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ABSTRACT

Changes in several technologies that handle, manipulate, and transmit information and ways in which these technologies are affecting businesses and homes are discussed in this paper, which also addresses the potential impact of these changes on public education. The first of four sections provides a very brief history of the computer revolution, with emphasis on certain salient characteristics of the devices and on their penetration into business, industry, and the home. The second section describes how schools have responded in recent years to the computer revolution and--based on interviews with school personnel--speculates how computers will be used in schools in the future. The third section describes some of the newer technological developments, including trends in microcomputer hardware and software, home information systems, integrated videodiscs for information storage and instruction, and computer conferencing. The relevance of these developments for education is discussed, and the final section proposes an agenda for federal involvement in the computer revolution. (THC)

COMPUTERS AND THE SCHOOLS: THE NEXT DECADE

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INTRODUCTION

This country is in the midst of a revolution in the way information is handled — information for decision-making, entertainment, transacting business, training employees, and educating the populace. New devices to handle, manipulate and transmit information are appearing at an astonishing rate. Far from being esoteric devices for a select few, they are being purchased for use in businesses, homes and schools with the expectation that they will enhance productivity.

This paper describes changes in several technologies and discusses how these are affecting businesses and homes. The argument developed here is that the changes will have an impact on public education in two ways. First, to the extent that social and commercial activity of the adult world is permeated by these new technologies the demand will be placed on schools to incorporate these same devices in the curriculum so that children will be prepared for the future. Similarly, as information handling skills become more important in the conduct of business, schools must respond with instruction in the uses of information. Second, instruction in the public school classroom is a complex collection of pedagogical activities, including teaching facts, developing intellectual skills, motivating students, etc. Many of the new devices can handle some of these tasks very effectively — in a few cases better than a teacher. At a time when there is well-publicized dissatisfaction with schools, and the cost of education is seemingly at the limits of what is possible with the tax dollar, schools and parents alike are open to exploring a technological alternative for some portions of instruction.

The paper has four parts. The first provides a very brief history of the computer revolution with an emphasis on certain salient characteristics of the devices and on their penetration into society. The second section describes how schools have responded in recent years to the computer revolution and — based on interviews with school personnel — speculates how computers will be used in schools in the future. The third section describes some of the newer technological developments, including trends in microcomputer hardware and software, home information systems, integrated videodiscs for information storage and instruction, and computer conferencing. The relevance of these developments for education is discussed. The last section proposes an agenda for federal involvement in the computer revolution.

THE COMPUTER REVOLUTION

Computers of all forms are rapidly making their appearance in every sector of American life. Their presence is influencing the expectations of parents and others in the community regarding the value and importance of computers in the schools.

The Computer in Business and Industry

The business world has used computers for several decades. Large main-frame units have been essential for accounting and inventory management. The emergence of the microcomputer has had an impact in two ways. Small firms now have the same access to computing power for accounting and inventory that once was reserved for very large corporations. But firms of all sizes have discovered the apparent advantages of computers for word processing, financial planning and — with networking — electronic information exchange. In the early 1970s word processing was available only on expensive dedicated machines such as the IBM MTST (Magnetic Tape Selectric Typewriter). This meant that most organizations with word processing had it as a central service run by a few trained professionals while the rest of the company's secretaries used standard typewriters. This situation is changing rapidly. In 1990 it is projected that in American businesses there will be 35 million work stations, most of which will be for word processing and electronic exchange of information.[1]

In the 1970s there were virtually no electronic message systems in business; in 1983 there were 225,000 electronic mailboxes for business customers and another 175,000 for private customers. There are several popular information utilities that provide data bases essential to the conduct of some business. Consider the growth of the three biggest information utilities between 1982 and 1984. Dow Jones News Retrieval: 70,000 subscribers in 1982 up to 150,000 in 1984. CompuServe 40,000 up to 110,000; and The Source: 40,000 up to 60,000.[2]

Teleconferencing is also joining corporate life. In 1981 there were 575 teleconferencing rooms in the United States; it is projected that by the end of next year there will be 4,000.[3] A recent survey of the Fortune 500 companies ascertained that 85 percent of them plan to install and use such facilities soon.

In short, the way workers are handling information in the white collar sectors of society is changing drastically. Almost daily these workers are seeing the tools of their jobs change. Many of them in turn interface

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[1]International Data Corporation. 1983 Information Processing Industry Briefing Session. Framingham, MA: International Data Corporation, 1983. As cited in, Rice, R.E., and Associates. The New Media: Communication, Research and Technology. Beverly Hills: Sage, 1984.

[2]Rice, et al, op cit.

[3]Quantum Science Corporation. Report on the Teleconference Market. NY: Quantum Science Corporation, 1981. As cited in Rice, et al, op cit.

with the public in a way that utilizes the same technologies. An insurance claim is processed by a human clerk, but the clerk is only a conduit for a computer which designates the appropriate questions and receives the responses. After normal business hours, a Sears phone-order customer will have the order taken by a machine with an automated voice. Bank customers can get case from their account using an Automatic Teller Machine.

White collar workers and the consuming public are not the only ones that have felt the impact of the computer revolution. The newer plants in heavy industry have all added computerized components to improve efficiency beyond what was possible with mere human judgment. As an example, the newest General Motors plant in Lansing, Michigan, is heavily computerized from inventory to production. The line workers come into direct contact with computers. They make production decisions on the plant floor with the help of a personal computer; these are decisions that once were the purview of supervisors. At certain divisions of AT&T all repair orders are computerized so that a repair person gets assignments directly from the machine, not from a supervisor. Auto mechanics at Ford dealerships get training in the repair of new products by sitting at an integrated microcomputer-videodisc training system. Training is provided in the same fashion for employees of other corporations with geographically dispersed employees — Digital Equipment Corporation, American Airlines, J. C. Penney, and Sizzler to mention a few.

Whether one looks at workers or consumers the computer in its many manifestations is coming to be an integral part of the fabric of American life. This fact can have a profound effect on people's perception of the skills that are important for success in both today and tomorrow's world. Parents want their children equipped to succeed in this new world. Most parents, themselves overwhelmed by the changes, will look for the training to come from the school.

The Computer in the Home

Information technologies have been invading the home as well. The microcomputer is one of the most visible manifestations of this. It is estimated that five percent of the homes in the U.S. have some form of computer (although currently the majority of these machines are capable of little more than playing games). Responding to a variety of motives, consumers purchased low-end machines at a growing rate during the early 1980s. Purchases of medium power personal computers (Apple II, IBM PC, Commodore 64, and Radio Shack TRS-80) have been justified largely by by their educational promise. The ultimate target of most purchases of these machines has been the children in households. In the last two years computer manufacturers have used a number of catchy ads to suggest that parents who get their children a computer will be providing them with the academic edge. More recently, the capabilities of word processing, spread sheets, and financial management have begun to open up possibilities for adults as well. (The home computer market weakened in the last quarter of 1984 and the first quarter of 1985. Its future is less certain at the time of this writing.)

