Part One: Policy

Information Technology and educational change

The phrase 'Information Technology' is used to encompass a range of 'new' technologies and their applications, including all aspects of the use of computers, microelectronic devices, satellite and communications technology. These emerging technologies seem revolutionary because of the speed of their development but they can also be seen as the most recent developments in our evolving ability to record, access, manipulate and communicate information.

Increasingly, 'Information' is regarded as a major economic resource, which can be used by individuals, corporations and nations to political and economic advantage. Like other major resources, information offers the greatest possibilities to those who know how to *use* it, rather than than to those who merely *store* it.

Access to information has shifted over time from the hands of the few to the hands of the many. For instance, the advent of printing and the wide distribution of books generated an explosion of new ideas as more and more people gained access to the printed word. Five centuries later, although there are still millions who cannot gain information from print, the spread of information continues through 20th century technologies such as radio, television, cinema and video, offering new sources of information for the literate and non-literate alike.

Schools, whose role involves the dissemination of information, are still mainly teaching using 19th century technologies and methods, while their students have access to vast quantities and varieties of information which, until recently, would have been available only in printed form, and only to a privileged few. In a number of countries, students also have access to computers, which can be used not only extend knowledge but also as powerful thinking aids which support cognitive development.

In the midst of what amounts to a global information revolution, most schools continue to offer a curriculum based on a view of information which dates back to the time when knowledge seemed stable and bounded - when we used to think it was enough for students to learn from books or course notes, and then to be able to reproduce the facts or opinions they had been taught.

The curriculum of any country's school system needs to take account of identified national priorities and to offer *demonstrably* relevant ways of helping children and young people to contribute to such development as well as meeting their individual development needs. In this rapidly changing world, the school curriculum must also take into account the skills, the attitudes to learning and the experiences young people will need if they are to benefit from the wider opportunities the future will bring.

Information technology is a large part of that future and is already having a significant effect on the world in which we live. Some ministries of education are so convinced that future citizens should be able to use computers that they are treating computer literacy, in their schools and colleges, as a new basic skill, along with literacy and numeracy. Others, either because they are more cautious or because they are financially more constrained, are exploring various applications of computers through pilot projects. Even the poorest countries are examining ways and means of incorporating an awareness of information technology at some level in their education system.

The way in which policy makers decide to make use of information technology in education will have important implications for national development and so the criteria upon which they choose their advisers is also important. If they choose their advisers on the basis of

technical expertise, more *technical* uses of computers are likely to become a priority. If they are chosen on the basis of *educational* expertise, *educational* considerations will guide decision-making to a greater extent.

Equally, those who believe that children learn best by memorising information will want to use the computer as a sophisticated electronic textbook, testing the children's retention of information from time to time; whereas those who believe that the role of the teacher is to encourage the child to question, to solve problems, and to work co-operatively with other people will advise activities and choose software to support these intentions.

Policy makers need to have a clear idea of why they want computers introduced into schools. They must be able to communicate these reasons to teachers, and clarify what is expected of them in the classroom. Without guidance and appropriate training, most teachers will use computers simply as a more sophisticated way of doing what they already do, and if this is the case, many significant learning opportunities for individuals will be lost and important opportunities for national development will be delayed.

The computer is not a panacea for all educational ills, nor is it, in itself, a remedy for any of them. The significance of computers for education lies in ***the way*** they are used, not merely in their presence in schools.

What reasons are given for using computers in schools?

There are now a number of 'Computers in Education' or 'Information Technology' projects being undertaken in Commonwealth nations and elsewhere which have been launched for various reasons. Whilst the rationale for every project depends upon its particular national context, those introducing them do not always have a clearly defined set of aims and intentions at the outset. In most cases, the reasons for initial commitment of resources is linked to a desire on the part of politicians, the business community and parents to advance or improve *technical education*, or generally to raise *computer awareness*. However, as might be expected in such a rapid development, the rationale for these projects has often become elaborated as the projects themselves have progressed.

What follows in this section is an attempt to summarise and compare four main reasons that are given, at a national level, for introducing computer technology into schools, and to outline the basic assumptions underlying them.

By crudely categorising all approaches to computer education into four main groups we have attempted to translate the various economic and educational arguments that are made for the use of computers in schools into four distinct forms of action.

These do not represent exclusive choices. Whilst the distinctions between them are important, any one information technology programme is likely to include a number of different aims and to reflect more than one rationale. The resulting blend will depend on the economic, social and educational priorities of the country concerned.

In the first two rationales, 'computer education' means education *about* computers, either in a general or in a more specific sense. In the other two cases the focus is on the computer as a means of improving the educational process itself.

