some extent, are controlled by the computer .

AN EXAMPLE OF CMI

Wisconsin System for Instructional Management

General Description. The Wisconsin System for Instructional Management (WIS-SIM) is a system of computer-managed instruction developed at the Wisconsin Research and Development Center for Cognitive Learning at Madison, Wisconsin. Although WIS-SIM pilot tests and implementations are in elementary schools, the system is capable of supporting secondary curricula, provided they conform to design requirements of WIS-SIM. The goal of WIS-SIM is to improve instructional decision making in order to maximize the educational progress of each student while making efficient use of the available human, material, and financial resources (Spuck, Hunter, Owen, & Belt, 1975, p. 21). Functional capabilities provided by the system include:

1. Program data base initiation
2. Student data base initiation
3. Entering student achievement data
4. Achievement profiling
5. Instructional grouping recommendation and implementation
6. Diagnostic reporting
7. Student data base maintenance
8. Monitoring overlap between instructional programs
9. Data base purging
10. Curriculum and program evaluation (Douglas, Belt, Owen, and Chan, 1977, pp. 12-14).

In summary, WIS-SIM is a management information system which provides support for the management functions associated with education in addition to assisting teachers with the requisite record-keeping and clerical tasks involved when instruction is individualized. The objectives, therefore, are to collect and process student information and to supply it at appropriate times and places so that it is directly applicable to instructional decision making.

Features. WIS-SIM is designed to support any instructional program which meets the assumptions specified above. Examples of curricular products which have been used with the system are the Wisconsin Design for Reading Skill Development (WDRSD), Developing Mathematical Processes (DMP), Science—A Process Approach (SAPA), Holt mathematics, and SRA DISTAR. Data can be entered interactively via a terminal in the school or by batch systems using a courier service. Sheet scanner input is currently being added as a feature of the system. Report requests can be obtained at the school on the terminal or printed at the central computer facility for purposes of speed or economy.

Student data base functions are provided to allow the user to insert, move, delete, or reinstate students. In order to keep the student data base at a reasonable size, the system allows for periodic purging. Purged data is saved in a historical data file.

SITE SELECTION FOR THE IMPLEMENTATION OF CMI

A question which often arises and which is clearly appropriate concerns the selection of a school or school district in which to implement a system of computer managed instruction such as WIS-SIM. The answer to such a question would obviously require an investigation directed toward this single issue. Although this evaluation was not designed to address this question in depth, there are several areas to which the findings of this study do indicate attention should be given. Although these respective areas may not contribute individually to the success or failure of a CMI implementation, collectively they may be important determinants.

Perceived Need and Participation. Based upon the experiences gained during the pilot test, the decision on the part of the teacher to utilize computer-managed instruction, rather than its implementation being imposed on them, appears to be an important consideration. Beyond teachers' perception of need is the importance of teacher involvement in system design and modification. The most successful WIS-SIM sites are those at which teachers, themselves, perceived a need for assistance in the requisite and considerable record keeping and decision making associated with individualized schooling, and in which teachers had participated in system design and modification.

Organizational Structure. The real value of a management information system such as WIS-SIM is its ability to enhance the decision-making process and not simply reduce clerical and record keeping tasks. The instructional management in a school dedicated to individualized education will derive benefits from such a system which would not be realized in a more conventional environment. If teachers view a system of computer managed instruction only as a clerical aid, they likely will not be satisfied with its performance and may, in fact, consider system usage as an additional task.

Size. The size of the school is an important criterion to consider. Although rigid guidelines cannot be determined, the evaluation indicates that a school with a minimum of about 400 students would represent a reasonable inside parameter. A small school likely will not perceive the need for computer support for record keeping or instructional decision making in educational programs such as Individually Guided Education.

Administrative Support. Closely related to the concern of teacher support or perceived need and involvement is the concern of administrative support. It is unlikely that an unsupportive administration would provide an environment for a successful implementation. Ongoing success requires appropriate allocation of personnel (e.g., aides for computer-terminal operation, time (e.g., inservice training), and resources (e.g., supplies, travel, materials). These are areas within the administrative domain over which teachers may have little or no control.

STAFFING AND INSERVICE

The introduction of a computer-supported system such as WIS-SIM usually represents a totally new experience for the faculty and staff of a school. Associated with the introduction of the system there may be considerable apprehension and anxiety about the system unless steps are taken to ensure staff knowledge about and commitment to the proposed system implementation. The importance of staff preparation and involvement cannot be emphasized enough.

Closely related to the necessity for staff development is the need for a facilitator or coordinator. A school staff member who is given the time and training to be an active resource person is extremely beneficial and may be essential. The evaluation suggests that the most successful implementation sites were those with a person designated to be responsible for coordinating implementation efforts at the site. This coordination may include overall supervision of system-related activities, answering questions on planning and evaluation, and acting as a liaison between the school and the computing center staff. The evaluation also indicates that the principal may not be the person best suited for this assignment because of the time obligations necessary in preparing for and carrying out this role.

SUMMARY AND CONCLUSIONS

Effects of CMI on Student Achievement

CMI system effect with respect to student achievement is the most difficult area in which to reach definitive conclusions. Apparent to any researcher are the problems associated with establishing the necessary controls in such an investigation (e.g., intervening variables, nuisances, and statistical "noises"). These include but are not limited to variances and changes in school/classroom organizational structure, fluctuations in the school staffs, administrative philosophy and policy, curricular methods, and social factors related to the home, school, and community.

The available evaluative data appears to indicate that an increase in student achievement is associated with the implementation and utilization of CMI. In the absence of a longitudinal, empirical study of adquate scope and complexity, it is reasonable to assume that the utilization of an appropriate instructional management information system results in more efficient use of time—by both teacher and student—and improved usage of available resources.

Effects of CMI on Time Usage

One of the design objectives of CMI systems is the enhancement of teacher and student time usage. It is assumed that more effective utilization of time will result in greater educational productivity. The available research does not provide conclusive evidence that time utilization is enhanced significantly through CMI.

