Microcomputers in Schools: Policy and Implementation Guidelines

Commonwealth Secretariat

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Education Programme
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Preface

Many countries have begun to use microcomputers in the classroom; others are considering their use. The purpose of this book is to help those making decisions about their use and about the role of information technology in the classroom. Ministers of Education, at their conference in Cyprus in 1984, asked the Commonwealth Secretariat to look into these issues in order to produce unbiassed advice, based on Commonwealth-wide experience, to help member countries.

As a result, the Secretariat, in co-operation with the government of Alberta in Canada, called a pan-Commonwealth meeting of specialists which was held in Edmonton in May 1986. This report is one product of that meeting. It reflects the experience brought to the meeting from Barbados, Britain, Canada, Cyprus, India, Kenya, Singapore, Sri Lanka and Trinidad and Tobago. The report was then considered at a meeting of Caribbean educators held in Barbados in June 1987 and revised in the light of their comments and advice. It is a pleasure to acknowledge the work, the insights and personal contributions of the participants at the meetings which have informed this short report.

We are glad to acknowledge too, the help we have had from Robin Bartlett, Bill Broderick, Geoffrey Hubbard, Lorraine Stone and John Wood who contributed to and commented on drafts of this report. It does not, however, necessarily represent their views but is a working document prepared for the Secretariat.

We hope it will be useful to Commonwealth educators of many kinds. We would welcome comments from users and critics in the hope that we can, in due course, produce a fuller and better edition.

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Introduction

This book is about information technology in the classroom. Its purpose is to provide information to anyone who might be involved in the planning and implementation of a national programme for the introduction of computers into schools.

Computers have already made their mark in industry, commerce and education all over the world. In the early days, their size, cost and complexity meant that they were available only to large, rich corporations and well-endowed universities and research establishments. As they have become smaller, cheaper and more reliable, they have become available to small businesses, schools and colleges and, in richer countries, to individuals in their own homes.

Many countries, in spite of restricted education budgets, have found the resources to introduce sophisticated microcomputers into their schools and colleges. There are, however, many countries in the Commonwealth with scarce resources and other urgent priorities for development. Computers in schools may seem to many in these countries to be a self-indulgent luxury which rich countries can afford because they have no more urgent priorities. On the other hand, they may take the view that the introduction of computers into the curriculum of their schools and colleges is an essential step in the struggle to close the technological gap between rich and poor countries.

Until recently, there has only been limited information available on the experience of using microcomputers in education, their costs and effects; and most of this information has come from industrialised countries. To fill this information vacuum, educational planners often turn to computer specialists for help and advice about how to proceed. However, computer specialists are rarely in a position to take full account of a country's development priorities, and they usually have little experience of curriculum development at school level. They tend, as a result, to recommend courses of study which are abstract and theoretical, and to specify computer equipment and software which is more appropriate to commercial or scientific environments. This book builds upon the experience of *educators* in an attempt to support the formation of policy on the use of microcomputers in education in developing Commonwealth countries. It is based upon the advice of Commonwealth specialists who came together in May 1986 to pool their knowledge and experience.

This book is organised in two parts. We look first at the background against which policy decisions can be made, outlining the kinds of educational activities which can be supported by computers and some of the reasons normally given for introducing information technology into education. In the second part, we consider the kind of support structures which will facilitate the implementation of a national computer education project and examine the main cost items involved in such an implementation.

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.

Part Two: Implementation

Information technology in schools is still a relatively new area of curriculum development. As more educators become involved, and as the technology itself develops, new opportunities for education will become apparent. It is important, therefore, that structures which are created to implement a national project are flexible enough to respond and react to new developments, as they occur.

In this part, we give consideration to the main functions which any central organising groups will need to fulfil, and make some suggestions about the kinds of specialisms which need to be represented in these groups.

