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ABSTRACT

Reasons underlying the growth of interest in Asia and the Pacific region in educational computing and issues raised by such developments are examined in this paper, which begins by describing three main areas of use of microcomputers in schools--for teaching computer studies, for computer assisted learning, and for school adminstration. Reasons for microcomputer use are considered as well as internal and external influences that affect the decision to incorporate computers in school activities: (1) the need to relate education to the needs of the economy; (2) parental pressures; (3) pupils' expectations; (4) the need to facilitate data processing for reporting to external groups; (5) the need for better information for decision making; (6) demands for increased efficiency; (7) assumptions of increased learning effectiveness; (8) push from technical experts; and (9) marketing policies of manufacturers and suppliers. Also considered is the impact of the introduction of computers in schools on teaching methods, curriculum content, and the organizational structure of schools. Issues that are likely to arise with the use of microcomputers in schools are discussed, e.g., funding, suitable computer programs, teacher training, equipment requirements, cost effectiveness, responsibility for computer use and management, and contingency plans for equipment breakdowns. The importance of feasibility and cost benefit studies and consideration of the organizational, behavioral, and managerial issues involved in planning for computer based programs in schools is emphasized. Twenty references are provided. (MES)

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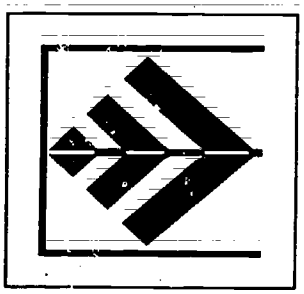

MANAGEMENT AND PLANNING ISSUES IN THE USE OF MICROCOMPUTERS IN SCHOOLS

by

David Lancaster

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Introduction

One of the most significant educational developments currently concerns the use of microcomputers for teaching purposes and for school management. Although microcomputers are still relatively expensive in comparison with other pieces of educational equipment, they have fallen rapidly in price during the last few years to the extent that in many countries it is now meaningful to consider their feasibility in both educational and financial terms. As with all resources, particularly relatively expensive ones, this raises a number of questions about anticipated and actual benefits and costs, both financial and non-financial, and implies that decisions and plans will need to be made both within Ministries of Education and schools.

Many of the decisions are apparently concerned primarily with educational efficiency and effectiveness (such as: should microcomputers be used only in one area of the curriculum or across the curriculum?; with what ages of pupils should they mainly be used?). Nevertheless, such resource utilisation matters inevitably also raise fundamental questions of educational access and equality including urban/rural differences, the effects on national and regional cultures of the adoption of a technology developed elsewhere, and the balance in the education system between modern and traditional skills and values.

The purpose of this paper is to examine the reasons underlying the growth of interest in educational computing and the issues which such

developments raise if the innovation is to be managed so as to exploit the potential benefits of the new technology. Although the paper points out the limitations, disadvantages and problems associated with the use of microcomputers in schools and does not assume that their use is necessarily appropriate in all contexts, it does attempt to identify and address questions which are relevant if microcomputers are being considered for introduction or are currently being used in an educational system. Whilst the paper focusses on schools, a number of the issues raised are relevant also in the context of colleges and vocational training institutions and some are applicable also to institutions of higher education.

The paper starts by discussing three main areas of use of microcomputers in schools and then considers the reasons for their use and the influences and pressures, from within and outside schools, which affect the decision as to whether to incorporate computer use into the activities of schools.

The impact of the innovation on the school is then considered, particularly in respect of potential changes in the content of jobs and of organisational structures (both within the school and in terms of the relationship between the school and regional or national educational offices) which may be associated with the introduction of computer technology. This section draws extensively on research on the impacts of the introduction of computer technology in sectors of the economy other than education, and considers the extent to which effects in those sectors may be expected to be replicated within the education system. Three possible future scenaria relating to educational computing are then reported.

Finally, the issues raised by the development of educational computing are considered in respect of both Ministries of Education and schools.

The paper is based partly on the experience of the author, partly on discussions with educators in the Asia and Pacific region and partly on educational, computing and management literature from the region and elsewhere.