The WIS-SIM evaluation (Spuck, Bozeman, & Lawrence, 1977) indicated a reduction in the amount or percent of teacher time required for clerical tasks. Teacher comments regarding planning time indicated that, although the actual hours involved in planning have not changed appreciably, the planning process is more effective and more is accomplished during the time.

User Attitudes Toward CMI

In general, the available information indicates a favorable or positive attitude toward CMI systems. This conclusion must be tempered by the fact that often such measures reflect only a certain subset of the district population. Such groups may reflect special characteristics that led to their decision to implement computer-based information systems. Such characteristics may include acceptance of innovations, low anxiety about technological systems, perceived need for assistance in decision making, and administrative support. Unfortunately, the literature often reflects only the sites where implementation was successful and does not discuss unsuccessful implementations.

Cost and Cost-Effectiveness of CMI

Determination of costs associated with any CMI system is a difficult matter. Factors affecting CMI costs may include the following: (a) extent or level of system usage, (b) number of curricular areas supported, (c) computer system employed and actual computing costs, (d) turn-around time demand, (e) on-going maintenance of hardware and software, (f) number of support personnel including both technical personnel and coordinators, (g) types of processing (e.g., bath, timesharing, input/output media), (h) development cost, (i) facilities, (j) inservice and related training.

While many of the costs may appear transparent in a given implementation, their inclusion obviously will have considerable impact on the true expenditure. For example, if a school district already owns or accesses a computer facility, many of the hardware costs may not be included unless a program allocation budget system is employed.

The only conclusion that can be drawn with any degree of certainty is that costs of actual computer processing will continue to decrease in the future while the costs of personnel will continue to increase. The advent of microprocessing technology likely will have a dramatic effect on these costs, permitting a school to support all or most data processing at the local site rather than at a centralized computer facility.

Each situation must be considered as a unique case when determining costs. The factors outlined previously should be reviewed when contemplating a CMI system or when negotiating a contract or purchase/lease agreement with a vendor.

While it is the opinion of the writer that CMI is cost-effective, there is little data which can support this conclusion. Probably the cost-effectiveness of CMI resides more in its enhancement of educational decision making and facilitation of individualized instruction than in the elimination of manual operations and pencil-paper record keeping. With few exceptions, the implementation likely will result in additional expenditures.

IMPLICATIONS FOR FUTURE RESEARCH AND DEVELOPMENT

The information available about CMI raises a number of concerns regarding the state of the art, its progress, and prospects for the future. CMI appears to have suffered from numerous reinventions of the same wheel by different agencies. This is likely a result of the lack of adequate information dissemination and linkages between research and development groups. Therefore, it is recommended that users and potential users of CMI establish a network for the purpose of information exchange. It is conceivable that, in some cases, this network may be computer based or computer linked.

In summary, CMI appears to be a viable form of instructional management. Numerous projects have demonstrated proof-of-concept. Unfortunately such proof is often inadequate for boards of control who must make decisions regarding the allocation of limited monies. It is the opinion of the author that CMI is an effective alternative to traditional management processes and should be considered by schools requiring assistance with educational decision making and record keeping. This belief, however, is accompanied by the caveat that such an implementation may be a failure unless it is executed within a total systems framework.

CMI has also suffered from the lack of a well-designed longitudinal study. Such a study should be directed toward the measurement of objectives in many areas related to CMI utilization and effect.

Although some research has begun at the Wisconsin Research and Development Center, an effort should be directed toward the development of CMI software operable on microprocessing units. If microcomputers do eventually replace timesharing, as some predict, CMI should certainly profit from this technology.

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CHAPTER NINE

Computer Literacy For Students and Teachers

Barbara R. Sadowski

One of the most recent "buzz" words to come along in education is the phrase "computer literacy." Like other words and phrases from technology (e.g., feedback, input), it has no one universally agreed-upon meaning. Much like the educational term problem solving, computer literacy is an empty vessel to be filled with whatever meaning an individual desires, however broad or narrow the definition. It is not the intent of this chapter to provide the definitive word on computer literacy, but rather to alert you, as teachers, to what the so-called experts define as computer literacy and then to briefly outline what implications these definitions have for students. Finally, I would like to discuss some considerations in the definition of a computer literate teacher.

Defining Computer Literacy

The November 1980 *NEA Reporter*[1] defined computer literacy for students as "at least a non-technical knowledge of how to use a computer—knowledge that will be essential in order to handle the jobs that will await them in the 1990s and beyond, most of which are jobs that do not yet exist." This definition is comparable to defining computer literacy as knowing what computers can and cannot do, i.e., knowing the capabilities and limitations of computers. As Marion Ball said in 1972, "Computer literacy is knowing about computers. What they are, how they work, and what they can and cannot do."[2]

Contrast these definitions to one which appeared in a recent issue of *Classroom Computer News*:[3] ". . . computer literacy . . . [is] that collection of skills, knowledge, understandings, values, and relationships that allows a person to function comfortably as a productive citizen of a computer-oriented society. This includes the following four interrelated areas:

1. The ability to control and program a computer to achieve a variety of personal, academic and professional goals. This includes the abilities to read, understand and modify existing computer programs, and to determine whether or not the program and/or the data it is using are correct and reliable.

2. The ability to use a variety of preprogrammed computer applications in personal, academic and professional contexts. This includes the abilities to make informed judgments as to the suitability of a particular software tool for a particular purpose, and to understand the assumptions, values and limitations inherent in a particular piece of software.

3. The ability to understand the growing economic, social and psychological impact of computers on individuals, on groups within our society and on society as a whole. This includes the recognition that computer applications embody particular social values and can have different impacts on different individuals and different segments of society. It includes the understanding necessary to play a serious role in the political process by which large and small scale decisions about computer use are made, and to transcend the dependent roles of consumer or victim.

4. The ability to make use of ideas from the world of computer programming and computer applications as part of an individual's collection of strategies for information retrieval, communication and problem solving. This aspect of computer literacy corresponds to the effect of learning to read and write on intellectual functioning and is probably the most difficult to incorporate specifically into educational programs, since the effects themselves are still not entirely clear.

