Computers and Education: Opportunities for the 1980s

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Public education is one of the most expensive and pervasive activities in our society. If we identify "education" with "learning" then education can be seen to be an essential part of the way we live.

Computers and their associated technology also perform an important role in modern society. During the 1980s, computers and computer communications will become even more pervasive.

It is inevitable that these two domains will interact and merge. It is now technically and economically feasible to apply computers to the processes that we know as "education."

The purpose of this paper is to outline some of the factors in computing and in education which will determine the nature of their interaction, to identify the opportunities and issues raised by the interaction, and to pose challenges for our computing professionals and educators.

The Long-Term: What Might Computers Do For Education?

The Printed Word

Much of the activity in education has to do with the written word and its associated skills, reading and writing. If we think back several centuries, one of the important reasons that scholars gathered to learn was to share the use of books. It was Bertrand Russell who said, "the only reason the lecture system is in use in British universities is that they have not yet discovered the invention of printing." On a more sarcastic note, someone has observed that the last big technological breakthrough in education was the invention of the megaphone.

Cheap, readily available, printed material makes possible mass public education as we know it today. Also, it is already clear that the computer is the greatest single innovation in the production of text since that of the printing press. Computers are

being used to assist all phases of editing, printing, and publishing, using the gamut of technology from word processors through to phototypesetters. Our authors and publishers are struggling to adapt.

Yet the text-processing revolution continues far beyond this point. The linking of computers to the national telecommunications systems means that some of the fundamental reasons for production of printed pages are beginning to be eroded.

Of course, it will be a long time before most of us dispense with books entirely and rely upon imagery reproduced on the surface of a cathode ray tube. It will be some time before the storage and retrieval of information from computer systems can rival the efficiency of our modern publishing industry. But it is already clear that in the long term, if the computer is used for the capture, editing, and publishing of text, in many cases it will be more convenient, faster, and perhaps cheaper to deliver the information by computer as well.

To the extent that computers affect the production and dissemination of books, they will affect the educational process as well.

Mathematics and Arithmetic

Mathematical skills are considered to be an important part of education at all levels. In elementary education the emphasis is upon computational skills, that is, arithmetic. In higher education we move on to mathematics and mathematical logic. The purpose of this is to enable the student to acquire skills deemed important in our modern society - to understand the processes by which business, engineering, accounting, scientific, and personal financing decisions are made.

Almost all numerical processes of any significance are now performed by computers. Business accounting systems are based upon computers. Engineering and construction are planned and carried out with computer assistance. It is computers that do the arithmetic, even if only through the means of a hand-held calculator. So the chosen instruments for carrying out mathematical and arithmetic processes have changed and will change further. In the long term, it seems essential that students learn to use these instruments.

For a long time, the perceived relevance of mathematics, as it has been taught in the classroom, has been a problem in the motivation of the students. With the computer it is possible to instruct in both applications of interest and the necessary skills at the same time. It seems certain in the long term that this is the way it will be done.

Logic and Reasoning

A frequently stated goal of education at all levels is to "improve people's ability to think." Thinking includes, in part, the ability to reason, recognize logical processes, make decisions, and so forth. Increasingly, decision-making processes are being carried out with computer assistance.

Computers also seem ideally adapted to the teaching of logical reasoning. This extends from instruction in elementary logic through to complex decision making based on simulated environments. For the latter, the computer may provide the only economically practical method of instruction.

Continuing Education

One hears much about the increasing need for continuing education. The fundamental idea of education taking place at a time and place convenient for the learner

seems inevitable when we consider the needs of modern industrial society. Continuing education occurs after the student has entered the "environment." That is, he is in a job situation and at a location remote from schools. But he needs access to the facilities that our institutions of education provide.

There are two possibilities: transport the student to the educational facilities, or make the educational facilities accessible to the student in his job situation. The latter will be an increasingly preferred choice.

The most effective learning takes place when the student has a problem that he is motivated to solve and needs instruction for that purpose. This will occur in life situations, on the job or off the job, in the student's place of work, or at home. Telecommunications coupled to computer-based educational resources has made education at a distance more feasible. If instruction is delivered or assisted by computer in the classroom, it can be equally well-delivered at a distance, using the methods which are now available.

Preparation for Jobs

One school of thought maintains that the purpose of education is to prepare students for their "life work." This means preparation for the jobs or occupations they will be engaged in.

In the future, computer technology will touch upon most occupations. It has been estimated that by 1990 up to 60 percent of the working population will use computers on a regular basis when performing jobs. In the longer term, the percentage will likely by higher. If preparation for jobs is an important part of our educational objectives, we must consider teaching skills in using the computer systems as a prerequisite for effective job performance.