We go on to discuss the three main cost items which occur during the implementation of an information technology project: the computer equipment (hardware), the programs which will be used (software) and the training of teachers. Decisions which are made initially about all three areas will have long-term curriculum effects as well as long-term cost implications. At the planning stage, therefore, it is important to consider with great care *which hardware to purchase,* whether to invest in the *local development and production of software,* and to ensure that *initial training for teachers is appropriate* and that *continuing support is provided.*

Support structures

A programme of information technology needs an organisational structure to support policy formation and the implemenation of policy decisions, to identify existing expertise, to ensure the efficient use of resources and to facilitate communications between the various groups who are involved.

The aims and intentions of the programme need to be clearly articulated in the early stages of planning and clearly communicated to those people responsible for implemenation. It is quite likely that, as the programme of implementation progresses, these aims will need to be revised in the light of practical experience. However, if no attempt is made at the beginning to commit to preliminary aims, there will be no way of evaluating progress, making resource decisions or planning teacher training and unnecessary costs may easily be incurred.

There are at least five major functions which need to be fulfilled:

- policy development, in the light of national and educational needs;
- project management;
- continuing support for the professional development of teachers;
- curriculum development, including the creation of curriculum support materials for classroom teachers;
- technical support and maintenance.

Policy Development

Policy formation and development can be carried out by a specific group such as a selected advisory or steering group, containing representatives of the various interested parties - government, employers, educational specialists, universities, teacher-training institutions, parents, and practising classroom teachers. This broad representation is advisable in the case of information technology because policy decisions will need support from all the various groups if they are to be successfully implemented, and the realism of policy decisions will be constantly assessed from a variety of perspectives.

Unless there is broad representation, decisions about, for example, hardware support may easily be made on technical grounds, without reference to the curriculum implications of such decisions. Obviously, new technology should not be introduced for technology's sake. That possibility can to some extent avoided by ensuring that educators and curriculum specialists are involved in all discussions about the use of microtechnology in schools.

Some educators claim that computers can revolutionise teaching, offering children and adults alike new opportunities for learning and providing an additional means for achieving many desirable changes in teaching methodology. Others will argue that if the same amount of money currently being spent on computers was spent instead on teachers, teacher training, community education projects and more traditional resources such as books, then education could come much closer to achieving its aims. Both claims are valid, so it is important that computer technology should be viewed in terms of how it can contribute, if at all, to *national* plans for educational and economic development.

The success of an such an initiative, particularly one which is likely to make extensive demands upon available resources, will depend to a great extent upon the articulation of a clear set of aims and objectives. This not only has the advantage of supporting project managers and ministry officials to make difficult decisions, but it enables the project to be regularly evaluated so that unnecessary expense can be avoided and ineffective strategies can be changed.

Project Management

The day-to-day management of the implementation usually requires a full-time professional group whose main skills lie in their ability to manage educational change. Computer awareness, and the ability to handle hardware and software effectively is also necessary, but such skills are relatively easy to acquire. Professional educators will already understand many of the possibilities and constraints in bringing about educational change and will have greater credibility with the teachers they will be working with.

Such a team would require access to specialist advice, from time to time, and would need to work in close collaboration with other teacher trainers at colleges and universities. They would also be responsible for interpreting policy and translating it into action and for keeping policy-makers and administrators informed about the project's progress.

Whatever the rationale, implementation will demand the same combination of care and determination as other educational innovations. It is very useful, therefore, if those professionals who are given responsibility for computer initiatives have some experience of managing changes outside the area of computing. Although computing in schools may be seen to be different from other educational innovations, it requires many of the same skills needed for any form of educational innovation. Project leaders should be chosen with care. Some may lose touch with the objectives of a project, perhaps requiring technology which is more sophisticated than necessary, and more software than is necessary, and fail to understand that teachers are in need of a great deal more support than knowing how to use the equipment technically and what to teach. They have to be aware that principals, teachers, parents and children all have to be sure that there will be benefits for them when teachers change their traditional ways of working.

Structures for evaluation and feedback are particularly important. A successful project will need to have feedback in order to ensure that it is meeting its objectives. It will also need to ensure that principals and teachers can make their feelings and views heard; the involvement of school or college principals can be crucial to a project and it is important to secure a high level of commitment from them.