In one decade, computer literacy has been expanded to include much more than merely knowing what a computer can and cannot do. While you as a teacher may be surprised or even shocked to learn that all of the above are seriously considered as appropriate components of computer literacy with the implications of adding this to an already crowded curriculum, consider the following definition of computer literacy.

"Computer literacy consists of being able to:

I. Understand the functions and use of the components of a computer system.

II. Utilize a systematic problem-solving technique in developing solutions to a problem.

III. Analyze the role of computer technology in society. Understand its past, present and possible future impact upon human life."[4]

While these three goals seem to be reasonable and fairly uncomplicated, the goals are further defined by a list of 55 program objectives. Some of the objectives are achievable with minimal expertise such as: Describe in general terms how a computer system works, or discuss the potential misuse of computer technology in the area of individual freedom and identify areas of value conflict. Yet other objectives are very specific and require a high level of computer sophistication. Two such objectives are (1) Program in at least two computer languages; (2) Describe the function in a computer system of each of the following: Bits, Bytes, Words, Binary, Octal, Hexadecimal representations and Binary, Octal and Hexadecimal arithmetic *and* perform arithmetic operations in each of the above numeration systems.

Admittedly these objectives are perhaps extreme examples of what is generally regarded as goals for computer literacy. However, you as teachers should be aware of the extremes in the definition of computer literacy, if for no other reason than your own protection. For example, you might agree to teach a unit on computer literacy thinking it meant telling students about what a computer can and cannot do, while someone else had a list of 55 specific objectives in mind. So be forewarned! When computer literacy is being discussed, be sure that both parties are in agreement about what it does and does not include. As you can see from the above examples, there is no universal agreement among the experts about the term.

Before leaving the problem of defining computer literacy, I would like to tell you what is being done today in schools which actually teach a unit on computer literacy and then to suggest what the content of a computer literacy course might be.

In a 6-week, 35-hour computer literacy course in Saskatoon, students cover three basic objectives. These are:

1. Made aware of what computers are used to do and what they likely will be used to do.
2. Shown what a computer consists of, and how one operates.

3. Introduced to the topics of flowcharting and programming in the BASIC language.

This course is taught as part of the 7th- and 8th-grade mathematics program in 12 elementary schools, each with 2 terminals hooked to a HP-2000. These three objectives are broad enough to cover a wide variety of student abilities and interests, yet there is a lack of specificity in defining the course content. The following list of 12 topics covers the content of a comprehensive computer literacy course which was compiled from responses by 50 schools districts throughout the country.

1. History of Computing
   Topics vary from dates, places and people, ancient computing devices to a concentration just on the most recent generations of computers. Some courses seem to place a heavy emphasis on the history of computing.
2. How Computers Work
   The structure of computer systems and the function of five major parts are usually covered.
3. Control of Computers
   How people communicate with and instruct computers is discussed.
4. What Computers Can and Cannot Do
   Capabilities and limitations of computers are topics designed to dispel misconceptions the students may have.
5. Characteristics of Computers
   Students are taught that computers are fast, accurate, tireless, and that they need to be instructed.
6. The Effect of Computers on Society
   How computers impact individuals, groups, the economy, education, jobs, crime, etc., are common topics. Included is a discussion of both the benefits and dangers of computerization.
7. The Application of Computers
   How computers are used in business, government, science, education, etc., are topics covered along with discussions of careers that involve computer use.
8. Computers and the Future
   Implications that computers have for the future are discussed. The rapid historical development of computers is extrapolated to the future.
9. Terminal (or Microcomputer) Operation
   An introductory unit is often included as an effort to make

the student feel at ease at the terminal or microcomputer.

10. System Library Usage
Students run "canned" games and simulation programs. The purpose seems to be to familiarize the students with the communication process, and to provide motivation.
11. Flowcharting
Prior to actual programming in a computer language, students often flowchart procedures such as computing a payroll, preparing for the school day, etc.
12. Programming
Most programming is done in BASIC. The following program statements are the minimum set covered in most courses: PRINT, LET, END, GO TO, IF . . . THEN, INPUT, READ, DATA, FOR . . . NEXT, DIM, GOSUB, RETURN, REM, and RESTORE.

This list of topics meets the definition of computer literacy put forth by computer educator David Moursund as ". . . a knowledge of the non-technical and low-technical aspects of the capabilities and limitations of computers, and of the social, vocational and educational implications of computers."[5]

Aspects of Robert Seidel's definition of computer literacy as "understanding the impact of computers on society, how computers work within a discipline, and the actual programming process,"[6] are also included. If the definition of computer literacy includes programming and flowcharting, then decisions must be made about when to teach computer literacy and who should be responsible for teaching it.

Ideally, each teacher should be teaching aspects of computer literacy as an integrated part of the school curriculum. The science teacher should teach how computers work and how to use the computer as a problem-solving tool; the social studies teacher should examine the history of computers and the changes in society resulting from a computer-permeated society; the English teacher should investigate computer-related words; and the math teacher should teach the operation and programming of computers. Unfortunately, this is not what usually happens in a school. As reported by the NEA, a recent University of Nebraska survey found that only 3% of K-12 teachers felt confident they knew how to use a microcomputer. The lack of knowledge, strange vocabulary, and the mystique surrounding computers add to the teachers' "computer anxiety," an anxiety that needs to be replaced with "computer literacy." Yet the usual school scenario is one in which a single teacher is identified as "the computer person" and when that person leaves, the interest in and use of the computer as an instructional tool leaves with the teacher. It does not help that most of the teachers who have been interested in computers for the past 10-15 years are mathematics teachers. The "math anxiety" of other teachers only adds to "computer anxiety," further complicating the problem. Teachers regard the computer as one more technological device that has come along to revolutionize education. Some believe that this fad, too, will pass and end up in the storage room gathering dust with previous types of educational hardware that failed to live up to their glittering promises. All the teacher must do is out-wait the fad and everything will return to the way it was before computers. But the microcomputer can work for the teacher. It is possible that the microcomputer will take over the mountains of paper work, freeing the teacher for more teaching that involves touching children's minds. It is an exciting possibility to consider as a teacher. As Dr. Carbonari mentioned last night, teachers are essential for computers are not curious; they cannot impart a love of learning, and the wonderful sense of adventure that accompanies it; only teachers can do this.