It is likely, of course, that the reasons for introducing (or deciding not to introduce) microcomputers in schools will be different in different countries or regions. Further, in relation to the effects of the innovation, the position which is taken in the paper is not one of technological determinism. It is suggested, rather, that the effects of this, and other innovations, are mediated by the social, political and cultural context in which the technology is introduced, and the effects occurring in one setting may well not be repeated in another. And, although the paper considers first some of the factors influencing decisions about the introduction of microcomputers, and secondly the effects of their introduction, these two aspects are not considered to be independent. The effects of using microcomputers in schools are likely to be systematically related to the reasons for their introduction, which is again contrary to the technological determinism perspective. The rejection of that perspective makes it inappropriate to assume that the experience in one or more countries is directly transferable across national or cultural boundaries. Although the issues addressed in the paper are believed to be widely relevant, they will not all be universally applicable.

The paper is presented, then, not as a blueprint relating to the introduction of microcomputers in education but as an analysis of, and in some parts a speculation about, aspects of an innovation concerning which there is substantial interest in many countries in the Asia and Pacific region and which may become as significant in education systems as it is in some other sectors of national economies.

Uses of microcomputers in schools

There are three main areas of use of microcomputers in schools: for teaching computer studies, for computer assisted learning in other areas of the curriculum and for school administration.

(i) For teaching computer studies

Computer studies is one of the most rapidly growing subjects in a number of countries in terms of the number of pupils studying it. There is clearly a self-reinforcing relationship between the teaching of computer studies and the use of computer equipment; the teaching of the subject creates a demand for computing equipment, and the provision of equipment facilitates the teaching of the subject. The growth of the teaching of computer studies has taken one or both of two forms. In some cases the focus has been on the teaching of the subject to a minority of pupils who will take an externally certified examination in the subject alongside the other established subjects in the curriculum. In other cases the emphasis has been on the provision of a 'computer awareness' course, in which case the course will probably not be geared towards an external examination. Computer awareness courses can be focussed either at the later stages of secondary education or in the earlier years of secondary school or in primary education. Initially, such courses tended to be developed for senior secondary pupils, but these have increasingly been replaced by or augmented by courses for younger pupils.

With limited computing resources available in each sector of education, the decision about whether such resources should be used to give a limited exposure to computing to as many pupils as possible via a

computer appreciation programme, or whether to utilise the equipment for more advanced study by a minority is likely to reflect views about both equality of educational opportunity and the relationship nationally and regionally between education and the economy. It is also significant in respect of the messages about computing which that decision sends to pupils. A decision to offer only examinable courses in computer studies, which prcbably contain substantial elements of computer programming, to a minority of pupils may imply that computers are technically complex esoteric devices which are relevant to and can be understood by only a minority of people. Conversely, the decision to provide a computer appreciation course, of perhaps very limited duration, for as many pupils as possible can imply that developments in computers and other information technology is likely to be relevant to the future life of a substantial proportion of the population and that some understanding of the capabilities and limitations of computers should therefore form part of a general education.

(ii) For computer assisted learning

The use in computer assisted learning (CAL) has been characterised by a wide variety of learning modes and in a wide range of subjects. Some of the early CAL programs used microcomputers as an 'electronic chalkboard', though it was quickly realised that computer based instructional materials which did not incorporate any pupil interaction and response had no advantages over other media such as film or video and had a lower quality visual output than those media. Another type of program characteristic of early computer assisted learning was drill and practice, where the computer typically presents the pupil with a number

of questions, checks the answers given by the pupil and perhaps records the pupil's performance.

A more sophisticated development is the use of computer managed learning. This normally incorporates didactic material and is followed by a diagnosis of responses and the provision of further instruction at an appropriately higher or lower conceptual level. In computer managed learning, the teacher would normally be provided with information about each pupil's progress and his specific difficulties.

The more recently produced CAL materials have been characterised by the increased use of simulation or data-base approaches rather than drill and practice or tutorial modes. Simulations may be considered as a means of providing learning experiences similar to those in experiments and may be used when experiments are not available because of constraints of cost, time or safety. The simulations involve an inductive mode of learning by encouraging the pupils to ask questions of the type "What would happen if...?" In a data-base mode the computer is used as a means of storing, accessing and processing a mass of data which is typically used to enable pupils to explore relationships between items of data.