Professional Development of Teachers and Curriculum Development

Some of the most valuable uses of computers challenge existing attitudes in education, particularly those about the role of the teacher. If this factor is ignored during the training of teachers, and they are allowed to use the computers with their previous attitudes and practices intact, the initiative may prove ineffective in enriching the quality of education provided. Alternatively, if the teachers sense that the introduction of computers is threatening their role and they are given no way of articulating this fear, they may see the initiative as an expensive and irrelevant experiment which is out of touch with the realities of the classroom, and effectively reject the innovation.

If computer scientists or trainers more used to a commercial environment are given responsibility for the introduction of computers, these fears will only increase. It therefore makes far more educational sense if teacher training and curriculum development are carried out using existing educational expertise and existing structures for the support of teachers and the development of curriculum materials. It also makes economic sense to build on, and make use of, exisiting expertise.

Where there is an existing network of teacher resource centres, or support centres, these could be equipped to carry out much of the in-service education programme to support information technology, and this is discussed later.

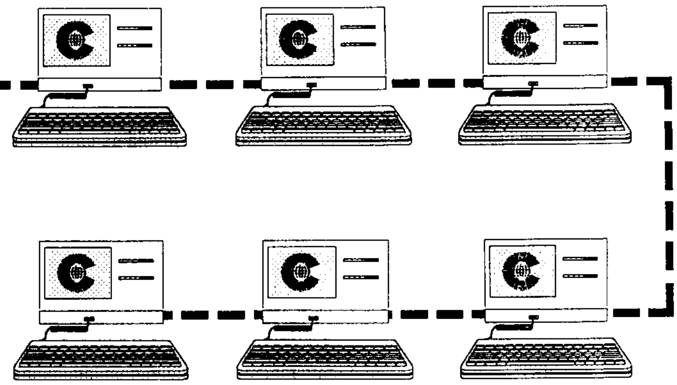
Subject inspectors, educational advisers or curriculum specialists can also be supported to develop their understanding of information technology, and be encouraged to take account of new developments in any teacher training they undertake in their curriculum area.

While the technology involved may be new, most of the educational issues and support needs are familiar, and the skills to work with them are probably already present within existing teacher support structures. Where such support structures do not already exist, it may be necessary to set up special support centres on a local, national or regional basis, depending upon the geographical area the centre is designed to support.

Technical Support and Maintenance

Microcomputers do not need to be kept in a special enviroment, or treated with exaggerated care. They are in fact suprisingly robust, but there are some measures which should be taken for the avoidance of trouble. Unless machines are kept in good repair, and teachers have access to technical support for minor repairs, or for answers to simple questions about hardware and software, much of the impetus of the project will dissipate. In the longer term, it is certainly important that a good, local maintenance environment is developed to create an independent facility for repair and maintenance. In the shorter term, computer manufacturers and dealers could perhaps, as part of their contractual agreement with governments, be required to make a contribution towards the training of local technical staff who can support schools in the early stages.

What Equipment is Needed?

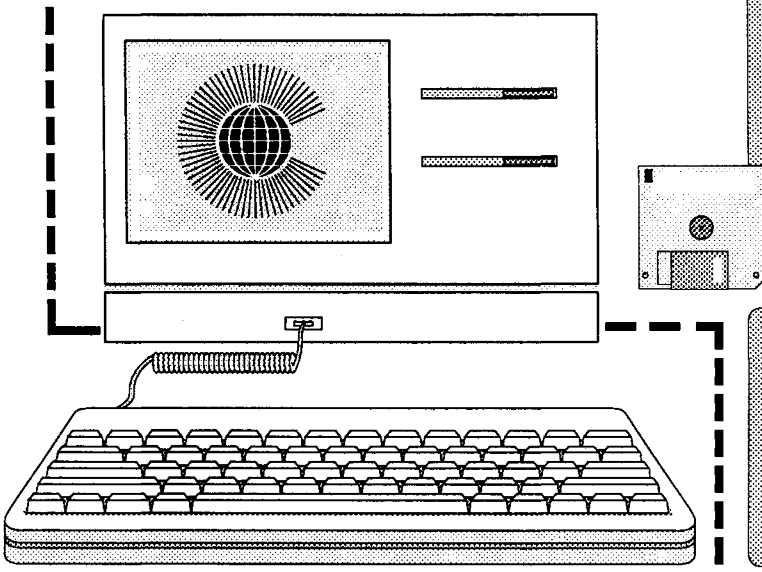


A Monitor or Video Display Unit (VDU)