Implications for Teachers

If computers are going to become a part of a teacher's world, then what should a teacher know about computers? Is the teacher to be required to become an accomplished programmer, able to write software and modify programs? Or are computers something better left to one or two expert teachers? I believe that computer literacy for teachers is somewhere in between these two extremes. First, computer literacy for teachers and students should include the nontechnical aspects of capabilities and limitations of computers. Second, the changes in society brought about by the computer and the way that these changes have affected and will affect individuals should be a part of computer literacy. Beyond this, every teacher should know enough about a computer as a delivery system for instruction to make informed decisions about the use of computers as an instructional tool.

Teachers should recognize that they possess knowledge about how children learn and that knowledge is as useful in evaluating educational software for the computer as it is evaluating textbook series. Just because a computer expert writes a program for teaching basic facts does not mean that the software is pedagogically sound. Teachers need to learn to evaluate software from their perspective as classroom experts who watch how children learn every day. Teachers also should learn enough about how the software is developed and written so that they can provide constructive feedback to software developers. This coalition of expertise is necessary if the full potential of the computer as an educational tool is to be realized. It is a difficult, time-consuming process to write high quality, pedagogically sound educational software. Good teachers who are also programmers are very rare. Thus, teachers need to learn enough about what a computer can do in order to effectively communicate with software developers so that effective instructional material will result. Thus, knowing the capabilities of a computer has a particular meaning for the computer literate teacher. It might not be a goal for every teacher to master computer programming, but teachers should be able to bend the computer to serve the instructional needs of their students in the same way that they modify other instructional materials. If this happens, then perhaps microcomputers will not be just a passing fad doomed to gather dust in the classroom closet.

Footnotes

[1]Microcomputers: Passing fad or educational revolution, *NEA REPORTER*, November 1980, pp. 10-12.

[2]Ball, M. *What is a computer?* Boston: Houghton Mifflin Co., 1972.

[3]Watt, Daniel H. Computer literacy: What should schools be doing about it? Classroom Computer News, Vol. 1, No. 2, November-December, 1980, p. 1.

[4]Kaufman, D. T., Jr. *Teaching the future.* A guide to future-oriented education. Palm Springs, California: ETC Publication 1976.

[5]Moursund, D. What is computer literacy? *Oregon Computing Teacher, Oregon Council for Computer Education*, Vol. 2, No. 2., June 1975.

[6]Seidel, R. As quoted in Research developments—computer literacy, *American Education*, June 1979, pp. 41-42.

CHAPTER TEN

The Computer As An Instructional Tool

Gary Marchionini

It has often been hypothesized that the computer has the potential to become a powerful tool of learning. During the 1970s this potential was actualized via a wide range of applications. The variety of equipment, content, and modes of use highlight the multifaceted nature of the computer as a tool of learning. The purpose of this chapter is to distinguish among the goals for using computers in education, describe specific applications of computers in education, and raise some issues related to the roles of teacher centers in educational computing.

Three broad goals for bringing computers into schools are: (1) to teach the use of the computer itself, (2) to provide students with access to and strategies for using the computer as a tool for learning, and (3) to use the computer as an aid to instruction. These goals are by no means mutually exclusive. Learning about the computer is a prerequisite to using the computer as a tool for learning and instruction. Most applications address both the second and third goals simultaneously since instruction and learning are mutually dependent. An important distinction between the first goal and the other two pertains to the object of instruction. In the first goal, *the computer is the object of instruction*, whereas in the other goals the usual content, e.g., mathematics, is the object of instruction and the computer facilitates the instruction or learning. For the purpose of this chapter, the applications which address the first goal will be termed *computer science*, and the applications addressing the use of the computer for teaching and learning will be termed *instructional computing*.

Computer Science

The computer is having increased influence on our lives and there is a need for intelligent citizens to understand how computers work, how they are used, what are the limitations of computers, what career possibilities exist, and what are the social impacts of computers. This understanding is generally termed computer literacy or computer awareness and has received considerable attention in both the popular press and professional literature. For example, The National Council of Supervisors of Mathematics and National Council of Teachers of Mathematics have included computer literacy as one of ten basic skill areas in mathematics, the National Science Foundation has funded several computer literacy projects, and computer literacy is a popular topic at most educational conferences.

Most computer literacy courses or modules include attention to: a model of operation, e.g., five basic parts and five corresponding processes of computers; vocabulary; a software scheme; the limitations of computers; the history of computing devices; how computers are used; career possibilities; social impact, e.g., automation and employment, privacy issues, computer crime; and an introduction to computer programming.

Literacy for teachers include all the above areas as well as awareness of educational issues that are yet unresolved. Which curriculum area should be responsible for computer literacy and where in the curriculum should computer literacy be placed; what grade levels are optimal for computer literacy; what educational applications exist and what are their advantages and disadvantages; these are just a few of the issues teachers must grapple with when becoming computer literate themselves. It is becoming increasingly evident that computer literacy must be flexible enough to address a rapidly expanding hardware and software environment.

A second application of the computer where the tool itself is the object of instruction is computer programming. Most large high schools, and many junior high schools currently offer courses in computer programming. Not every student will become a computer programmer but every student should be a computer communicator in the sense that students should be able to command the power of the computer in some language the computer understands. Upper elementary students can learn BASIC programming, younger children have demonstrated expertise with LOGO and in the most generic terms, pre-schoolars program today's electronic toys, e.g., BIG TRACK. Learning high level computer languages provide students with the facility to use the multifaceted tool to its fullest extent. Just as the machine itself is a tool, so is the language for communicating with the machine.