Rationale 1: *To build a resource of people who are highly skilled in the use of information technology*

Some governments see information technology as an opportunity to improve the efficiency of existing industrial, commercial or agricultural activities, thereby strengthening their economic position. They also see the opportunity for using information technology as a base for the

formation of a new industrial or commercial sector, which might produce or maintain computer hardware or components or be able to develop software and systems. Information technology may be seen as offering new employment opportunities in an area where demand for skilled labour is likely to increase. Some developing countries have recognised that, in this respect at least, they have the economic advantages of low overhead costs and a talented workforce who are eager to learn new skills. It is clear from recent developments that where a country can identify and service a global market for microelectronic products, it may be able to become a vital economic force in global terms.

With this rationale, emphasis is likely to be placed on much more specific and vocationally-orientated training in the secondary and tertiary education sectors, limiting the use of computer resources mainly to a selected group of students who are specialising in subjects which link with chosen focuses for development.

Commonly, students are encouraged to learn to program a computer using a suitable computer programming language. Local conditions usually determine the particular vocational areas where courses are developed, and may include subjects such data processing, micro-electronics, control technology (how to use a computer to control machines), computer aided design, or the use of business applications such as spreadsheets (for accounting) and wordprocessing (for increased secretarial efficiency).

This is the rationale that lies behind a number of courses entitled *computer science* or *computer studies*. They have usually been derived from the content of higher level university courses and lay stress on such topics as, the history of computing, electronic logic, microelectronics, data processing and programming. Whilst this is probably the most common initial approach to the introduction of computers into schools, many countries are already moving ***away*** from these kinds of courses because of a growing belief that the greatest economic benefits are to be found in *using technology* rather than in *producing technology.*

Any approach based upon this kind of rationale must be developed within the context of broader national development priorities, or there may be adverse consequences. For instance, resources may be too narrowly channelled, supporting the development of a new technically skilled elite at the expense of the educational needs of the majority. In an area as dynamic as information technology, it is not easy to predict precisely which skills will be needed in the future, so even greater care than normal needs to be taken in allocating scarce resources to the development of skills which may, even in the relatively short term, become obsolete.

Rationale 2: *To equip **all** students for a future in which technological awareness and basic computer skills will be increasingly important for greater numbers of citizens.*

Countries may adopt this rationale as part of their approach where they recognise that they will primarily be users rather than producers of computer hardware and software, and that they need to maintain an informed position in a world where information technology has increasing importance.

The aim of this kind of general awareness-raising programme would be to ensure that citizens of the future were in a strong position to take advantage of technological developments as they arise. Then, a sufficient pool of talent would be able to emerge to take advantage of any specific development in information and communications technology, in the national interest.

Such a programme would lead to a more general awareness of the power and relevance of computers rather than a technical or scientific understanding of their working, or of how to operate them. The approach will be designed to be as broad as possible, giving students the opportunity to examine a variety of different computer applications and to consider their impact on society.

It is unlikely that much emphasis will be given to introducing *computer studies* or *computer*

science, because these subjects would be seen as using the available resources to serve only a few students. However, it would be seen as appropriate for colleges and universities to offer courses for some students to study *computer science* in depth, whilst students in other disciplines would be given general awareness courses, similar to those offered in the schools. This approach to using computers is most likely to be introduced at the beginning of the secondary stage of education and, as more resources become available, may be extended to the primary sector.

In far too many cases where this approach has been chosen, it has been poorly implemented. The courses have been too general to meet *any* specific needs, with students receiving little more than an exposure to computers. Students spend their time learning relatively trivial ideas and concepts which make little contribution either to individual or to national development. Courses are often over-theoretical, with students looking at a computer, or learning about it, rather than getting the familiarity with it that comes from practical hands-on experience.

It is therefore important that the structure, content and teaching methodologies employed in general awareness courses are carefully monitored so that students are provided with a genuine foundation for future learning.

Where it is generally accepted that the most important reason for introducing computers into schools is to ensure access to information technology courses for *all* students, it is worth considering augmenting the programme with an extensive use of media, such as radio, television and print, to extend the opportunities for learning about computers to the population in general.

Rationale 3: *To use new technology to enhance the existing curriculum and to improve the way in which it is delivered.*

The computer has the potential, as a sophisticated educational teaching aid, to enhance traditional ways of presenting information to children. It can be used to present information in a more sophisticated way than is possible using textbooks. A child can sit watching the computer screen and respond to programmed cues and questions. The computer can carry out the traditional role of the instructor - to deliver information, to test understanding and then to offer reinforcement or practice in areas where weaknesses are detected. A large number of subject-specific programs have been developed which supplement exisiting schemes of work in many curriculum areas. Teachers seem to find this use of computers by far the least threatening, since it replicates what they are already doing, and requires little change in their ways of working in the classroom.