These are available with low, medium or high definition, so it is important to check the readability of the text. The quality of display of an ordinary television set is not satisfactory and may damage students' eyesight.

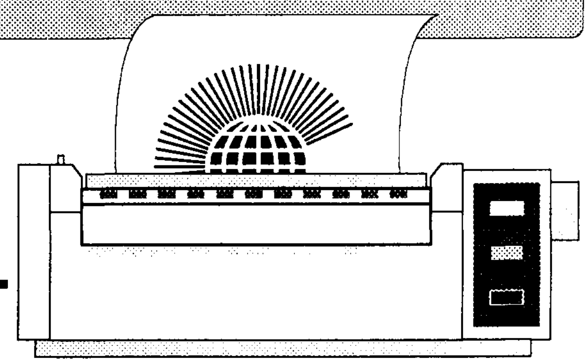
Disc Drives

These come in a variety of sizes and formats, of which the most common is the 5.25 inch. or 3.5 inch discs in plastic cassettes. Single or double disc drives may be used: at least one machine in each establishment should be fitted with two drives to make copying easier.



Dot Matrix Printer

It is valuable to have results on paper. Dot matrix printers are faster than the more expensive daisy-wheel printer. One printer can be shared between five or six machines.



The Computer Itself

Sometimes this will not be a separate unit but will be incorporated into the keyboard, the monitor or the disc drive. It consists of a processor and memory, and may also have a computer language such as BASIC.

Computer Networks

Networking, or linking a number of computers in a single circuit with access to a common disk drive or printer is increasingly popular. However, while such systems may offer savings they can also give rise to significant problems in setting up and support. There are advantages if all computers in the programme can be used on their own.

Hardware

While the cost of computer equipment has fallen dramatically over the past few years, it still represents a considerable investment. In addition to the computer itself, peripheral equipment such as disc drives, monitors and printers will be needed for educational use. The temptation to buy smaller, less powerful computers for schools because they are less expensive can be a costly mistake, once the limitations of the equipment become apparent. Some computer manufacturers will offer substantial 'reductions' on computers which have, in fact, been rejected in other markets or have become obsolete. It is important for developing countries to ensure that any equipment they buy can serve their purposes and be maintained locally. ***The most important consideration is selecting hardware is the availability of appropriate software.***

There are strong arguments for standardising on hardware. The main benefit that arises out of a decision to standardise on particular computer hardware is usually thought to be the purchase of cheaper equipment through bulk buying. However, many other benefits, which may effect even greater savings in the longer term, will follow from such a policy decision. For instance, it becomes much more cost effective to provide teacher training, technical assistance, and advice about hardware and software. It also facilitates the production of curriculum and teaching materials which can be disseminated throughout project schools.

Many administrators are concerned that the enthusiasts for new technology urge the frequent replacement of equipment. In fact there is a distinction to be made between the working life of equipment and the onset of obsolescence. In the present rapid state of development of microelectronics all equipment actually on the market is, in a sense, obsolescent; something better is always just about to be launched. But this is not a reason for indefinite delay; we must recognise that it is so and act just the same.

Fortunately another feature of the technology is that it is becoming increasingly robust, and lasts remarkably well. Computer equipment can be expected to have a working life of up to five years and, although older machines may be retired from their original function, they can often take on another educational role.

On what basis should the choice of hardware be made?