Learning programming on today's highly interactive computers allows students to truly learn by "doing." Students can experiment and revise programs based on immediate feedback. This implies that students must have access to computers, and that teachers with good computer science backgrounds introduce general programming techniques and pose good programming exercises.

Instructional Computing

Most instructional computing applications address both the goals of instruction and of learning. To avoid redundancy, instructional computing applications will be considered as a group rather than in two groups; instruction and learning. Applications which are strictly used by teachers will be considered last. The applications below involve a variety of cognitive levels and approaches to teaching and learning.

Drill and practice applications capitalize on the immediate feedback and recordkeeping capacities of the computer to provide drill in content material. Drill and practice applications are the most common uses of computers in schools. The general format involves the computer posing a question, the student responding, and the computer giving feedback on the response and keeping records on responses. Many drill and practice programs are written in the context of a game or challenging activity. Most drill and practice programs address lower cognitive processes since recall and conceptualization lend themselves easily to simple question and answer formats. One reason drill and practice is so popular is that its use demands little or no computer experience on the part of the teacher or the learner. Drill and practice typifies the overlapping goals of instruction and learning since the teacher assigns the drill to enhance or reinforce instruction and the student uses the program to enhance learning of the content.

Tutorial programs are meant to provide instruction as well as drill and practice. Since tutorial programs must anticipate a large array of student responses and provide an appropriate instructional sequence for each response, they are of necessity lengthy and difficult to write. There are few tutorial programs available that reflect effective instruction and are affordable for schools.

Using the computer as an information storage and retrieval device is becoming an important instructional application. Accessing large databases, usually over the phone line, can provide a powerful resource for students and teachers. Educators, for example, have accessed the ERIC database for years. One database that is available for a service fee allows the user to search all UPI files over a time period via a list of keywords. Many states have occupational information systems available to students. These systems allow students to search for specific and detailed occupational information via the computer. Computerized databases are revolutionizing research techniques and providing opportunity for masses of real world data to be used in the classroom.

Although this application of computers can be used by teachers in providing instruction, its greatest use is as a tool of the student for learning. As society becomes increasingly computerized and information based, this application will take on increased significance both at school and in the home. The word homework may take on a whole new meaning as students access databases through home computers.

Using the computer as a simulator of events, real or imaginary is perhaps the most powerful application for learners and teachers. The best simulations interact with students by giving immediate feedback on decisions they make in the context of a problem or experiment. There are a number of simulations available in science, social studies and mathematics. Some classics include: fighting battles of the civil war, traveling along the Oregon trail, landing a spacecraft on the moon, ruling an ancient city, fighting malaria in a jungle, and running hypothetical businesses. Using simulations demands many levels of cognition since students recall names or terms, conceptualize events or conditions, analyze and evaluate data, make decisions and revise hypotheses.

Since teachers can lead a class or group of students through a simulation or an individual student can use the program, both the goals of instruction and learning are addressed. Another form of simulation is strictly learner controlled and involves the writing of a program to simulate the conditions of a problem and successive "runs" of the program to solve or gain insight into the problem. These simulations belong to the class of applications known as problem solving.

In problem solving, the computer is used as a tool for learning, for experimenting, exploring and generating data. Problem solving applications are concerned with process rather than product goals and involve hypothesizing, feedback and revision strategies. An example of problem solving involves maximizing area of a rectangle, given a fixed perimeter. By writing a simple five-line program, students can explore the area resulting from any increments of length meeting the conditions of the problem. Similar problems for three dimensional objects are common. By using this technique seventh graders can explore maxima and minima problems usually reserved for college calculus courses. Using problem solving computer techniques requires programming skills on the part of students and a creative, knowledgeable teacher to pose the problem and teach the "learning to learn" strategies.

A related application is termed exercise solving. In exercise solving, students write programs, complete partially written programs, modify programs, or predict the output of programs to conceptualize particular algorithms. Students may for example, be asked to write a program to find the slope of a line passing through two given points, or be asked to supply a key line in a program to find the area of a triangle. Students practice concepts by "teaching" them to a computer via the computer program. As with problem solving, developed computer skills are required on the part of the teacher and student.

There are at least three computer applications which are strictly for instruction. Computer managed instruction (CMI) is used by teachers wishing to individualize instruction. A curriculum is classified by specific objectives, all available resources are entered and students are tested and the results analyzed by the computer. Diagnostic reports and individual prescriptions keyed to available resources are printed and the teacher is free to work with individual students or small groups. It is important to note that only the teacher uses the computer. CMI programs necessarily require huge amounts of memory and are usually time-share based. Large scale projects like PLATO or TICCIT provide CMI capabilities.

Computer generated worksheets and tests can be produced, thereby providing teachers with the ability to customize worksheets or tests for individuals or groups. A program such as the Minnesota Educational Computing Consortium's COMPUTE allows a teacher to sit at a terminal and choose from over 450 arithmetic objectives, specify the number of each to be included and print single or multiple copies with or without answer keys.

The graphics capabilities of microcomputers are providing a new application for teachers who wish to present graphic illustrations to enhance lessons. Graphs, charts, diagrams, or animations can be used or modified instantly during a class demonstration.

Issues for Teacher Centers

The applications of the computers as a tool in education listed above are not exhaustive but illustrate the variety of computer uses and differences in teacher training requisites. As with the use of any tool, the outcomes resulting from the application of the computer are dependent on the skill level of the user. A pencil in the hand of an artist, a writer, a draftsman, or a young child will produce very different outcomes.