Summarizing the Long Term

In the long term, computers and computer communications will fundamentally alter most of the important processes we call education. Therefore, our educators must come to grips with how computers will be integrated into our educational programs.

If this is true, and considering the characteristics of our educational institutions, we can see that change will be of revolutionary proportions. The interaction will be pervasive, important, and perhaps crucial to the future shape of our society.

It is natural to ask: "What are we doing now?" "Are we planning for change?" "What are the instruments for change and how are they being managed?" and "Is the 'educational establishment' positioned for change?"

The Short Term: How Are Computers Being Used in Education Today?

When we look at what is being done with computers in education today, we can see that the revolution has barely begun. Computers are being used to some extent in higher education and a little in public education. Computer communications technology is barely being used at all. The purpose of the following section is to outline some of the ways in which computers are beginning to be applied to educational processes.

There are three main ways in which computers can be used in education. These are:

1) Teaching with computers: Computer-Managed Instruction (CMI).

2) Teaching about computers: Computer Science and Technology.

3) Teaching by computers: Computer-Assisted Instruction (CAI).

Computer-Managed Instruction (CMI)

By "teaching with computers," I mean the use of computers to aid traditional instructional processes. This is being done in a number of ways, particularly with the use of data-processing equipment in our school boards and our departments of education. Activities which fall into this category include record keeping about students, teachers, and facilities.

So far, what has been done largely amounts to automation of the traditional record-keeping which was necessary in a school or at a system-wide level, such as in municipal school board offices. The facilities have been introduced to aid the work of administration of the schools or the educational systems as a whole.

Little has yet been done to directly aid the teachers and instructors who provide the information which is recorded for administrative purposes. Test results, grades, and the results of counseling are manually prepared, summarized, and entered into data-processing systems. We can readily visualize a means whereby computers are put directly at the service of the staff who are preparing this information. They could enter the data directly into an information system, thus eliminating the need for manual reports.

When the progress recording of a student during a course is automated, this is frequently referred to as CMI. With CMI, a teacher can more readily track the progress of students during the course, and retrieve information in a timely way to assist in counseling. This can free the teacher from onerous routine chores, and enable him to spend more time on the important matters of motivating, counseling, and dealing with learning problems.

However, the introduction of CMI has potentially a more revolutionary implication. A student given direct access to CMI facilities can get direct guidance without teacher intervention. The teacher can specify the instructional logic and leave the process of routine tracking of student progress to the computer itself. With the use of a computer it becomes feasible to permit individualized instruction. With individualized instruction, each student can progress at his own pace and through an instructional sequence relevant to his needs, rather than in lock-step as is typically the case.

One of the reasons that lock-step instruction is used is the sheer complexity of keeping track of the progress of 30 or more individuals. If the task of monitoring student progress can be turned over to a computer system, with exceptional or summary reports available to the teacher on request, then the barrier to individualized instruction is removed.

Once the records of student progress are available in machine-processable form, it becomes possible to begin to manage the instructional activity in a more rigorous and scientific way.

CMI does not require any alteration in the content of current educational curricula. It seems readily achievable with off-the-shelf technology. The cost might include one terminal per classroom, telecommunication lines, and a central computer either at the school or in the central school board office.

The amount of CMI being carried on today is almost nonexistent. Little direct use of the computer is being made by either students or instructors. Yet this is where the

short-term manpower savings are potentially the greatest!

Computer Science and Technology

Computer science has been taught at different levels in our educational system for several years. In spite of the dedicated efforts of many of our educators, there are still a number of deficiencies in the way in which this is being done.

At the public school level, computer science is not integrated into the curriculum but is taught as an option. The prescribed curriculum is also obsolescent and deals with topics such as computer-card punching and COBOL programming. Very little is taught about computer electronics, and virtually nothing is taught about computers from a system-wide point of view. This systems point of view may be even more important than learning about the electronics and technology of computers.

Microcomputers are being introduced, often on a voluntary basis, and sometimes using the personal money of teachers. Very little is being done to coordinate this work from a system-wide point of view. There is a great deal of duplication of effort and no systematic way of sharing experiences. We still lack a plan for introducing computers into mathematics and other subjects.

In our universities and technical schools, computer science educators are struggling to keep up with enrollments and to meet the needs of the community and their students. They have been hampered by institutional rigidities which are different at each institution. In universities, the increases in enrollment have not been matched by corresponding increases in staff because it is very difficult to quickly redeploy financial resources in a university, and there are almost no new monies available for staff appointments. There have been similar problems in the institutes of technology.