Videogames have gone from unknown status in the mid 1970s to a sizeable industry. In 1982 revenues from videogames (arcade plays and software sales) and other computer software accounted for seven billion dollars in gross revenues. This figure was higher than the combined revenues from all audio products: radio programming, records, and tapes. Much of the revenue can be accounted for by arcades, videogames are a part of the fabric of life for many children. (Revenues from videogames did fall in 1984, suggesting some softening in this area.)[4]

Thanks to the microprocessor, new "computerized" consumer products are becoming quite popular. The simple phone has given way to a sophisticated controller which can hold and forward calls, notify protective services of fire or burglary, transfer funds from one's own bank account to that of a merchant or call for emergency medical aid. Add to the phone other products which have been "computerized", such as thermostats, auto engines, and microwave ovens.

The videocassette recorder has become a fast-selling item. It not only enables people to record off-air for later viewing, but it has opened up a whole new market of viewer-selected offerings available from video rental stores. These stores stock almost exclusively pre-recorded movies, but recently the videocassette market has had new entries in the educational arena. The subjects have included Spanish, home repair, exercise, first aid, cooking —even how to watch football.

As new uses of video come along the hardware manufacturers are responding by producing more integrated products. It is now possible to get a console with the television, VCR, stereo, and telephone integrated into a single unit controlled by a wireless remote control. The television is of the new type that is in effect a video receiver which can be used for standard television broadcasts and as a monitor for a home computer. More about this development later.

The growing presence of computer-based — or more properly microprocessor-based — technology creates an acceptance and even an expectation that the computer can and should deliver many valued services to the home. Education — both traditional public schooling and continuing education of adults — is a valued service. The climate is there for the public to expect that computers have a role to play in education.

COMPUTERS IN THE SCHOOLS

What has happened in the schools during this revolution? How have they responded, and how have teachers and administrators assessed this response? What does their assessment and plans tell us about the future?

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[4]Booz-Allen & Hamilton, Inc. Information Industry Insights, Issue 9, 1984.

Two recent studies provide insights on these questions. Henry Becker at Johns Hopkins University completed a national survey of schools in 1983.[5] Jerome Johnston and his colleagues at The University of Michigan and Far West Labs completed five case studies of middle school use in 1984.[6] This section builds on these studies. The survey provides statistics about national distribution; the case studies enrich the survey data and add the perspective of future use by extrapolating from the assessments and plans of teachers and administrators. Although Johnston's study focussed on middle schools, the findings regarding expected future uses seem applicable for elementary and senior high schools as well.[7]

Today: The Middle School as Prototype

The Becker survey indicates that between 1980 and 1983 the percentage of public schools that purchased a microcomputer increased dramatically. Among all U.S. elementary schools the growth was from six percent 1980 to 42 percent in 1983. Senior high schools grew from a base of 10 percent to 85 percent. For middle schools and junior highs it was from less than 10 percent to 68 percent. What accounts for these dramatic increases? What role do microcomputers play in the educational process? Will this role evolve as teachers and students gain more experience with them? Will schools continue to purchase microcomputers at the rapid rate seen in the last few years?

The middle school case studies suggest these dynamics. Typically the machines were acquired quite recently, several years after the senior high and elementary schools in the same district. The acquisition of sufficient machines to have an articulated program for student use probably occurred in the 1983–84 school year — perhaps one year earlier. The most common use of machines is in an introductory course about computers. Such courses vary in content, but all of them familiarize students with machine operation (e.g., insert a disk, load and run a program, clear the screen, and enable the printer). Beyond this the courses vary widely in how much they cover on the uses and applications of computers in society, and how much they emphasize mastery of programming. The courses last anywhere from two to twenty weeks. Other types of microcomputer use — drill and practice, word processing, or other tool uses — are very rare, except in schools serving large numbers of underachieving minority students. Here they are frequently used for drill-and-practice in basic skills.

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[5]Henry Becker, School Uses of Microcomputers. Baltimore: Johns Hopkins University, Center for Social Organization of Schools. 1983.

[6]Jerome Johnston, Richard Luker, and John Mergendoller, Micros in the Middle School: A Snapshot in 1984. Bloomington, IN: Agency for Instructional Technology. 1984.

[7]An earlier version of this section of the paper appeared in the January, 1985 issue of Educational Technology.

How did a school's pattern of use come into being? It is likely to have been the result not of carefully planned curricular policy, but of initiatives made by one or more "product champions" or computer hobbyists on the staff, aided by a supportive administrator. Obviously these champions play a key role in educating students about the microcomputer.

What about the majority of staff who are unfamiliar with micros? How do they feel about computers in the school? They are almost universally supportive of making students computer literate — teaching them about computers and even teaching them a limited amount of programming skills. They express ambivalence, however, on the issue of using microcomputers as an instructional tool in a subject matter area. A common reason offered for this stance is lack of sufficient equipment; but equally important reasons appear to be personal ignorance of how specifically a microcomputer might be used. Few teachers own a microcomputer or even know how to use one. Almost none of them were exposed to microcomputers in their teacher training. They have not been exposed to computerized aids for teachers such as grade book managers or test construction programs. Similarly they haven't viewed useful software for their subject area, whether it be drill-and-practice programs, simulations, or tool software such as word processors or data base managers. School administrators and boards of education insist that computers be objects of instruction and these teachers support this notion. But few districts have urged their teachers to use computers as tools for instruction.

One further reason many teachers are hesitant about computers is the challenge they pose to existing instructional routine. An experienced teacher has a repertoire of tried-and-true lesson plans and well-honed classroom management techniques. Lectures, recitations, seat work, and occasional small group projects have worked smoothly over the years to maintain classroom order among 25 to 30 students. These teachers wonder how they would use just a single machine if they had it. As an electronic workbook, could they use it with the whole class like an overhead projector or movie? If only a few students use it at a time, which ones would it be? When it is used as a tool — as a word processor, for example — it is a novel device with the same problems. Every child has a pen and pencil, and occasionally a student will turn in an assignment that has been typed. But there seems to be no compelling educational reason to have all students do some of their text creation on a word processor when they don't even know how to touch type. Little wonder, then, that faculty can feel positive about training the next generation to be familiar with the new technology but ambivalent about using it themselves to augment their instructional repertoire. (More details on the response of staff to microcomputers can be found in Johnston, et al, 1984.)

Looking to the Future

What's in store for the future? The meteoric rise in microcomputer hardware and software acquisition that we have already witnessed will likely continue, but the way microcomputers are used in schools will change. Computers are already deeply imbedded in the fabric of American business, commerce, and entertainment, and promise to become even more so. Parents, administrators, and teachers alike believe that being familiar with computers is important for survival. It is proving so in their own lives,s and they want today's youth to be prepared for a world that's permeated by microprocessor technology. This societal demand will fuel additional purchases until, in each school, there are sufficient machines to fill at least one classroom so that each student in the computer literacy class can be assured of a machine for personal use during class time.