Since microcomputers are appearing in schools in increasing numbers, there is a great demand for training by teachers who wish to gain the skills necessary for effectively applying the tool. Teacher Centers are being called upon to provide this training. Some issues to be addressed if Centers are to provide more than cursory service for teachers include:

1. What hardware to acquire
2. What software to purchase or design
3. What to do after conducting intitial "awareness" sessions
4. Whether to provide programming courses or services
5. How to collect, evaluate and disseminate quality software
6. Whether to become involved in curriculum development or revision
7. How to research and/or evaluate educational computing training and projects

While some of these issues are the same issues Teacher Centers have grappled with in providing other kinds of service, some are unique to the computer. Individual circumstances will of course influence decisions related to the above issues. Types of computers in schools served by a Teacher Center, availability of university courses, budgeting constraints, access to consultants, and other local conditions will help determine a focus for Teacher Center educational computing services. Certainly, the most important thing that Teacher Centers can do is to provide access to computers for teachers.

CHAPTER ELEVEN

Less Thunder in the Mouth; More Lightning in the Hand*

W. Robert Houston

This old Indian proverb summarizes the potentials and perhaps the problems of the microcomputer as an evolving technological educational system in schools. Unbelievable advances have occurred during the past two years; the next two promise even more radical changes. In this last chapter, it is appropriate to examine some of these implications. More important, we must act, not just talk about the potential of this evolving educational resource.

Change is so pervasive in our society today that it is accepted as inevitable, though with some reluctance. Many of us, like Custer the Dragon in Ogden Nash's delightful story, might long for a nice safe cage where everything remains stable. But such is not the fate for educators. Particularly for those who are concerned with the development of microcomputers as educational tools, obsolescence is the "name of the game." New and improved approaches to instruction, computer programs, expanded computer capability, and new systems of technology are all dated even before they are adequately tested.

For four hundred years, the printed page has been accepted as the appropriate medium for transmitting knowledge; today this is being challenged by computers, television, microfiche and microdots, and other more transient and flexible media. Indeed, the authors and editors of this book were challenged to use another medium for conveying the status of the microcomputer revolution as of January 1981. We are under no delusion that what you are reading is current. Like seeing the light from a distant star, you are interacting with the knowledge-base that is months or years old.

* Old Indian Proverb

As we look forward, several generalizations and caveates seem appropriate.

1. *Soon after the turn of the century, the microcomputer will be accepted by children and youth as a typical and usual part of life.* Just as television and telephones are considered integral to homes today, so too will some form of microcomputer be accepted in less than one full generation. Experiments already are well-advanced in Japan and Ohio that demonstrate the power of cable TV/telephone/microcomputer systems. Children growing up in those homes are less likely to experience the trauma of many adults when faced with the computer age.

Computers are reshaping our lives at a rapid pace: plastic credit cards and their telephone/computer checking system are an accepted part of life today; airline reservations are computerized; billions of dollars are transferred monthly between banks—not by armored car but by computer transfer; letters are drafted on word-processors where corrections can be made readily before final typing; automobile ignition systems depend on small computers to monitor and control the flow of fuel. These are but harbingers of future changes. Toffler, in his recent book *The Third Wave* (1980), projects the electronic cottage as a future common place. Goods can be ordered and paid for; news items selected from a potpourri of possibilities on the evening broadcast (rather than the preprogrammed, singular, sequenced, and condensed evening TV news of today); letters typed and proofed on a word processor, then transmitted via phone lines to their destination; elections held and results announced almost immediately; and children studying at home.

The school as we know it may not exist. There may be testing centers and socializing centers. There may be curriculum production centers and tutorial centers. There may be, as Boulding (1980) proposes, inventories of the knowledge and skills of everyone in the community, with students studying with appropriate persons through interactive computers. Through similar processes, scholars and learners could keep in touch with counterparts throughout the world.

That world may seem strange to us now, but certainly no stranger than life and values of today would be to a Kansas farmer at the turn of the century. But society and individuals grow into a new culture, transform technology and that culture, and are transformed by them. Even in the dizzying blur of social change, the young will continue to accommodate to the new reality. There is nothing eternal about any particular culture—even the one in which we currently live.

2. *Schools will change, or cease to exist.* Because schools have been

assigned by society the task of translating cultural values to the next generation, they tend to be conservative in approach, content, and values. Innovations and radically new practices seldom grow directly from such institutions. When advocates of rapid change make their mark on school policy or practice, pressure builds from groups with more fundamental beliefs that force their position back toward more conservative postures. The experimental science, mathematics, and social science programs of the sixties were followed by back-to-the-basics in the seventies. The rise of academicians as determiners of school curriculum content led to the rise of consortia. Teacher shortages led to increased preparation programs, to teacher oversupply, to massive publicity, and then to teacher shortages.

In the preceding section, several potential impacts on schools were suggested. These will be resisted. But schools will change; they must. The microcomputer will be integral to that shift—not alone, but in conjunction with the videodisc, TV, telephone, and other advanced technologies.

3. *The impact of microcomputers is not limited to schools.* Television provides a parallel to help understand this notion. Television in the home has impacted the values and perception of youth to a greater extent than television in schools. Educational television has suffered from inadequate budgets, weak visual and auditory messages (talking heads, lectures), and inappropriate ties to curriculum and child development. As a social intervention, it compares poorly with commercial TV's fast-paced drama, instant news, football with instant replay for clarification and analysis, and thirty-second commercials.

The parallel with microcomputers is obvious. Microcomputers will become integral to the lives of people, and schools must base instructional programs on pragmatic realities. Schools must learn to cope with this new reality, use it, build on it, not be cowered by it. Children will grow up with computers, considering them as natural parts of their lives. Teachers will learn to interact with home microcomputers in ways similar to those of teachers today who use Sesame Street and the National Geographic Specials on TV as bases for instruction. Individualized, linked with other technologies, and interactive, the microcomputer broadens the concept of learning so as to provide powerful alternatives to current school practice.

4. *Schools have a dual responsibility: teach children and youth how to use the microcomputer and use the microcomputer to teach children and youth.* In the coming years, both uses of microcomputers will become more sophisticated. Its use will be considered routine, casual, integral, necessary to life and to teaching.

5. *Microcomputers as entertainment may enhance instruction.* The

parallel with television again is obvious. TV is viewed by most people as basically a means of entertainment, not education. Such was its first role, and its major one today. Microcomputers, too, are being used as much in electronic games of physical and intellectual skill as in purely educational contexts. The inherent interest and challenge in gaming poses a challenge for educators seeking more effective ways to engage students in higher-order cognitive processes.