When choosing hardware for school use, it is important to recognise that computers have been developed for different purposes, and that not all computers will be suited to an educational enviroment. The following criteria, again based on the experience of countries currently involved in information technology projects, may prove useful. Before these criteria become useful, however, it is essential that policy-makers have made decisions about what the project is hoping to achieve *in curriculum terms.* Unless curriculum aims are articulated as the first stage in the planning process, there will be no educational basis for the necessary decisions about software, hardware or training.

- Is there a range of appropriate software currently available?

  Computer manufacturers have a reputation for promising that the software product a client most wants is in production. Hardware decisions should be made on the basis of software which is already available.

- Has the hardware already proved to be successful in similar learning enviroments elsewhere?

  A great deal of time and money can be saved by learning from the experience of other people, and by making use of the materials which have already been developed.

- Does the manufacturer of the hardware you are considering have a good reputation for continuing to support models which have been superseded by new developments?

- Can you arrange for good, local technical support from the manufacturer or a reliable agent?

  The costs of maintaining equipment, and even of obtaining simple technical advice, can be prohibitive and often lead to equipment lying idle in a state of disrepair.

Once a decision has been made to standardise on a particular product, it can often be in the interests of other groups (such as public libraries, community centres and any other education support services) to make the same choice, and it will certainly be in the interests of the project to encourage that choice. The result will be an increase in the general availability of knowledge, support and expertise based upon that product.

Ill-informed decisions about hardware can easily undermine a project's curriculum intentions. For instance, the decision to install a networked computer room into every project school may remove the ability to have flexible computer use, if that is what the project is attempting to develop. Continual reference to the project's stated curriculum intentions will usually guard against the danger that money is spent on technology which is technically impressive, but educationally inappropriate.

If a country's industrial development policy is pressing for the creation of an indigenous microelectronics industry, there may be strong pressure to use the educational market to support that policy. The crucial importance of adequate suitable software should be particularly emphasised in these circumstances.

Software

The kind of software which is appropriate will depend upon what the project is aiming to achieve, but it should be stressed that there will need to be a substantial allowance in any budget to cover the purchase, maintenance and possibly the development of software. As the use of computers within a particular educational system develops, teachers will want to keep up to date with software, so it is also important to budget for ongoing costs for this. If software costs are to be passed on to the schools, head teachers need to be made aware of this issue, in case they assume that the teachers themselves, after a short training course, will be able to write sophisticated educational programs.

Does each country need to develop its own educational software?

Software development is expensive because of the time it takes to write and to test and because of the demands it makes on skilled technical staff. Moreover, good educational software needs to emerge from a close collaboration between experienced teachers and skilful programmers. The development of trivial software is a much quicker, and cheaper, process, but good software needs much more skill in programming than a practising classroom teacher is likely to acquire in the short term.

It is not economical, or indeed sensible, for every educational system to develop all its own software, although differences in the language of instruction and in cultural context may require that some software is adapted and maintained locally. Where there is a desire for a large number of subject-specific programs which are culturally relevant, however, local software development will be necessary. But experience in countries which have been using computers in schools for some time seems to indicate that subject-specific software is superseded relatively quickly by the more powerful aplications referred to here as 'generic' or 'content-free' software. It may be wise, therefore, for a country which is just about to begin using computers in schools not to commit too many resources to local software development in the early stages of the project.

Where a project has decided to use generic or content-free software, the main efforts required can be undertaken by ordinary teachers who have no programming skills. The main requirements, in this case, would be for the collection of data, and for the production of curriculum support materials for use in the classroom.

Provided that schools have a relatively small number of powerful software packages, students can be provided with computer applications for a whole range of activities: to help them analyse and understand, to be creative, to acquire a range of problem-solving skills and strategies, to present their ideas in written and graphical form, and to encourage them to collaborate and discuss their ideas. The starting point, therefore, may be to review existing software and consider how it can be adapted to meet local needs and circumstances.

Generic software packages, such as spreadsheets, information-handling packages, design packages and word processing programs can have a place in many subject areas. It is therefore possible that a small number of programs or suites of programs will provide ample opportunity for developing the use of microcomputers for various purposes in schools. A programme based on, say, five such widely applicable pieces of software would be flexible in its use and would not impose too many difficulties in the support which is needed for maintenance and training.