The decline of literacy and programming courses. The use of microcomputers in middle schools is going to change; the same will be true of senior high schools. Today the most common use of microcomputers is in a unit or course on computer literacy. More and more, such literacy is being acquired in elementary schools and at home. As this happens, the middle school computer literacy course will outlive its usefulness.

One middle school in the Midwest serves as a case in point. A computer literacy course consisting of two components was developed in the summer of 1983. One part of the course was designed to acquaint students with machine operation; the second was to develop their skills in writing BASIC programming code. In September of that year, the staff responsible for the course introduced it with great pride. It represented a very advanced offering for a middle school whose curriculum had never before included any type of computer training. Eight months later, they were bemoaning its inadequacies — not because the instruction was inadequate for the goals, but because the goals were no longer appropriate. The instructors were questioning whether learning BASIC was a good use of student time, and they were beginning to see that other uses of the microcomputer were more appropriate. These uses included more instructional programs for core curriculum courses such as English and science, and more tool uses such as word processing.

Schools vary in how much programming instruction they provide in their literacy courses. All of those visited for the case studies include minimal exposure to microcomputers, but many schools go well beyond. Those with lengthier introduction-to-computer courses devote most of the course to BASIC programming; others have a separate semester-long course as an additional elective. This emphasis on programming will change for two reasons. It is no longer important for a user to be able to program a computer. The most useful applications are available as software for purchase. These "canned" programs perform their intended operations much more elegantly than programs developed by a novice programmer. The cost of software will decline rapidly in the coming years through more economical distribution and — for school districts — low-cost licensed distribution of multiple copies. A second reason is the recognition that programming as a vocational skill is best taught at the high school level — a point closer to entry into the job market. Programming languages are evolving and rudimentary skills in BASIC will not long be considered useful.

If the most prominent current uses of microcomputers are going to disappear, what will drive their continued use? Teachers will discover a variety of applications that will prove very useful in their job. They will discover that microcomputers with the proper software motivate the students, provide important instruction, and help manage the classroom.

Microcomputers as tools for teachers. A microcomputer is a tool for teachers and administrators. The software exists to manage grade books; to format, print, and score tests; and to create memos to students and parents. Teachers who have used them this way find the machines more useful than any other instructional aid to date. Instructional television and overhead projectors can augment instruction, but they cannot help the teacher with the many clerical tasks that are a part of the teacher's job. Administrators, as well, are finding that the same micros, equipped with many of the same software tools, are helpful in their jobs. Word processing is the most obvious, but spreadsheet and data base management programs are tremendous timesavers when applied to budgets and inventory. Other programs alleviate class scheduling problems. It is the utility of a microcomputer to the managers of instruction that will keep this device in regular use and demand in the school. In most of the schools we visited, at least one teacher or administrator was using a microcomputer in this way. It takes only one per school to provide an example for others.

Microcomputers as student motivators. Complementing this kind of utility is the capacity of the microcomputer — however it is being used — to hold the attention of students. Wherever microcomputers are in use, they have an intrinsic fascination for both students and teachers. This is not lost on teachers and administrators who appreciate what microcomputers can add in terms of variety and interest to what is otherwise a fairly unexciting and predictable daily routine in schools. In the inner-city school in the AIT study microcomputers were being used for drill-and-practice with low-achieving students. In this application microcomputers captured student attention and, according to teacher reports, contributed to building important skills in computation, identification, and discrimination. While the effects were most obvious with students in need of basic skills remediation, a similar phenomenon was observed in classes composed of students achieving at average levels. Even among teachers who were not using drill-and-practice there was an almost universal expectation that drill-and-practice software exists that will help them in their classes, no matter what the subject matter. Assuming the software will be developed, and that sufficient machines will be available, teachers will look forward to using them.

Microcomputers as tools for students. The more innovative applications of microcomputers include word processing and data base management. It will be quite some time before these will become commonplace in the classroom. We observed a few teachers using microcomputers as tools to enhance their instruction. For example, in an algebra class studying linear equations, students entered their formulae and the results were displayed graphically as a check. It is apparent that at least a few teachers are using word processing programs, data base management programs, and spreadsheets in imaginative ways in English, social studies, math, and science. However, these tool uses pose a greater challenge, in that they require teachers to manage the classroom differently. Word processing challenges the supremacy of the pen and pencil. What can be done if there are only one or two machines available? Which students will enter or edit their text first? Using data base management programs may be a creative way to get students to enter and retrieve social science data like real social scientists, but the middle school curriculum calls more for learning the facts of history than drawing inferences from raw data. A similar case can be made for high schools, although there are a few more possibilities here. In early returns from his 1985 survey Becker (personal communication) is finding some examples in the vocational area. In agricultural regions it is not uncommon for students to be getting practice estimating feed requirements using a program for this purpose. Some high school drafting classes use CAD/CAM software. A few chemistry teachers indicate that they are using some simulation software. In general, though, what tool uses are being used are likely to be those that draw directly from the non-school world. They are used to demonstrate to students how the business world uses computers. This is not the same as adopting tools for general instruction in writing or social science.

It is possible to argue for a different scenario. Other electronic gadgets for education, such as television and computer-assisted instruction (the CAI of the 1960s), were characterized by an initial surge of enthusiasm. But when they failed to fulfill the educational promise, they fell into disfavor. They did not disappear, but they never became universally employed as educational tools. There were reasons for this. The CAI of the 1960s depended on a costly central computer. The graphics were of only fair quality and the response time slow. Television is a good medium for presenting visual material, but it is limited, among other things, by being a one-way technology.

The microcomputer is different. One part of the argument rests on the utility of microcomputers to help teachers and administrators with the administrative aspects of their job. These software tools already exist and seem of high quality. A second part rests on the widespread expectation of teachers that tutorial software exist which will help below- and above-average students and leave the teacher more time to spend with students in the middle. At present, enough teachers are finding enough good software to keep the promise alive. The scenario of expansion depends on the software industry continuing to release more and more instructional programs that will meet needs in every subject area. Given the potential for profit, the software will appear. The necessary conditions for developing quality software are discussed later.

Barriers and facilitators. The optimistic scenario will not proceed in all schools at the same rate. Adoption and implementation depend on several enabling conditions. First is a local product champion. Where a small number of computer enthusiasts were found in the AIT case-study schools, new applications were being tried regularly. Most important, the natural processes of contagion were reaching those who were not naturally disposed to microcomputers. Some districts that want to encourage the use of microcomputers have tried formal district-level programs to introduce teachers to computers. The more successful ones have tied incentives to teacher participation. In one district a school building receives a new computer every time three teachers attend the training.