6. *Microcomputers are limited because they do not process feedback effectively.* This is a basic flaw in most computer-assisted instructional systems to date. They are not able to process nonverbal effective feedback from learners and use these data in modifying instruction. They cannot give emotional support despite the pseudo-warmth often programmed into the interaction ("good job," "Hello, Tom, are you ready to study arith

Instructional materials dev r computer use must be much more precise and comprehensive than materials handled by teachers. Teachers use student verbal and nonverbal feedback to alter plans. Developing adequate computer-based instructional programs is far more complex because of this need for lack of ambiguity and the lack of noncognitive feedback. One of the problems facing the profession today is the dearth of even adequate, much less exquisite programs. Inadequately tested materials are flooding the market.

7. *Students are not machines.* Yet, many instructional processes appear to treat them as such. Some advocates, enthusiastic about the potential of the new tool, appear to consider the computer *inherently* as valuable rather than valuing what it can do for people. Dede (1979) warns us of the dangers of the "computer chip" mentality where children are trained to be machines.

The danger for many persons who are deeply immersed in technology is translating problems into algorithms or problem statements that are solvable through computer programs. While such a process may provide a more powerful data-cruncher, it is no substitute for intelligence nor for conceptually-oriented problem solving.

The Power

Despite the caveates listed in the previous section, thoughtful and innovative educators are finding the challenge of the microcomputer revolution, its vibrancy, and its potential to be invigorating and promising. It has the potential for freeing education from mass schooling where everyone learns virtually the same things in the same sequence.

It has the potential, too, of linking schools and society, schools and home, schools and the work place as no other technological advance has. The "synergistic linkage of communication and computer capabilities makes possible bookless libraries, paperless news (teletext), teleconferencing, portable language translators, and campusless and professorless universities—among myriad other mind-bogglers (Shostak, 1981, 357)."

Of such is the challenge and the promise of the 1980s. For educators, the watchword is drawn from a thousand-year-old Plains Indian culture: "Less thunder in the mouth; more lightning in the hand."

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Computerese Dictionary

Compiled by Dave Garner
Jefferson Junior High School, Oak Ridge, Tennessee

APPLE — A powerful microcomputer manufactured by Apple Computer Co. California.

ACRONYM — A word made from the initial letters of a phrase. Example: BASIC for Beginners All-purpose Symbolic Instruction Code.

A/D — Analog to digital.

ADDRESS — That which designated the location of information in a computer's memory.

ARRAY — Items of information arranged so that each one has a unique number.

ASCII — Acronym for "American Standard Code for Information Interchange." A common form of character transmission by computers.

ASSEMBLER — A program that translates Assembly language into machine language.

BAUD — In common use, a measure of the amount of information transmitted in a given amount of time.

BINARY — Numbers in base two and represented by ϕ and 1.

BUG — An error in a program.

BYTE — A collection of bits-8 bits.

BIT — The smallest amount of information that exists 1 or ϕ, off or on.

CENTRAL PROCESSING UNIT — The part of a computer that executes instructions. The brain of a microcomputer.

COMMAND — An instruction to a computer that is executed as soon as it is given.

COMPILER — A program that translates a higher level language into a lower level language.

CPU — See Central Processing Unit.

CRT — Cathode ray tube or TV set used to monitor a computer output.

DATA — Information.

DISK — A circular device that looks somewhat like a floppy 45 RPM record and serves to store computer data for quick recall.

DISKETTE — A small circular device used to store data. Sometimes called a disk.

DISK DRIVE — A small box used to read and write programs on a diskette.

DOS — Abbreviation for "Disk Operating System."

FLOPPY DISK — Same as a diskette.

HARD COPY — Information printed on a printer.

HARDWARE — Physical parts of a computer.

IC — Integrated Circuit abbreviation.

INTERPRETER — A program that allows a computer to directly run a program written in higher language without compiling it.

KILOBAUD — One thousand baud rate for transmission of computer data.

LOAD — Command to put a program from storage on tape or disk into computer memory.

MEMORY — Part of computer that stores programs. Found in RAM Chips.

PEEK — Computer command used to program in assembly or machine language.

POKE — Computer command use to program in assembly or machine language.

RAM — *R*andom *A*ccess *M*emory, used to store computer programs.

ROM — *R*ead *O*nly *M*emory, used to store and control the language the computer understands.

RUN — Command to execute program stored in memory.

SUBROUTINES — Used in computer language as a way of repeating instructions to save time and memory space.

TRANSLATOR — A program that converts one high level language into another high level language.

ZERO -- ϕ

EDUCATIONAL COMPUTING RESOURCES

Gary Marchionini

...ollowing resources are by no means exhaustive. The emphasis is on non-static resources, i.e., periodicals and organizations. The bibliography is very select because the technology is evolving so rapidly that printed materials become obsolete very quickly.

RESOURCE PROJECTS

MINNESOTA EDUCATIONAL COMPUTING CONSORTIUM (MECC)

MECC is a statewide organization of educational institutions which coordinates computing activities of member systems and serves those systems by supplying hardware and software at wholesale rates and training and consultation. MECC markets Educational Software at reasonable rates.

Contact: MECC
2520 Broadway Dr.
St. Paul, Minnesota 55113
(612) 376-1122

INTER – Informal Network for Technological and Educational Research

INTER is a network of Teacher Centers for sharing and exploring research on educational software.

Located at: Educational Development Center
55 Chapel Street
Newton, Massachusetts 02160

TABS – PROJECT

TABS is an Education Department funded project at the College of Education at Ohio State University. The purpose of the project is to develop, collect and disseminate exemplary mathematics curricular materials in which computers and other information processing technology are used.