All of these modes of use can be seen in a wide variety of subject areas. Computer assisted learning has certainly been extensively used within the sciences, for example in the simulation of industrial chemical processes where students may be asked to investigate the relationship between the efficiency and cost of production of particular chemicals and changes in operating characteristics such as temperature, pressure or concentration of various chemicals. The use of computer

assisted learning, particularly in the sciences, is discussed by Tung (1980) in the context of Hong Kong and by Kow (1982) in relation to secondary schools in Malaysia. Some of the most notable developments, however, have been in areas outside the physical sciences. A number of programmes, for example, have been developed to simulate national economies where the student, by taking the role of a Minister of Finance is asked to explore the relationship between output, taxes, imports and exports, inflation, growth and other economic variables. Historical data bases, often using population census data, have also been used for investigating historical developments, for example, population growth and changes in age and occupational structure. There have been few subjects in the secondary curriculum for which computer assisted learning materials have not been developed, and it is possible to see innovative uses of CAL program in subjects ranging across the mathematical, physical and life sciences, the humanities, languages and creative subjects.

Whilst the diffusion of the use of computers has been most extensive in the secondary sector, some of the most innovative and exciting developments in computer assisted learning have been in primary schools and in the education of pupils who are handicapped or have various learning difficulties.

The development of simplified computer languages, such as LOGO, have been particularly significant in primary education by enabling even the youngest children to communicate easily with computer equipment. The LOGO language is used in schools commonly to assist in the development of concepts in mathematics, particularly geometry, in logical problem solving and control technology. A common method of its use is by small

groups of children using the programming language to control the movement of various simple mechanical devices, which may plot diagrams as they move, thereby providing an environment for experimentation and problem solving. Whilst such activities are directly comparable with industrial control engineering applications, a narrow view of the skills which are being learned has been seen as of less significance than that the learning is active rather than passive and that the children individually and as a group become more self-reliant and learn from their own mistakes and experience and may become less dependent on the teacher and more dependent on their own abilities and those of their peers.

The availability of high resolution graphics and colour output of both static and moving images have given an added impetus to developments in the primary sector. They have also been utilised in special education in facilitating the provision of visually attractive output from microcomputers.

The developments which have been most characteristic of special education, however, relate not to output but to input, in particular to a variety of means of input to enable pupils with specific disabilities to communicate with and via computers. The use of input devices such as special keyboard overlays, joysticks, suck and blow devices and voice input have been found to be particularly useful. Some software has been produced to assist pupils with specific difficulties, but extensive use has also been made of standard software, for example word processing programs can be used in conjunction with the above input devices to enable physically handicapped pupils to produce high quality written materials.

The facility to use microcomputers for individualised learning has also been found to be beneficial within special education, for example in assisting dyslexic pupils. Although the provision of microcomputer equipment in special education has been relatively expensive as it has commonly been used by individual pupils rather than by groups and has often utilised non-standard input devices, some of the most successful uses of computer assisted learning have occurred within the special education sector.

(iii) For use in school administration

In addition to the benefits within administration which are obtainable by the use of microcomputer assisted school administration, the use or absence of use for such applications of any computer equipment which the school possesses can again be significant in terms of the messages sent to pupils. If pupils are taught within a computing course that computers can easily and beneficially be utilised for a wide range of administrative applications and for efficiently storing, retrieving and processing information, they might expect such claims to be reflected within the administrative work of the school itself.

One of the most sophisticated computer based school administration systems is that developed at Lok Sin Tong Ku Chiu Man School in Hong Kong (Chan, 1982). Use in school administration, as in teaching, is characterised by a wide range of applications, including the maintenance of stock records and school library records, examination entries and the processing of assessments and examination results, and attendance registers. The most common applications, however, are probably pupil records, timetabling and word processing.

Pupil records applications vary in sophistication, but usually incorporate the storage of information about the name, address, age, sex, grade, subjects studied and possibly test results in those subjects for each of the pupils in the school. This information can be accessed and sorted for various purposes within the school, from the simple automatic production of lists of pupils in a particular subject group or grade, to cross-tabulations of the type: Which pupils have attributes A, B, C and D but not E or F as in "Which boys in the school aged 14, 15 or 16 are studying both physics and chemistry but not metalwork", which are very time-consuming to produce by the manual sorting of individual lists. Such pupil data bases can also be used to extract the aggregate statistical information which schools may be required to submit for local or national educational administrative purposes.

The history of computer aided timetabling shows a gradual move away from attempts to produce a single-shot optimal timetable to more pragmatic and heuristic attempts to assist the timetabler at various stages in the production of a satisfactory timetable. It can, however, result in a timetable which surmounts more of the educational and technical constraint and/or is produced more quickly than a conventional manually produced timetable.