Clearly, a school must have sufficient numbers of machines with the capabilities to take advantage of the most popular software. Whatever the "sufficient" number is, it is larger than most schools currently have. Securing additional machines is an interesting interplay between "product champions" (teachers and parents alike) who create a demand, and creative administrators who figure out ways to manipulate budgets so that funds for hardware and software are found even as longstanding line items are being cut in these lean times. The downward trend in the price of hardware (see next section) will make it much more likely that schools will buy larger numbers of machines. But the community support for school-based computer literacy is the key factor influencing purchases.

The definition of "sufficient" is relative. It depends on the flexibility and creativity of staff. It depends on teachers developing a vision of ways to use just a few machines with many students. Most teachers tend to think of computers in one of two ways: like movie projectors, where one is sufficient for an entire class, or like pencils, which must be supplied to each student in a class. While one microcomputer or 30 can be useful for instruction, there are many configurations in between. There are a variety of ways that the vision can be provided. One way is to have informal sharing in school buildings. Another is to have more structured opportunities through the district, professional meetings, college courses or television programs. Learning the operation of a microcomputer requires hands on training, either with a colleague or in a course. But learning how to deploy a computer creatively in the classroom often requires little more than seeing another teacher doing it effectively.

Several structural factors can affect the rate of adoption. The current popularity of computer literacy courses — courses about computers — may initially hinder but ultimately help expand instructional uses of microcomputers. On the one hand, the courses tend to identify microcomputers with a single specialty such as math, science, or even computer science. This tends to alienate teachers in other subject areas who don't see the applicability to their subjects and who may be jealous of the resources going to the so-called computer nerds in the school. On the other hand the courses get microcomputers into the school, permitting teachers in English and social studies to see the machines and observe the positive response of their colleagues and students.

NEW DEVELOPMENTS FOR HOME AND INDUSTRY

Many trends in the development of information technologies will have important ramifications for education, both at school and in the home. This section describes some of these and speculates about their educational impact.

Evolution of the Microcomputer

The microcomputer is rapidly evolving. The changes are all in the direction of making it a tool that will have increasing acceptance and use among the public. The years 1983 and 1984 saw dramatic changes that were largely unforseen only months before the changes were introduced. The most dramatic change was in the architecture of machines. In January, 1984, Apple introduced the Macintosh. Using a new microprocessor, the Motorola 68000 chip, Apple implemented the first large-scale commercial application of bit-mapping the computer screen. In practical terms this enabled software designers to make the operating system a more natural looking visual and physical environment. Instead of remembering complicated command language to instruct the microcomputer to format text, choose a typeface, or align a column of numbers, the user "points" to an icon which represents one of these functions and the machine responds instantly. The pointing is done with a "mouse," a device that is faster and easier for the novice to use than cursor keys. It is difficult to overestimate what this innovation contributed to making the microcomputer less intimidating and more attractive to the average non-user considering a purchase. The change was too revolutionary for other manufacturers to follow suit immediately. But Atari has adopted this architecture for its entirely new line of microcomputers being introduced in Spring of 1985, and other manufacturers have new products in advanced development which utilize this revolutionary architecture. Indeed, the new GEM operating system from Digital will allow software designers to emulate the MacIntosh on existing CPM and PC/DOS machines.

Another development is the exponential increase in the size of random access memory (RAM) available in all the newer microcomputers. RAM is the memory area used by microcomputers as their internal work area. It is measured in thousands of bytes, where the thousands unit is denoted by the letter K. An 8K machine has 8,000 bytes of work area. In 1982, when 8K and 16K RAMs were common, the question frequently heard among school-oriented computer buffs was whether a rare 64K machine was available to run novel software such as Logo. Today 128K machines are becoming the standard with 512K expansions quite common. In Atari's new line of low-cost computers 128K is the smallest amount of RAM available. We can reasonably expect that RAM capacity will multiply again in the coming year.

The significance of this development rests with what RAM does for microcomputer programs. Large amounts of RAM are required by sophisticated programs. This is particularly true of spreadsheets and wordprocessors, and some educational programming languages such as Logo. Larger RAM also speeds up processing time, and this is important in many intelligent instructional applications in which complicated instructional branches are necessary to match the mental processing time of a diverse population of learners. Larger RAM also enables software designers to build in better self-help overlays which make the software more user-friendly.

Local area networks are becoming available to link together groups of microcomputers. This can facilitate group applications of microcomputers. In schools, for example, a single hard disc with 10–15 megabytes can store a wealth of educational software as well as data on every child's progress in completing each program of instruction. The local area network enables multiple microcomputers to use the same hard disc, and the same printer as well. (The availability of networks will not necessarily lead to greater use of microcomputers by schools. They introduce a level of technological complexity which may inhibit many teachers and administrators.)

Hard discs have emerged as a viable reasonably priced storage medium. Two years ago the Winchester hard disc with 10 megabytes of storage was experimental and expensive. In January, 1985, Atari announced a 10 megabyte hard disc for under $600.

There are dramatic changes in the size and cost of microcomputers. The cost of existing machines is continually dropping. Consider that the Macintosh was priced around $3,000 at its introduction; it is closer to $2,000 a year later. New computers are being introduced that are smaller, less expensive, yet more powerful. The Apple IIc and IBM PCjr are examples of this point. Atari is introducing machines this year that are similar to the Mac, with the complete package (including printer, disk drive, and color monitor) reported to be less than $1,000. The entire line is built around the same microprocessor as the Mac (the Motorola 68000). The least powerful of the new line is the Model 130ST with 128K RAM. It will sell for less than $400. The prices of the dot matrix printer, disc drive, color monitor, telecommunications package and integrated software are each well below current standards. While it is easy to point to Atari because it is a feature in today's news, similar stories will be told in coming months and years.

The result is that microcomputing is becoming affordable for the average American household and the average school system as well. In 1983 Booz-Allen and Hamilton predicted that two percent of American households would have a high performance microcomputer in 1984 and 18 percent by 1990.[8] Using Becker's data on school computers from the same year it is easy to project a high-performance computer in almost every school by 1986, and multiple computers (say 12–24) as the average.[9] But these projections were made without knowing about the most recent hardware advances noted above. There may well be many more computers in every school by 1986.

Home Information Systems

Earlier, the evolution of home entertainment centers was described. Let's project this ahead a few years with the help of a strategic assessment study conducted by Booz-Allen. Thirty sponsors, ranging from AT&T and IBM to Metropolitan Life and Xerox Publishing, supported a study to determine public acceptance and desires for new kinds of technologies that were on the drawing boards of various manufacturers. Using a nationally selected sample of households, they exposed subjects in the study to a prototype of a future device and the services that might be available on it. The device included a touch sensitive TV monitor for display and data entry; computer-generated graphics, TV-quality still pictures and full sound-and-motion video. The device had 14 transactional and/or information-oriented services, including banking/bill paying, entertainment-ticket purchase, household budget, personal calendar, home monitor, vacation/travel information, learning games, news, shopping information (similar to what one might imagine as an electronic Sears catalog), electronic mail, classified ads, insurance and investment information.