Where the emphasis is on the development of technical skills, particularly programming, it may be necessary to purchase additional programming languages for use in schools. *Basic* is the computer language most commonly found in microcomputers, but it is by no means the most useful language for students to learn. Increasingly, structured programming languages such as *Pascal* and list-processing languages such as *Logo*, are seen to provide a far better basis for computer science students, although these usually have to be purchased separately.

Training

By far the most important factor in the success of any educational innovation is the training and support of those people involved in its implementation. The needs of teachers, principals, administrators, technical support staff, college staff and those involved in teacher education all need to be considered. If, as is often the case, this is under-budgeted, or receives a lower priority than hardware or software purchasing, then much of the investment will be wasted. There are several general issues to be examined before determining a training strategy.

First, it is important to recognise that many people feel anxious about new technology and have doubts about its importance for education. Training activities, for all groups, need to take this into account and try to create an atmosphere where participants feel free to express doubts, uncertainties and prejudices as well as to share their insights and excitement.

To help this process, tutors responsible for training and support need as far as possible, to be people with whom teachers can readily identify. If all the tutors are male, for example, then teachers will be given the impression that computing is mainly a male activity. If the tutors are technically orientated and fluent in computer jargon, this reinforces a perceived need for technical skills, whereas if they are seen as educators teachers will receive a very different message, and their training is likely to focus on the difficult but important educational issues.

When selecting teachers for training there are good reasons for seeking educators from various backgrounds. Many Commonwealth countries have a severe shortage of mathematics and science teachers and cannot afford to exacerbate this problem by asking them alone to introduce information technology. Most uses of computers do not need mathematicians or science specialists and many of their uses demand skills from other disciplines. Those selected to lead developments in schools need primarily to be good practising educators who are interested in using computers with children. If they are also good communicators, and have some professional status within their own establishment, they will be willing and able to pass on their new skills to their colleagues as well as to the children they teach.

Professional development is, of course, a continuing process. The recognition of this is particularly important in the field of microelectronics because of the rapid rate of development and the magnitude of its potential impact on the curriculum during the coming years.

Who needs training?

There are several different groups of people who may need training, including policy makers, teacher trainers, heads and principals and classroom teachers.

The attitudes of policy makers and those responsible at the higher level may be crucial. They do not need to have a detailed knowledge of what is involved or to be personally proficient in the field, but it is important that they should show interest in, and demonstrate support for the programme. High level conferences devoted to an exposition of the aims and intentions may help to achieve such support.

Those responsible for the training and support of teachers are a key group, and the time and resources allocated to their training needs to reflect this. At all levels of training it is important that the training method as well as the training content is directly related to the aims of the programme and its implementation in schools.

Attention also needs to be paid to the needs of heads of institutions. They have an important role in that their understanding and enthusiasm can be a major factor contributing to success, while their indifference or opposition can be an almost total bar to progress in their establishment. They need to be provided with opportunities to consider and discuss the rationale behind the programme and their role in training, management and support, and they may request assistance in developing their role in relation to the professional development of their own staff. They will also need opportunities to gain an understanding of the educational implications of information technology.

What kind of training do teachers need?

The in-service training of teachers needs to be directly related to their classroom work. It should include a deal of practical work with the computer, using software appropriate to their own teaching. Training courses require generous provision of hardware and software. It is also important that the teachers' training relates directly to the resources which are to be provided in their schools, otherwise they will experience frustration when attempting to practise their newly acquired skills. In-service training in information technology should be seen as a continuing responsibility. While short courses, of perhaps two to four weeks, may serve to introduce teachers to ways of using microcomputers, they will have further needs for training and updating.

The strategies adopted for training should take into account any existing structures for pre-service, in-service training and continuing support for teachers. They will also depend upon the nature of the programme; what is appropriate for the national programme designed to provide education about computers for a majority of children, may not be appropriate to a programme aimed at a small group in the tertiary sector.