Word processing applications in schools are similar to those in commercial organisations. They are commonly concerned with the personalising of correspondence in which the majority of the text is identical but in which some details change, for example letters to parents which contain standard paragraphs but in which some information specific to their children is included. Another common word processing application is the production of up-dated drafts of documents in which

some additions, amendments or deletions occur between successive drafts, but in which some of the text remains unchanged. This paper, for example, was produced using a word processing program on a microcomputer, which enabled successive drafts of the paper easily to be updated and the final version to be formatted in terms of the size of paper on which it was to be printed and with a vertical right margin typical of printed output rather than with the 'ragged' right margin characteristic of typed materials.

Editing and updating features of word processing programs can be particularly useful in educational organisations in the production and modification of handouts, pupil worksheets and similar documents. Although word processing is used extensively in school administration it is also finding increasing use in the teaching of writing. The ease of editing and updating and the facility for altering parts of a text without the need for re-writing the whole or producing a paper which includes obvious deletions and insertions can be used by pupils to enhance their own written work. Word processing is also directly relevant, of course, in the teaching of commerce and secretarial studies.

The extent to which the benefits of word processing can be obtained in countries in the Asia and Pacific region depends on the availability of character sets for the languages used. Programs for handling Arabic, Chinese and Japanese characters as well as those based on the Roman alphabet have been available for some time and are available or being developed for some makes of computers for other character sets also.

In educational systems in which significant amounts of accounting and financial work are carried out within the school rather than at district or regional level, microcomputers may also be used for basic bookkeeping and for the processing and storing of accounting information.

Much of the administrative work presently carried out by computers in schools is relatively simple in principle. The search has been for efficiency in carrying out existing administrative procedures rather than effectiveness in achieving organisational objectives. This reflects the pattern of development of computer use within the business sector, which has typically involved routine administration such as payroll, sales and purchases ledgers and stock control as the starting points to be followed by the development of management information systems and the use of models for planning and other strategic purposes. The focus has consequently changed from an emphasis on the generation, storage and retrieval of data to the filtration, condensation and transformation of information and the use of management by exception as a control mechanism, and from a concern with the improvement of existing procedures to the development of new procedures. The same pattern of development from initial administrative tasks to more managerially oriented applications, such as curriculum modelling, may similarly occur within the education sector.

Three major uses of computers in schools have been identified - teaching computer studies, computer assisted learning and use in school administration. Although many authors discuss each of these applications, for example Sakamoto (1981) in the context of Japanese schools, different priorities amongst the uses have emerged in different countries. Whilst in most countries use in all three areas would be

regarded as beneficial and an eventual aim, it is appropriate to consider as a strategy of innovation whether in the circumstance of each country separately it is preferable to develop in all three areas simultaneously or whether to focus initially on only one or two.

Reasons for the growth of microcomputer use in schools

There is probably no single dominant reason for the use of microcomputers in schools. There are a large number of pressures which can be identified which facilitate the development of microcomputer use, some of which are more relevant in some contexts than others. Among these pressures are:

(i) Relating education to the needs of the economy

There have, in many countries, been moves to make education more concerned with the knowledge, skills and attitudes which are directly related to the present and future needs of the economy. Employers, particularly, are commonly concerned that the curriculum should be closely aligned with industrial and commercial needs and that students should be technologically literate.

Whilst there is a clear demand in the modern sector of the economy for specialist computer scientists, there is similarly a demand in some economies for some familiarity with and understanding of information technology by all or most young people as they enter employment. This is significant in relation to the provision of computer studies courses, discussed earlier, particularly the decision as to whether to provide advanced courses for an elite or introductory courses for as many pupils as possible.

Such considerations relating specifically to educational computing are inextricably linked with the wider issue of the balance in the education system between orientations to the modern sector and to the traditional

and/or informal sectors of the economy, which, in turn, may be associated with activities mainly carried out in urban and rural areas respectively. There is a self-reinforcing relationship between the use of microcomputers in schools and the economic infrastructure of an area. Educational computing requires access to electrical power and can be more easily be provided and supported in areas of a country where there is access to repair facilities and computing expertise; such access is, of course, usually more readily available in urban rather than rural areas. The acquisition of computing skills in schools can, in turn, feed into the local economy and may therefore reinforce differences between the urban and the rural economy.