[8] Booz-Allen & Hamilton, Information Industry Insights. Issue 7, 1983, p. 13. High performance denotes machines such as the Apple II series, Radio Shack TRS-80, and the IBM PC which are capable of functioning well above the videogame level.

[9] Becker, Henry J. School uses of microcomputers: Reports from a national survey. Baltimore: Center for Social Organization of Schools, Johns Hopkins University. 1983–84.

Based on the study responses and on their knowledge of new hardware and software being developed, Booz-Allen analysts project the following scenario.

In terms of hardware, we are currently in a phase of second generation computers and video equipment, symbolized by the higher speed and capacity microcomputers such as the IBM PC and the high resolution video recording devices. This phase will last through 1986. About that time there will emerge a third generation of equipment, characterized by several new capabilities similar to those described above in the prototype instrument used in their study. Importantly, these capabilities will be integrated into a single unit, much as can be seen in the recent trend toward integrated TV, video recorder, and stereo systems. Booz-Allen has labelled such a system a Home Information System, or HIS for short. It will enable consumers to purchase products, manage financial affairs, communicate with businesses and personal acquaintances, work and learn — all through an interactive TV set. Based on the survey results, to succeed, this new technology must be able to provide a number of diverse capabilities, including videogames, news, reservations, home banking, electronic mail, shopping, investments and insurance, home budgeting, tax preparation, home security, and learning. Just as the current wave of microcomputer purchases is fueled heavily by the motive to own a device that can help children learn, so the new integrated system is thought to require this same capability if it is to succeed.

Booz-Allen found that almost 80 percent of the households in their survey showed a "high propensity" to obtain the kind of system described above. "Conservatively interpreted, our market research and analysis indicate 10 million U.S. HIS households by 1990 and more than 30 million by the end of the 1990s."[10]

It has been noted that the recent boom in microcomputer sales has been fueled at least partially by hopes that it will meet educational needs of the consumer. Clearly, the software must become available which will at least partially meet this need if the learning goal is to continue to fuel computer sales. I will not develop a documented case in this regard; however it is my observation in reviewing software over the past few years that two generalizations hold. There is a lot of awful software being developed and distributed in the name of learning. Some of the factors that make software "awful" include these: The scope of the content is too narrow or fails to match common educational goals. The content never goes beyond rote learning of facts. The response time or content levels are not adjustable to the needs of a wide range of learner abilities. The graphics are unappealing, and the feedback regarding correctness of response is unrewarding.

But there is an increasing number of very good programs, both in the category of drill-and-practice and in the more creative domains such as simulation. Let me mention just one good example of learning software that represents an important departure; an example of what awaits us on the horizon. This is the *Voyage of the Mimi* developed as part of the Bank

[10]Booz-Allen, op cit., pp 3–4.

Street College Project in Science and Mathematics. It is a "multi-media" package in the new sense of the word. It is a dramatic television series (available by broadcast or videotape) which develops an intriguing adventure in which a group of children and adults go on a scientific voyage in search of whales. The crew is faced with a number of dilemmas related to navigation, whales and their environment, and ecosystems in general. All of these problems require computing, mathematics, and science to solve. There are four computer software modules to accompany the video. These simulations help learners integrate science and math concepts and help students learn about computers as they solve the dilemmas presented by the television drama. The important departure here is that two media -- video and electronic text -- are integrated in a way that draws on the strengths of each to reach the educational goals of the series. Video-based drama can motivate and provide important images better than the electronic text and graphics of computers. The computer software can provide the individualized instructional guidance which only electronic text and graphics can handle.

The importance of *Voyage of the Mimi* is what it suggests as new directions for the development of learning software which will fit the HIS system described above. Consider the already-available motivational video programs such as *Sesame Street* and *3-2-1 Contact*. These programs are regularly watched by youth and counted on by parents to both babysit the children and teach them valued lessons in things as diverse as letter recognition and scientific principles of flight. An integrated HIS system will have computer power built in. It is fully reasonable that software will be developed to accompany such popular television programs as *Sesame Street*. A program on the letter "A" could have an accompanying computer module giving a child a half-hour practice session built around this letter. A similar thing could be done for *3-2-1 Contact*, very much like what is already available for *Voyage of the Mimi*.

Emerging developments in the cable industry can alter this scenario in a way that could create a market for such software far more attractive to software developers than currently is the case. At present, the software is distributed largely through computer dealers. The volume is low enough that it is necessary to charge $25-$75 for a diskette. Add to the high price the problem of synchronizing television programming with software reinforcement modules and you come up with a market that is probably insufficient to galvanize much interest among software developers. There are two ways the situation could be altered. One is to do as Bank Street did with *Voyage of the Mimi*; sell the television show on videotape along with the computer modules. But this is a very expensive package. Alternatively, the software for a particular show can be transmitted directly to the home at the conclusion of the show. This potential currently exists in cable systems which operate a pay-as-you-see channel for premium movies or sports events. The same technology which sends digital signals to the home decoder is capable of transmitting a software module and charging the customer for it. If the cost was relatively low -- say $1.25 -- it could be sufficiently attractive to developers. *Sesame Street* regularly reaches into at least 10 million homes. If just one percent of the viewers had a HIS system and wanted to download the module it would generate $125,000 in gross revenue *for just one module*. A variation on this technology might emerge in which HIS would have not a powerful computer, but just a terminal. This could fit the same scenario. A user could dial into a computer which held the software and engage the program on-line. Either way, it is not unreasonable to expect that such dynamics will drive the development of this new kind of educational venture.

The several developments in the HIS arena will make home "infotainment" (as Booz-Allen calls the new kind of software mix) centers much more important to education, especially in families where the custodial function is important — families with single parents or both parents working. If this new educational amalgam is successful in teaching children knowledge or skills that parents value, these same families will put pressure on schools to either inject some of the same technology into the classroom, or allow this type of learning to take place in the school resource center outside the traditional classroom configuration.

Integrated Videodisc for Instruction

One of the most intriguing developments in educational software technology is the videodisc integrated with a microcomputer. It permits precise integration of high quality still or motion pictures with computer-based instructional software. At present the technology is very costly, but it holds great promise based on recent experience.

A videodisc resembles a long-play phonograph record. One side of a disc can hold 54,000 frames, either pictures or pages of text, along with an accompanying audio track. Each frame has a numerical address and can be retrieved and displayed on a TV monitor. The visual image and audio track are stored in billions of microscopic pits on the disc. Inside a videodisc player a laser beam translates these coded pits into sound and pictures. In contrast to film or videotape, the disc is almost indestructible. The pictures are of very high quality. A single frame or beginning of a sequence of frames can be retrieved from anywhere on the disc in less than one second. Retrieval is at the command of a user or a computer program, as either a still frame or pictures in motion. The still frame looks exactly like a 35mm slide, without the distortion associated with freeze-action of a videotape. Motion sequences are equivalent to videotape, only of higher quality.