It is difficult to be categorical about the length of initial training which is required. Teachers need to acquire sufficient knowledge, confidence and competence to allow them to use their skills in the classroom. Without aquiring confidence, teachers will be able to achieve little. An initial course of one or two weeks, followed by frequent subsequent meetings has in some cases proved an effective strategy, even though it restricts the rate at which teachers can be introduced into the programme.

Teachers will continue to require some kind of support, even after they have attended a number of short courses. There will be scope for them to receive some of their training at a distance, perhaps through the development of correspondence materials to supplement their practical initial training.

How can continuing support be provided?

During the initial stages of a programme, the various groups which are to provide curriculum advice, teacher training, technical support and so on, whether they are newly created groups, or part of existing structures, should be in a position to provide day-to-day advice and help teachers with classroom organisation and provide information about hardware, software and training.

Fast access to quite simple advice, most of which will have been covered during training, can ensure that the newly aquired computer systems are not left unused, or treated with such exaggerated care that they are under-used. For instance, there may be problems with power supply and stabilizing devices. Where mains supply is unreliable, programs and files of data can occassionally be lost unless careful attention is given to making 'back-up' copies of discs. Or questions may arise about the portability or siting of equipment, or about locking equipment away when not in use. It is sometimes necessary to balance the need for security against the benefits of easy access.

One of the functions of a support service is to provide information. It may be possible to make arrangements for gathering and disseminating information from within the programme, and from external sources, using newsletters, information sheets, an enquiry service, or by setting up special libraries or information centres. Where a reliable telephone service exists, it may be possible to use the computers themselves to support the collection and dissemination of information, for example, through an electronic mail service.

The creation of programme centres may facilitate the provision of continuing support for teachers. As part of their role, such centres can provide:

- a focal point for the development of curriculum materials;
- short courses and further teacher training on a regular basis;
- a meeting place for teachers to discuss curriculum issues or classroom practices
- a library of books and journals for teachers to study, borrow or reference;
- a venue for small seminars and exhibitions to take place;
- somewhere for teachers to phone if they run into difficulty;
- technical support and maintenance;
- information about classroom practices, hardware or software, taken from teachers' own accounts;
- information about the programme and its policies.

Such centres need to be reasonably accessible to teachers in the programme.

In general, it is wise to be generous in providing resources and equipment for groups who are going to be directly responsible for supporting teachers. It allows them to gain wide and varied experience themselves, and it enables them to be generous towards requests for help from schools and for the short-term provision of a replacement for a machine needing repair.

Costs

Computer education programmes have, in the main, been introduced without careful advance costing, and it is has been difficult to assess costs after the commencement of a project when they are made up of a number of different elements, often paid for by different agencies, and many of them hidden. Hence there is a shortage of good cost data. Below we summarise the main items that make up the cost of introducing and using computers, making some generalisations where possible.

Costs can usually be classified under eight headings, the first three of which represent capital costs while the remainder represent cost which are recurring:

a) **Buildings**. Special buildings are now seldom needed for microcomputers. Whereas air conditioning used to be necessary, this is no longer the case. However, costs may be incurred by, for example, the installation of new electricity supplies, making the building secure, or providing special benches.

b) **Equipment** (including microcomputers and peripherals). The price of equipment has been declining dramatically so that,in rich countries,a private individual can now afford to buy a home computer with the power that only a university could afford twenty years ago. Further reductions in the cost of microcomputers or improvements in their performance can be expected. But the costs of peripheral equipment - disc drives and printers - may not show such dramatic falls, as they depend on precision engineered moving parts whose manufacturing costs show no signs of similar decline. As the technology is changing rapidly, it is difficult to say how long the euipment can be expected to last under classroom conditions. A figure of about five years may be reasonable.