Contact: Suzanne K. Damavin
TABS Project
ARPS Hall 202-A
1945 N. High St.
Columbus, Ohio 43210

MICROSIFT

MICROSIFT is an NSF-funded project located at the Northwest Regional Educational Laboratory. MICROSIFT's purpose is to act as a clearinghouse for microcomputer K-12 instructional software and information. Member organizations will collect, evaluate and disseminate instructional software.

Contact: Don Holznagel
MICROSIFT
500 Lindsay Bldg.
710 S.W. Second Ave.
Portland, OR 97204

REGION IV EDUCATION SERVICE CENTER

Region IV is one of twenty state funded regional organizations in Texas. The center offers a wide range of support to member schools. Region IV provides computer support by supplying training, wholesale hardware rates, and participates in the MICROSIFT software evaluation project.

Contact: Pat Sturdivant
Region IV Education Service Center
P.O. Box 863
1750 Seamist St.
Houston, TX 77001

DATASPAN PROJECT

DATASPAN has recently been funded by NSF to assemble resource materials, programs, information files, and other media for resource people concerned with science education. Print and non-print resources are expected for 1981-82 academic year.

Contact: Dr. Karl Zinn
University of Michigan
109 E. Madison
Ann Arbor, MI 48104

ASSOCIATION FOR EDUCATIONAL DATA SYSTEMS (AEDS)

AEDS is a professional organization for educators interested in the application of computers and technology in teaching and learning. A journal, monographs, a newsletter and conferences are benefits of membership.

$30.00/year dues

Contact: AEDS
1201 Sixteenth St. N.W.
Washington, D.C. 20036

NEWSLETTERS, JOURNALS, MAGAZINES

Classroom Computer News — 1 year $9.00
Box 266
Cambridge, MA 02138

Creative Computing — 1 year (12 issues) $15.00
P.O. Box 789-M
Morristown, NJ 07960

The Computing Teacher — 1 year $10.00
c/o Computing Center
Eastern Oregon State College
LaGrande, OR 97850

Personal Computing
1050 Commonwealth Ave.
Boston, MA 02215

TRS-80 USERS

CLOAD Magazine
P.O. Box 1267
Coleta, CA 93017

80-U.S. Journal
3838 S. Warner St.
Tacoma, WA 98409

TRS-80 Microcomputer News
700 One Tandy Center
Fort Worth, TX 76102

Softside
P.O. Box 68
Milford, NH 03055

APPLE USERS

Apple Orchard
International Apple Corps
P.O. Box 976
Daly City, CA 95017

Softalk
Softalk Publishing Inc.
10432 Burbank Blvd.
N. Hollywood, CA 91601

PET USERS

Cursor
Box 550
Goleta, CA 93017

PET User Notes
PET User Group
P.O. Box 371
Montogmeryville, PA 18936

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Appendix

Teacher Centers' Computer Technology Conference

Planning Groups

Executive Committee	Sally Vogel, Director, Mid-Coast Teacher Center, Camden, Maine; Teacher Center Director Liaison; Committee Coordinator
	Jack Turner, Project Director, B.E.S.T. Teacher Center, Eugene, Oregon
	Rick Krueger, Director, Staples Teacher Center, Staples, Minnesosta
	Charles Lovett, Teacher Centers Program Office, Federal Government Liaison
	W. Robert Houston, Professor and Associate Dean for Research and Faculty Development, College of Education, University of Houston; Director, Houston Area Teacher Center; Houston Liaison
	Edward Damburch, R.I. SEA; Director, National Teacher Center Resource Center; SEA Liaison
	Vincent Gazetta, Director, Division of Teacher Education and Certification, New York SEA, Albany, New York; SEA Liaison
Management Strand	Jack Turner, Project Director, B.E.S.T. Teacher Center, Eugene, Oregon; Strand Coordinator
	Marge Curtiss, Director, Western Nebraska Rural Teacher Center, Sidney, Nebraska
	Robert Richardson, Director, French River Teacher Center, Oxford, Massachusetts
	Steve Kingsford, Director, Ventura County Teacher Center, Ventura, California

Dennis Spuck, Associate Professor and Chair, Department of Administration and Supervision, College of Education, University of Houston; Houston Liaison

Charles Lovett, Teacher Centers Program Office; Washington Liaison

Instruction Strand

Rick Krueger, Director, Staples Teacher Center, Staples, Minnesota; Strand Coordinator

Jinx Bohstedt, Director, Oak Ridge Teacher Center, Oak Ridge, Tennessee

Lessley Price, Director, Norman Teacher Center, Norman, Oklahoma

Linda Roberts, U.S. Department of Education Fellow; Washington Liaison

Barbara Sadowski, Assistant Professor and Director of the Research Center, College of Education, University of Houston; Houston Liaison

Information Strand

Sally Vogel, Director, Mid-Coast Teacher Center, Camden, Maine; Strand Coordinator

Myrna Cooper, Director, New York City Teacher Center Consortium, New York, N.Y.

Ann Spindel, Director, Teacher Center of Ardsley, Greenburgh and Elmsford; Hartsdale, New York

Joseph Carbonari, Associate Professor, Foundations of Education, University of Houston and Associate Professor, Baylor College of Medicine, Houston, Texas; Houston Liaison

Cheryl Chase, National Institute of Education, Washington, D.C.; Washington Liaison

Cluster Representatives

New England, Sally Vogel, Cluster Representatives Coordinator

Middle Atlantic, Ann Spindel

Southeast, Jinx Bohstedt

Southwest, Lessley Price

Midwest, Rick Krueger

Northwest, Jack Turner

California, Steve Kingsford

Houston Planning Team

W. Robert Houston, Professor and Associate Dean for Research and Faculty Development, College of Education, University of Houston, Houston, Texas; Coordinator

Lynn Hale, Director of Curriculum, Region IV, Education Service Center, Houston, Texas

Pat Sturdivant, Coordinator of Computer-based Instruction, Region IV Education Service Center, Houston, Texas

Ronnie Veselka, Assistant Superintendent for Research, Houston Independent School District, Houston, Texas

Marcy Kirks, Director, Professional Development Center, College of Education, University of Houston, Houston, Texas