(ii) Parental pressures

At a time of high unemployment of school and college leavers, the demands of industrialists for vocationally relevant education are supported by many parents who see job-relevant skills including computing skills as instrumentally beneficial in terms of the future employment prospects of their children. Where parents have expressed wishes for the inclusion of computing in the curriculum in order to improve the future employment prospects of their children, this has commonly been expressed as a wish for certificated courses to be taught rather than for a computer appreciation module to be included.

Schools are responsive to parental wishes to varying degrees, so the extent to which this factor is significant probably varies in different situations. In cases where parents have collectively been a major source of funds specifically for the acquisition of computer equipment it has been difficult for schools not to respond to parental wishes.

Whilst schools may vary in the extent to which they are willing to react to parental influences on the curriculum, they are likely to be proactive in promoting a positive view of the school to parents and other members of the community. The acquisition and use of computer equipment and the inclusion of computing in the curriculum have been used to enhance a school's image and been presented as examples of the progressive character of the school.

(iii) Pupils' expectations

The extent to which pupils' expectations can be a significant influence on an educational innovation, and the knowledge which they have acquired outside school can be a threat to some teachers are particularly interesting phenomena currently in the context of educational computing. A number of pupils are becoming familiar with the educational potential of computer technology via television and other media and may be familiar with the operation of some microelectronic devices from various electronic games which are becoming increasingly popular in a number of countries. The current and anticipated growth in the use of home computers is also significant in this context. It is commonly found that children become familiar and at ease with the operation of such equipment more readily than do adults. As more pupils become familiar with microcomputers an expectation may develop that teachers will use microcomputer technology confidently and appropriately in the teaching context. Such an expectation can be particularly threatening to some teachers who may be less confident about the operation of microelectronic equipment and less familiar with it, and who operate with the model of education that teachers are knowledgeable and skillful

and pupils are not, and that the function of teaching is to transfer knowledge and skills from teacher to pupil.

(iv) The facilitation of accountability

The increasing influence of employers and parents is a facet of the move in some education systems towards greater accountability to client groups. Computers can also have a significance in respect of the more narrowly bureaucratic interpretation of accountability - the stewardship function. Educational institutions are normally required to account to external groups for the use and disposition of their resources, particularly financial resources. In the same way that commercial organisations have utilised computer based systems for the processing of their basic accounting data, the availability of simple financial programs operating on microcomputers can facilitate the accurate and rapid processing of accounting data and the production of basic accounting statements, which may be used in reporting to external groups.

(v) Need for better information to facilitate decision making

Quality of decision making depends at least in part on the quality of information available to decision makers. Decisions may be improved by the provision at low cost of information which is clear, timely, reliable, valid and accurate. Although the sophisticated decision support information systems which are used in some large commercial and governmental organisations are unlikely to be replicated within educational institutions, it should be possible to utilise microcomputer based information systems in schools and colleges to support decision

making relating, for example, to resource allocation or to performance evaluation.

This can affect decision making at two distinct levels. The more rapid provision of accurate information or the supply of information which was not previously available can be used within the school to support internal decision making. Alternatively, or additionally, the increasing availability of information at regional or national level can facilitate cross institutional comparisons and that information can be used at the more central level to make decisions about institutions.

(vi) Demands for increased efficiency

The cost of provision of education and the proportion of Gross National Product devoted to education ensures that questions of the efficiency of resource utilisation are of central concern in the management of the education system.

There is a common expectation that the use of computer technology can increase the efficiency with which various organisational activities are carried out. This may well be feasible in the context of the administrative work of schools and colleges where the use of microcomputers can be expected to improve the efficiency with which existing tasks are performed. Computers can also be used to implement some management science techniques which may be difficult or impossible to utilise without access to computer facilities. Wilson (1977) discusses the use of operational research techniques such as critical path analysis within Ministries of Education and within schools which have a terminal connected to a mainframe computer. The availability of microcomputers makes the efficiency and effectiveness benefits which are

claimed for such techniques more easily obtainable within schools. If teaching and learning is viewed as a technological production function, the same assumptions about efficiency can apply and lead to the expectation that the use of computer assisted learning can result in the same outcomes with the use of fewer teachers (which, with salary costs in countries in the Asia and Pacific region typically accounting for in excess of two thirds of expenditure and salary costs increasing whilst the cost of computing equipment falls rapidly, is a financially attractive proposition) or that the same number of teachers can enable an increased amount of learning. Although some improvements in learning efficiency may occur, it would be unwise to expect that the use of computer assisted learning will dramatically improve learning efficiency to the extent that there will be a significant impact on pupil teacher ratios.