c) **Software** (purchase and/or development). The costs of educational software have not declined in pace with the reduction in the cost of hardware. For,while advances in the technology have made it easier to do some parts of software development,much of it demands many hours of writing and testing: it demands the use of skilled manpower and costs of this show no signs of declining. It is difficult to talk about the life of software,but this is likely to be limited for several reasons. As hardware changes, so it may be necessary to adapt the software, and where one of the purposes of the progamme is to familiarize students with the uses of computers they will meet at work, they may need to use current commercial software. A figure of three to five years may be reasonable for the life of software.

d) **Maintenance**. Maintenance costs will arise for both hardware and software. It would probably be unreasonable to estimate these at less than ten percent of the original capital cost. And the wide, sad experience of capital equipment of all kinds lying idle for lack of spare parts and maintenance, is a warning for us in education as in industry and transport.

e) **Consumable Items** (eg paper and floppy discs). Computers also need consumables. Their appetite for paper can be considerable. Printers need ink or ribbons.

f) **Training for Staff Working with Microcomputers**. Training and support costs will depend on the programme and the existing structures, but will certainly be needed.

g) **Specialist Staff**. Some specialist staff may be needed. If only a few schools are using computers, then it may be possible for them to be serviced and supported by regular ministry of education staff and by the local computer support industry. Once a project becomes bigger, specialist staff may need to be appointed.

h) **Other Running Costs**. Running costs for a computer service will include the cost of electricity,of consumables, and for items such as travel and transport for training, support and maintenance.

We can draw two broad conclusions from the very small number of cost studies that have been done.

- The use of microcomputers in education increases the cost of education. We do not have enough data to suggest what level of add-on cost might be expected, or how this would compare with the costs of other educational innovations. Nor do we have measures of the benefits to set against the costs.

- The cost of hardware is only the beginning of the story. Training, support costs, staffing and software are likely to cost at least as much as the hardware when we look at costs on an annual basis. If, therefore, a decision is taken to put computers in schools then it is reasonable to assume that the schools will need to spend at least as much on resources to support those computers as was needed to buy them.

How can costly mistakes be avoided?

What follows in this last section is a brief summary from this report of some ways in which costly mistakes can be avoided, based upon the lessons learned from the experience of others.

As noted above, the temptation to buy smaller, less powerful computers for schools *because* they are less expensive can be a costly mistake, once the limitations of the equipment become apparent. The 'bargains' offered by some computer manufacturers will be on computers which have, in fact, been rejected in other markets because there is little, if any, existing software to support their use. This is particularly an issue for developing countries who need to ensure that any equipment they buy can serve their purposes and be easily maintained locally.

Standardising on a particular make of computer can bring cost benefits. The main benefit that arises out of a decision to standardise on particular computer hardware is usually thought to be the cheaper prices of equipment obtained through bulk buying. However, many other benefits, which may effect even greater savings in the longer term, will follow from such a policy decision. For instance, it becomes much more cost effective to provide teacher training, technical assistance, and advice about hardware and software. It also facilitates the production of curriculum and teaching materials which can be disseminated throughout project schools.

Poor decisions about hardware can easily undermine a project's curriculum intentions. For instance, the decision to install a networked computer room into every programme school may remove the ability to have the flexible computer use that the project is attempting to develop. Continual reference to the project's *educational* aims will help to avoid the possibility that impressive technology will not be purchased unless it has a role to play in the project.

The national objectives for introducing information technology into a particular school system, if communicated well down the organisational structure, should form the basis for policy decisions about the specific curriculum aims and intentions which teachers will be trying to achieve in their use of computers. Translating those curriculum aims into worthwhile educational activities will require curriculum materials which will support teachers in their work. Some of the support materials will be books and other paper materials, but the most important prerequisite for the success of a project is the appropriate educational software.

Software does not have to be an expensive feature of a programme. Whilst it might be important for the curriculum support team to keep up to date with developments, it is now clear that with only a relatively few powerful software packages students can be provided with computer applications for a whole range of curriculum activities.

New structures do not necessarily have to be created when many of the implementation issues are common to other areas of educational practice. It may be possible to make considerable savings by building on strength and using existing structures.

The use of computers in education is essentially an educational issue, not a technical one.

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