In many cases, our institutions of higher education are not providing what the business community would like to see. What is being taught in our courses is often several years behind the time. There is an overemphasis on the "science" of computers and programming, and insufficient emphasis on systems methodology, the management of information technology, and the use of computers as problem-solving aids.

There is no doubt that many students are being frustrated by the lack of opportunity in our institutions of education. Brighter students frequently pay for computer time and equipment out of their own pocket in order to prepare themselves for what they realistically believe the job market requires.

Computer-Assisted Instruction (CAI)

As a result of the pioneering work of some educators over the past 10-15 years, it has now been conclusively demonstrated that instruction by computer can be effective in almost any subject area. Systematic research has demonstrated that it is possible to enhance the speed of learning, retention, and skill level at reasonable cost using a computer as the teaching medium. More important, the computer can be programmed to adjust to the student's own pace and special learning requirements through pretesting and control of the instructional logic which adjusts to responses that the student makes to the computer.

When properly applied, most students find instruction by computer to be interesting and motivating. Usually, the instruction in a course will not be completely replaced by computer but will be supplemented by computer for appropriate material.

For example, in a course in economics, the computer can be programmed to simulate the results of economic decisions in a model economy. This may be very difficult to teach by other methods. The range of methods which have been shown to be effective include drill and practice, dialogue, simulation, tutorial, and direct computation.

The cost of CAI has been reduced sharply by advances in computer technology and will continue to fall. It is claimed that the cost of instruction is as low as 25 cents per student contact-hour in some cases. Personal computers such as the APPLE, TRS-80, and PET can be obtained in the $1,000-$2,000 range, and courseware is becoming available for these machines.

In public education, microcomputers are being used for CAI in some schools but teachers are struggling with inadequate courseware, and there is little system-wide planning as yet for the use of these facilities. Experience has shown that the development of effective courseware requires a long-term commitment and perhaps 100-150 hours per student contact-hour of instruction. Only the most dedicated instructors are prepared to undertake the development of courseware in addition to their regular teaching load. There is often scepticism about the validity of using computers for instruction, and hence most institutions do not have a policy to reduce the workload of an instructor who has dedicated himself to the development of courseware.

Careful attention must be paid to the instructional design and lesson content as well as the programming in order to produce effective lessons. Few educators have skills in all of these areas, and there is a high risk of failure when the development of courseware is undertaken on an individual basis. Courseware would be best developed on a system-wide basis but in most provinces there is neither a system-wide plan for doing this nor a general framework within which the work could be undertaken.

The 1980s: A Time of Opportunity

The 1980s will be a time of great opportunity for the application of computers to the problems of education. There will be opportunities for government, computer suppliers, our institutions of public and higher education, and our professional associations.

The opportunities have been created by the amazing and unprecedented decrease in cost for computing power. This trend has continued through the 1960s and 1970s, and most informed opinions indicate that it will continue through the 1980s. The cost of computer logic circuits will be cut in half approximately every three years, leading to a large increase in cost effectiveness by the end of the decade. Costs for other kinds of peripherals will also fall but not at a similar rate. Costs for such devices may be three or four times less ten years from now than they are today.

Although cost effectiveness for educational applications is a complex function of the cost of computer equipment, software, and personnel, it is probable that during the 1980s we will cross over the point at which it will be less expensive to perform functions which are capable of being performed by computer with the use of a computer. We have already passed this point for many important applications in computer-managed instruction and education in computing science.

The problems are many, but so are the opportunities. To properly

exploit the opportunities will require the cooperation of many different agencies in the private and public sectors, and also of our professional groups.

Summary and Conclusions

My biases will have become clear at this point. Looking to the long-term future, I am convinced of the following:

1) Computers and computer communications will become the indespensable tool of public and private enterprise in the future.

2) An "educated man" will need to understand at least the basics of computers in order to function effectively.

3) Appropriate educational policies for computers, information technology, and computer communications will become a necessity in a modern, industrialized nation.

4) Computing technology will affect every aspect of the educational processes.

5) Educational institutions which do not take up the challenge and exploit the opportunities will be replaced by other agencies.

6) A fully effective program for the educational use of computers requires the cooperation of our educational institutions, of industry, of governments, and of professional associations.

The choice is clear. We can sit back and await developments and thus play a second-class role, exploiting the advances which will be made in other jurisdictions, countries, or provinces, or we can dedicate ourselves to the objective of creating the finest program in the world for computer-based education. We certainly have the resources and the educated people. Perhaps we have the willingness to accomplish this objective. As educators and computer professionals, what could be more worthy of our efforts?