Computer programs geared to the content of a particular syllabus, and which take over the function of teaching, have been published in a variety of subjects, across the whole spectrum of the curriculum. Such *computer assisted learning* is designed to help the pupil to learn some particular subject matter. In its simplest form it may be a drill and practice program; for example, asking the pupil to complete sentences by typing in the correct tense of the verb in a foreign language. In a more developed form, the program acts as a tutor, asking the pupils questions and adapting the subsequent stages depending on the student response.

The costs involved in pursuing the use of computers to replicate traditional content are necessarily high. Equipping all schools with enough computers to be used in a number of different subject areas would be a major initial cost, but added to this would be the cost of retraining subject teachers.

Most programmes of 'computer assisted learning' have been developed in Europe and North America and naturally reflect content and curriculum approaches which are more relevant to the country of origin. Therefore, further cost may be involved in adapting software, so that it is culturally relevant, or in developing software to support local curriculum content and practice.

Over the coming years, as computer technology and computer software become increasingly sophisticated, it is certainly possible that computers will enable many students to learn skills and to understand important concepts without the aid of a teacher. However, at present, there is no evidence to suggest that computers can replace teachers in significant ways. On the contrary, the successful introduction of computers, particularly at primary and secondary levels of education, seems to require a major additional commitment on the part of teachers, particularly if the full benefits of their use are to be made available to young learners.

Rationale 4: *To promote change in education by moving towards a more relevant curriculum and a new definition of the teacher's role.*

As more educators have gained experience of using information technology in schools, there has been a perceptible move towards using computers to achieve educational aims which, although desirable, were previously difficult to achieve, such as:

- to place more control of what is learned in the hands of the learner and to equip people to learn more independently;
- to move away from an educational system dominated by 19th century values and the delivery of the curriculum through arbitrary, traditional subject divisions, towards an approach which is more relevant and more integrated;
- to place more value on the practical learning of information-handling and communication skills (as opposed to an over-concentration on memory and the ability to regurgitate facts);
- to encourage collaboration and more emphasis on children being able to solve relevant problems together, using each other as sources of information and expertise.

These ambitious examples of educational change all depend upon a significant redefinition of information, knowledge, learning and the role of the teacher. Therefore, it should not be surprising that the introduction of a computer - the most powerful information processing device yet devised - can enable existing attitudes towards education to be challenged, and affect the skills and knowledge-base being delivered by the education system.

A useful factor to consider when introducing computers into education is that teachers, school administrators, parents and students have an openness to change which on other occasions may be lacking (perhaps because people perceive computers as something different from what is usually done at school). This makes it much easier to use the introduction of microcomputers as an opportunity to implement such desirable and ambitious policies.

This kind of approach requires a clear statement of ***educational*** intentions, preferably before decisions have been made about hardware and software. It also requires the professional involvement of people experienced in teacher training, curriculum design and educational project management, because teachers are going to be asked to use new approaches which are significantly different from their traditional ways of working.

For instance, teachers may be required to ask their students to collect information from local sources (eg newspapers, relatives and elders) for the computer. If the teachers have not been well-prepared for this kind of task they will worry that the information gathered will be incomplete, inaccurate, out-of-date or biased, and they will see this as a problem rather than an opportunity to talk about the nature and validity of all sources of information.

Depending upon the educational aims of a project, such "data handling" activities can be used to encourage students to formulate questions about the particular data that the computer holds, to create their own hypotheses, to devise tests and to discuss and evaluate their results. They can encourage them to work collaboratively, to promote self-reliant and independent learning and to support the development of scientific process and research skills. However, it also requires that teachers allow their students to discuss what they are doing with each other and give them the flexibility necessary to investigate their own lines of enquiry.

In this way, the introduction of the computer can be used to strengthen and diversify classroom teaching, perhaps initially in an introductory information technology course, and later extended to a wide variety of subjects.

On their own, computers cannot reform an entire educational system, but as part of a skilfully implemented programme they can provide the opportunity to challenge many of those existing ideas about the educational process which are considered outdated and slow to change.

What kinds of educational activities can computers support?

The computer is a versatile, many-purpose tool and there are many different uses to which it can be put in the classroom; just as computers are used for many different applications outside. The best educational uses of computers have been developed where teachers themselves, or curriculum units working with teachers, have employed the computer to meet their own specific educational objectives.

Microcomputers are programmable, that is to say, it is the program of software that determines the function performed, not the construction of the machine itself.