A videodisc player contains the laser beam and translation circuits. A separate TV monitor presents the picture and sound. The player contains manual controls to specify a single frame or sequence of frames to be shown. Frame selection can also be controlled by electronic impulses emanating from a microcomputer. By itself a videodisc and associated player comprise a very sophisticated audio-visual device, allowing the advantage over other linear video technologies of random access to material.

The most intriguing instructional capabilities of videodisc require a microcomputer. It can be attached directly to the player and instructional software can control which visuals are to be selected from the disc. An overlay circuit card and high resolution graphics card in the microcomputer superimposes computer text and graphics on the video so a single TV monitor can be used for both. Beyond this, courseware in the microcomputer provides the interactive part of the instruction. It is written in a way which calls for video on the disc at appropriate times. Here is a sequence which might typify use of a videodisc and microcomputer in tandem. In a lesson on carburetor repair the computer provides text, asking the learner what aspects of carburetor repair he wants to study. In response to directions typed on the computer keyboard a videodisc segment is shown on the monitor which points out the salient physical features of the carburetor and goes through the necessary sequence of steps to adjust it for particular malfunctions. The learner can control the pace of presentation or even stop the presentation to study a visual for a longer time than set by the program. The distinguishing feature of this type of instruction is the inclusion in the computer software of diagnostic and remediation loops. Authors design the courseware to query learners frequently about their understanding of the material presented. This information is used to control the videodisc presentation. When response to a query suggests the learner has not understood, a sequence of previous instruction is repeated. Alternatively, a new sequence of videodisc instruction is activated which explains the material in a different way. Learner responses can also be used to verify mastery or to control the pace of instruction. This integrated instructional system attempts to mimic a tutorial situation. An important key to success is building into the courseware effective and realistic responses to every possible learner difficulty.

Various peripherals open up additional possibilities. A mouse or touch-sensitive screen on the TV monitor permits the learner to respond with the finger instead of the more intimidating computer keyboard. Light pens can be used too as a source of learner input. In the carburetor repair example taken from an existing Ford Motor Company training program, the mechanic uses a light pen to simulate the steps he would take with a vacuum gauge and screwdriver to adjust the carburetor. Voice input is available also, although the current recognizable vocabulary is limited. On the output side a voice synthesizer and sound generator provide both variety and flexibility. The most novel peripheral is a simulator which approximates motion. At American Airlines a pilot trainer simulates the motions felt at takeoffs, landings, and abnormal responses of the plane. Pilots can practice their flight procedures and "feel" the results of their adjustments in a very realistic way. The motions are coordinated with visuals stored on the videodisc, all coordinated by computer.

Videodisc instruction is, at present, very expensive. The cost of developing and producing a videodisc ranges from $35,000 to $100,000 per hour of instruction. This is almost the same as the cost of producing film or videotape because it requires a production crew and cast. In fact, all of the visual material for a videodisc is first produced on film or videotape. It is transferred to disc only when it is judged perfect. Like a phonograph record, a disc is a read-only device and cannot be modified once it is pressed. The cost of producing the associated computer courseware which drives the videodisc ranges from $2,000 – $20,000 per hour. The cost of the disc mastering is relatively low, less than $10,000. Once a master is made copy costs depends on volume. At volumes more than 500, the cost is less than $50. In addition to the disc, consumers need hardware to use it. It costs about $5,000 for a videodisc player, monitor, microcomputer and special circuit boards. An integrated version of the hardware complete with a touch screen costs about $19,000.

There are many more videodisc courses available for business and industry than for schools. In situations where there is frequent change in the product or high turnover in the workforce, integrated videodisc instruction is being turned to as a more cost effective means of training workers than face-to-face instruction. Most of the courses are very recent — completed in 1983 and 1984. Most of them cover technical skills for company employees. Examples include:

- Ford Motor Company, carburetor repair
- General Electric, repair of jet and diesel engines
- Digital Equipment Corporation, computer repair
- AT&T, installation and maintenance of new phone products
- American Airlines, pilot training
- Maritime Institute of Technology, mariner pilot training
- Sizzler, taking customer orders for food
- J. C. Penney, inventory control
- Xerox, sales techniques
- Florida Department of Health, determination of eligibility for benefits under Aid to Families with Dependent Children

Unlike the training sector in business and industry, the education community has not perceived a great need for the integrated videodisc instructional system. A few discs have been produced experimentally. With funding from the Annenberg/CPB Project the University of Nebraska recently produced six experimental videodiscs to simulate several college-level science laboratory experiments on the topics of titration, respiration, chemical decision making, physics in motion, climate and life, and energy transformation.[11] These discs simulate the laboratory experiment. "In these simulated science labs, students use a microcomputer and video screen the way they use test tubes, lab equipment, or chemicals in a traditional lab. Electronically, they mix chemicals, modify temperatures, and then observe the results (Davis, 1984:1)." At WICAT Systems, Inc. in Orem, Utah several discs have been developed to teach Spanish as a second language.[12] In these lessons a learner is presented a setting or context with Spanish being spoken. The learner is given opportunities to both hear the language properly spoken and look for visual cues as well; then s/he practices it. The lessons do not provide a critique of learner responses, but

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[11] Davis, B. G. The evaluation of science lab videodiscs. Paper presented at the Fifth Annual Nebraska Videodisc Symposium, August, 1984.

[12] Williams, D. D., Quinn, W., and Gale, L. E. Evaluating the use and effect of student-controlled interactive videodiscs. Paper presented at the annual meeting of the Evaluation Research Society, Chicago, IL, October 1983.

it is interactive at points. The learner gets to choose which Spanish response is the correct one for the situation, and the videodisc continues according to the selection.

The formal evaluations of the videodisc show great potential. They can cut the time a student spends on an experiment, it can provide a wider range of situations to examine than a traditional laboratory, it can help focus learning in useful ways, and it can foster more independent thinking on students' part. On the other hand, their are distinct limitations and the technology has a long ways to go before it is ready to be a regular part of traditional school-based instruction. It is very time-consuming and costly to develop. Even the best of programs have shown "glitches" in programs and quality control constraints in the production of the discs themselves. The technology is changing rapidly and compatibility is an issue of real concern. The biggest difficulty relates to the fact that they are designed to be stand-alone. Designers must build in every possible consideration that a human teacher makes in responding to a wide variety of students. Instructional technology is not yet at that point. (See Davis, 1984, for a good critique.)

The evaluation of the science lab discs points to the difficulty and expense required to produce high quality courseware for the videodisc. But there is great interest in the potential of the videodisc to substitute for some aspects of the even more costly real-time science labs. Shortly there will likely be a new project to develop science lab videodiscs for high school applications.

Laser Discs for Information Storage

The videodisc has another use as an information storage and retrieval medium. A firm called Laserdata is developing its potential as a device to store large quantities of printed text and pictures electronically. A videodisc can store a set of encyclopedias or a bibliographic database such as ERIC on just a few discs. An inexpensive device provides an interface between a videodisc player and a microcomputer, allowing the retrieval of information on the disc. A single disc can store 1800 megabytes of information. This makes it a good medium for information storage. Laserdata will publish the entire Grolier Encyclopedia on discs. Several advantages accrue to this form of electronic publishing. With sufficient volume the cost to the consumer is less than the equivalent hard copy, and the space to store data is much less. The most significant advantage is that all the text is searchable down to the level of a single word.

A related development has occurred in the area of "compact audio discs." These devices use a technology identical to the videodisc, but are much smaller and are suitable for recording sound and digital information. Their capacity is very great, equivalent to hundreds of floppy disks. They are read-only devices and well-suited to store large quantities of educational data and software. It represents one of many new developments that will likely become an important link in the evolution of educational applications suitable for the Home Information System described earlier.

Computer Conferencing

As computer networks have increased in sophistication, computer conferencing has grown among computer buffs. A conference is an ongoing electronic text interaction among a group of individuals. The conference provides a focus and organization for people's interchanges, automatically keeping track of items and comments members make in public (to all members of the conference) as well as private messages exchanged among just a few members. Conferences have worked effectively to help people coordinate projects and explore new interests. The two largest conference systems are EIES at New Jersey Institute of Technology and CONFER at The University of Michigan. Their potential as educational devices are just now being exploited. On CONFER a number of experiments are ongoing to use it as a device to extend class time. The instructor provides topics for discussion by students; and students use it to discuss class projects. Fred Goodman at the University of Michigan has implemented his International Simulations Game on the system and school children from widely dispersed districts engage in the simulation. An advantage of conferencing is its ability to foster interaction among groups in which race, gender, age and physical appearance count for nothing. Dr. Goodman argues that in time, conferences could be the electronic busing of the future. Obviously, for this to occur in sufficiently large scale would require topics that fit into the school curriculum, extensive hardware, and a degree of cross-district cooperation heretofore unseen. But the possibilities are intriguing.

THE FEDERAL ROLE IN THE COMPUTER REVOLUTION

I have argued in this paper that computer-based technologies are pervading all parts of society. As a result, parents and others will continue to exert pressure on schools to incorporate computers into the classroom. Is there a place for federal involvement in this revolution? Can a federal entity do something to shape the revolution so that it is of maximal benefit to public education? Some would argue that the revolution should be left in the hands of state and local education agencies and that new products are best developed by private business — computer manufacturers, software developers and textbook publishers. But there are a number of needs in this area that require the resources available only at the federal level. They fall in the categories of facilitating the development of software, enhancing the skills of teachers, and promoting equitable opportunities for students.

Development of Innovative Software

In considering the educational potential of computers the most important element is the software. Indeed, the long-term viability of computers in the classroom is dependent on the availability of software which is judged by parents and teachers alike to contribute to the growth of students. This development is largely in the hands of the private sector. For the best products to emerge there must be sufficient economic incentives to attract developers. This condition does not hold for some categories of software.

There are several types of software: drill-and-practice, tools (e.g., word processors and data base managers), programming languages, simulations such as *Rocky's Boots* and *Catlab*, and multimedia products such as *Voyage of the Mimi* which include both instruction, tutorials, and simulations. There is already appearing good drill-and-practice software, although even the best covers only a narrow span of subject matter. There is clearly room for much more software which can help the teacher in the tutorial area and thus free up time for other important instructional tasks. The tools and programming languages will be suitably developed by the private sector. But the simulations and multi-media productions currently lack a sufficient market to attract the necessary resources. They are extremely complex and expensive to produce, and the curricular priorities of the nation's school districts do not call for them yet — not because they are not of value, but because they represent a departure from existing instructional practice that is too radical.

A textbook-driven curriculum lays heavy emphasis on the presentation and mastery of facts, concepts and principles. There is limited emphasis on application in a real or simulated environment. It is very difficult for one teacher with 25 or more students to develop children's problem-solving and inferential skills, and to help them think through the interrelationships among complex systems. The computer (electronic text and graphics) and video (television, videotape, videodisc) are unusually well-suited to assist the teacher in this effort. But the approach is novel for teachers — so novel that it will be some time before computer-based simulations are in sufficient demand to lure private investment. Accordingly, a federal effort could appropriately be mounted along several lines.

Software development fund. A simulation package such as the *Voyage of the Mimi* described earlier is an example of ground-breaking educational courseware (videotapes, computer simulations, and print materials). It is highly unlikely that such materials would have been developed had the federal government not underwritten the experiment. Holt, Rinehart and Winston now distributes it, but they became interested only after the materials were fully developed. A similar case can be made for the Science Lab Videodiscs produced experimentally for colleges. A lesson should be taken from educational television. High quality programming such as that produced by Children's Television Workshop, Bank Street College, WGBH, or the Agency for Instructional Television requires more capital than private developers/publishers are willing to risk. A season of *3-2-1 Contact* costs well in excess of five million dollars. *Voyage of the Mimi* was developed by Bank Street College with an original grant of only 2.6 million, although the real costs were almost twice that. The initial funding came from federal funds, as it had to; and there were no alternatives to supplement this amount until a product was in hand. A possible solution is a software development fund to which software developers could apply for large-scale projects. If their product is successful, they could pay back the loan. If not, the federal government would absorb the loss. A review process could be set up to insure that projects were sound in their conceptual and administrative plans.

Identifying Targets for Technology. There is a need to know what educational problems might be helped by technology. The approach of the Harvard Educational Technology Center is to examine the content of various curricula and ask where these holes might be. Such an approach is called identifying the targets of difficulty. There is room for more efforts such as this at other Universities. The private sector can build on such efforts by developing software identified as important and needed.

Saul Rockman, drawing on his lengthy experience with the Agency for Instructional Television, notes that many good product ideas come from teachers or school systems. But development of the appropriate educational products is far beyond their means. "A clearinghouse or buyer's market might be set up whereby locally designed and created products could find production houses looking for investment possibilities. This would be especially useful when teachers have created materials that tie closely with an existing textbook series (Rockman, personal communication)." Currently the Joint Dissemination Review Panel provides a kind of certification that educational programs have passed the test of effectiveness. It is not clear whether the research criteria of JDRP are appropriate in the area of electronic products. Equally appropriate might be certification by a federally financed learning materials center located at a university. Testing new product ideas could be part of a larger effort in instructional methods research. Existing Labs and Centers are devoted to classroom research; the mandate could be broadened to include electronic instruction.