Like most other educational materials, items of software usually carry the cultural values and the educational philosophies of their authors. This is particularly true of ***subject-specific*** packages, where the content is often clearly defined, the activities of students are usually predetermined by the software author, and the packages are normally based on the cultural and curriculum assumptions of their country of origin.

More recently, computer educationalists have been able to develop packages which use the computer as a tool to enrich and extend the curriculum by supporting activities which are not possible by traditional means. These computer programs allow curriculum specialists and teachers in various disciplines, and in different countries, to develop learning activities for their own students instead of being limited by imported curriculum objectives. Such software is sometimes known as 'content free', implying that teachers and students can define its use in schools or is referred to as '***generic software***', suggesting that its use is not confined to particular subject areas.

Subject-Specific Software

A wide range of subject-specific software is available for most computers which claim to be educational computers. Most programs of this type deal with a specific teaching topic, or with a discrete skill or concept which forms part of the traditional curriculum in a particular subject. Using mathematics as an example, there are programs which attempt to teach topics such as 'area' or 'volume', programs which offer practice in number skills, and programs which demonstrate the relationship between, for instance, time, speed and distance. In language development, there are programs which deal with the technical aspects of language such as spelling and puctuation, and programs which claim to support the more creative aspects of language development.

The vast majority of subject-specific packages are culturally specific and simply replicate what is currently taught using pencil, paper and blackboards. These packages also tend to treat the student as if he or she is a passive recipient of learning, rather than an individual capable of questioning, experimenting and actively engaging in their own learning. It is difficult to justify the use of expensive computer equipment and teacher training for such purposes. It must be said, however, that a few subject-specific software packages do exist, which are flexible enough to allow children to interact with the computer program, making decisions and changing parameters, so that their learning is active rather than passive. For instance,

some computer simulations in science or in economics can allow children to experiment by "infecting a healthy population" or by "lowering prices" in order to provide indirect experiences of that which would otherwise be impossible to experience in the classroom. Despite the obvious potential of this approach, good examples of this kind of software are very difficult to find.

Generic Software

In contrast to software which essentially adopts the traditional role of the teacher, generic software provides students with tools which can extend and enhance their thinking and their learning. A report in the Carnegie Quarterly, based on the work of Marc Tucker, maintains that successful technologies create new possibilities as well as enhancing old ways of doing things. In educational terms, it is claimed, computers can provide *qualitively* different intellectual possibilities:

"Five very different examples come to mind, although the number of applications are many.

"One area is writing. As it is now, few elementary school children are taught to organize their thoughts, to make a persuasive argument, or to express themselves clearly, and far too few high school graduates succeed in doing so. Computers make it much easier for students to write and to edit what they have written and for teachers to read and comment on students' writing - the essential conditions for learning how to write well.

"Another example is in science and technology. Computers can make it possible for students to grasp the power of scientific theory by applying it to real life. There are school labs where fourth graders learn some fundamental principles of engineering by designing, programming, and building computer-controlled devices that make use of light sensors to guide motor-driven model vehicles. There are school districts in California where high school students have built computer-controlled automatic data-gathering systems used to predict local weather in remote mountain valleys.

"A third example is in drafting. We know that computer-aided design and computer-aided manufacturing are already changing the whole notion of what it means to design and produce something, whether it is a machine part or an industrial process. Students should be learning those techniques, not the manipulation of a T-square and pencil, which cannot begin to give them the design power of computer graphics.

"A fourth example is in training for jobs in the building trade. Vocational students could be learning and using sophisticated computer-based job-costing, project planning, and management techniques, rather than the rule-of-thumb approaches commonly used in small contracting firms.

"The fifth example is in the social sciences and other areas where the tools now available for microcomputers enable students to manipulate large volumes of data and increase their capacity to analyze them. Data sets stored on disc and text files accessible by telecommunications make it possible, for example, for history and economics students to do research using the same data that experts use. High school students could learn how to apply these techniques of statistical analysis to many subjects in the curriculum, gaining a skill increasingly in demand in the work-place.

"Across the curriculum...the computer could make intellectual and creative efforts possible in art, music, mathematics, and science that are not even contemplated in schools right now."

Computers have been used as tools for industrial, commercial and research purposes for many years. The above report summarises the experience of increasing numbers of educators world-wide who feel that the most effective way of using computers in schools is as a tool, rather than as a teaching-aid. Whilst the report is based on American schools, many of which are richly-resourced, the principle of using computers as an intellectual tool can be applied universally.

Where students have access to word-processors, data-banks and information packages, spreadsheet programs and control technology in the classroom, and their teachers are supported by appropriate training, the possibilities for enriching the learning environment for all children may be significantly enhanced.