Economic incentives and software. Henry Becker notes that an honest district — one that paid for every piece of computer software in use in the district — would go broke. There are two solutions to this problem. One is to develop a pricing scheme which encourages high volume use. A piece of software priced at $49. a copy will not be purchased by a district in multiple copies; a few will be bought and additional copies made illegally by those teachers who feel they need it. If developers recognized this they could price an original copy for a district at $49. and make additional copies for use in the district at, say, $10. If the right price was chosen a developer might realize more income this way, and districts would not be so tempted to copy illegally. But school districts need an advocate in this effort. The Department of Education could take the lead in bringing together the constituencies to discuss this.

Staff Development

Technology on television. There is clearly a need in almost every school district in the country to have more information about what is good software, how can classrooms be organized to effectively utilize technology, and how can districts finance the expense of technology. While the need is great, what can the federal government do to help? Professional associations in various curricular areas are stepping into the gap. National teacher associations, publishers, intermediate school districts, and state governments are all responding too. What is needed that goes beyond the capacities of these organizations? One thing is the funding of one or more high quality television series that would document (in an entertaining way) effective utilization of technology at various levels — elementary, secondary, and post-secondary. The caliber of most *Nova* shows come to mind. If properly produced they would be appropriate for prime-time broadcast on PBS, but also could be made available by cassette for use in the teacher lounges of schools around the country. The *Nova* program on Logo is a good example. Logo is a programming language that is widely discussed in education circles. Yet few teachers have a good sense of what it entails. The *Nova* program provided a good overview in just one hour.

There are a large number of talented teachers in the nation's schools; many of them simply need "images of potentiality" to help them take the first step to use technology in the classroom. This is not to prejudge the value of the technology and "sell" the schools; it is only to insure that the nation's teachers have considered the possibilities of technology before society criticizes them for not using it. We already see in its infancy a private-sector initiative to take advantage of computer technology to provide remedial education for K–12 students. Enchanted Village, Sylvan Learning Corporation, and Youth Enrichment Services are all private companies making a bid for parents' educational dollars by providing computer-based remediation and enrichment. Higher education is being challenged by the recent Carnegie Foundation report *Corporate Classrooms: The Learning Business* in which traditional schools of post-secondary education are criticized for the illiteracy of their faculty in the area of technology. We must provide today's school teachers and college faculties with the opportunities to see first-hand what technology has to offer, and let them judge from knowledge, not ignorance.

Tax benefits. In this same vein, technology is expensive. The income base of schools is dwindling in most areas of the country. Federal legislation to make it attractive to manufacturers to provide hardware and software to schools at reduced prices could help here. Similarly, tax benefits for teachers which encourage them to buy computers is an excellent investment. Only when teachers are themselves comfortable with a technology are they likely to bring it to their students with confidence.

Travelling Chautauqua. The technology boom is rushing along. The forces that keep it moving are not ones that are based on a careful assessment of technology's ability to solve crucial educational problems. As a nation we must carry on a dialogue over the costs and benefits of technology for learning. The federal government could fund at small cost a travelling seminar in which the values were debated. The seminar could be made a part of the annual meetings of many teacher organizations. It could be sponsored by state and local educational agencies. Universities throughout the country could apply for funds to provide such a conference annually for educators in their region. The federal role would be to support the dialogue, not provide the answers. It would be a facilitator to help local initiatives.

Information literacy. In recent years emphasis has been placed on computer literacy. The typical literacy curriculum was described earlier. It was noted that such curricula are rapidly evolving; indeed, they are likely to disappear in schools as more of this training is provided in existing courses (math, English) which incorporate computers into regular instruction. (An older generation learned to use slide rules in a math or science course at the point where such skills were required.) Computer experiences outside of school will also reduce the need for courses which only show students how to make a computer operate or teach them rudimentary programming skills.

But there is a hidden agenda in the computer revolution. The present focus is on the machine, but a major application of computers is in the management of information. Data bases are being used to get information for all types of purposes. Stock brokers query a data based to find the price of a stock much as sales people in may retail operations query a data base to find the price of items ranging from mufflers to men's wear. Newspaper reporters digest the nation's news as it comes over electronic news services, and then they write a story using a word processor that is linked directly to the system that composes and prints the newspaper. A researcher conducts an on-line search of several centralized bibliographic databases to see if relevant articles have been written on a topic of interest; he then accesses a local library catalog by computer to see if a desired title is available.

It is simple to teach someone how to use a computer terminal to do these tasks. But the tasks represent a different way of thinking about information; this has ramifications for how text is written and commerce is conducted. Is "written" composition a different task when done on a word processor? Does the capacity to revise and move text electronically suggest a "writing as assembly" model? Does all of the electronic editing lead to greater "borrowing" of other people's text? What is gained and given up as all information becomes electronic? Does the multiplication of information cheapen its value? Are there ethical issues in the easy borrowing (and perhaps altering) of electronic information?

It is not clear what the answers are or what the implications are for school curriculum, but someone ought to be thinking about this matter. What are the essential skills that students of the 21st century need in the area of handling and using electronic information? The federal government could stimulate groups to think about this issue, and encourage them to suggest ways that schools could respond. The response is a local matter, but the ideas come from a cost-effective centralized effort to think through the relevant issues.

Equity for Students

There are a number of ways in which current uses of the computer in schools illustrate inequities. Becker's 1983 survey shows inequitable distribution of resources between schools serving the rich and the poor. The data also indicate the possibility that racial minorities and girls do not have the same opportunities to develop computer skills. If additional studies confirm this, and communities find this unacceptable, the question arises, how can it be remediated? There are two aspects to the solution. One is the distribution of hardware, and this is a relatively simple matter (given the political resolve) to remediate. But, to the extent the problem lies in subtle forms of unintentional discrimination, then the solution is more difficult and may require resources from outside a district. The possibility for discrimination rests in the cues which parents and teachers give to students. For example, Eccles and her colleagues found that parents do not encourage their girls to excel in math in the same way they encourage boys. Minorities can be overlooked when thinking about who should be encouraged to elect a computer programming course. This type of discrimination is best dealt with by an intervention whereby teachers and parents are sensitized to the ways in which their unconscious behaviors might contribute to perpetuating inequities. Just such an intervention is provided by Project EQUALS at the Lawrence Hall of Science, UC Berkeley. The training consists of five days of workshops and various additional activities carried out between the workshops. There are special evening programs for parents. It is hard to imagine such training being developed and sold at a profit by private enterprise. As recent history has shown, efforts to promote equity in education have varied with the ebb and flow of political currents. But local and state districts that accept a responsibility in this area need resources to help them with the problem. Federal funding of projects such as EQUALS makes it possible for a district to get this kind of service at the cost of delivery — a figure which they can afford — as opposed to the cost of development plus delivery — a cost which would surely be unaffordable.

The computer has revolutionized many aspects of life in the United States. To realize the potential of the computer in the educational sector requires a concerted effort by local and state school districts in concert with the developers of hardware and software. There are several areas in which these entities by themselves cannot develop the most effective response to the revolution. It is in these areas that the federal government should step in to become facilitators and help each sector do the best job possible.

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