(vii) Assumptions of increased effectiveness

Particularly in countries which have yet to achieve universal education, the twin problems of increasing the quantity of education to provide for children who are presently partly or totally outside the education system and increasing the quality of education for those within schools pose a major dilemma. Insofar as computers have been claimed by some people to enable educational provision to be made more efficient and by others to make it more effective, educational computing offers the tantalising possibility of achieving progress towards either or both goals.

A concern for effectiveness rather than efficiency has been the focus of interest of many educators who claim that the main justification for the

use of computers is that they can be used to produce educational experiences which would be difficult or impossible to achieve without their use. The use of microcomputers in simulations in the teaching of economics and chemistry, to which reference was made above, are examples of such use. Papert (1980) argues that the main justification for the use of microcomputers in teaching is that they can provide rich learning experiences which are otherwise unobtainable. Specifically, they can be used to generate new ways of thinking in pupils by encouraging them to control their environments via the exploration of non-structured problems, rather than react to their environments by encountering structured problems set by the teacher, and hence to move from dependence towards independence in learning.

A related aspect of the provision of learning experiences which are not otherwise obtainable concerns educational provision in relatively isolated rural areas. Morrison (1984) discusses and advocates a system in the Australian context for using microcomputers in areas which are geographically remote but which have a telephone link, to enable microcomputers to be used not only as stand-alone instructional devices but also, by connecting the computer to the telephone, to enable students to receive teaching materials from a specialist teacher some distance away and to transmit assignment answers for marking, evaluation and subsequent feedback.

(viii) Technological push from technical experts

Innovations can be categorised as either 'needs pull', where the development meets an existing need, or 'technology push', where the driving force is the technical capability to produce something which did

not previously exist. Using this distinction, it is often fruitful to consider which educational applications of microcomputers are carried out because a need has been identified and which because computing equipment is available and individuals have the expertise to make use of it.

Pettigrew (1973) documented a strategy used by technical experts (in his case, significantly, computer experts) of promoting technical solutions to problems as a means of increasing the power base of those individuals with the relevant technical expertise. It is widely accepted that the control of information confers power. An understanding of the information system used in the school, particularly if that understanding is restricted to a few people, can increase the power and prestige of individuals. The use of a computer based information system will increase the dependence of the school on those individuals who have computing expertise and will give such experts increased access to decision makers and an increased opportunity to influence the decision making process. Similarly, the more widespread use of computer assisted learning across the curriculum increases the expert power of those with computing skills. It would not be surprising, then, if teachers with computing expertise argued for the more widespread use of computing, both in administration and in teaching. Similarly, within administration particularly, if the change to a computer based administrative system involves the redistribution of influence or the perception of the redistribution of influence, it is likely to be resisted by individuals without such expertise who have traditionally controlled administrative systems.

It is significant that needs pull innovations have normally been found to be both more successful and more enduring than technology push innovations.

(ix) Marketing policies of manufacturers and suppliers

In situations of competitive marketing, manufacturers and suppliers of microcomputer equipment and software clearly have an interest in promoting the use of microcomputers in schools and colleges. There are two distinct reasons for this. Firstly, the educational market as a whole is potentially a very large and therefore attractive market. Secondly, in terms of their future markets, manufacturers and suppliers have an interest in the future generation of computer users becoming familiar with their make of microcomputer rather than that of another manufacturer. It has been possible in some situations, as discussed below, for the education system to benefit from the second reason for the interest of the computer industry in the education sector.

In countries in which governments have provided funds to the education system specifically for the purchase of microcomputer equipment, this has commonly been tied to the purchase of equipment which was designed, manufactured or assembled in that country and has been used as a means of facilitating the development of a microcomputer industry within that country. Such a symbiotic relationship has, therefore, been of benefit to both the education system and to the industrial sector.

Impact of the innovation

The extent to which the introduction of computer systems causes or enables changes to occur within an organisation or between an organisation and others in its environment has long been a focus of attention in research into the organisational impact of computers. The most consistent conclusion has been that

"It is virtually impossible to introduce a computer into an organisation without creating changes in workflows, structure and organisational relationships". (Tomeski and Lazarus, 1973, p21).

This is consistent with the perspective of systems theorists such as Leavitt, Dill and Eyring (1973) who view organisations as systems in which the significant variables are task, technology, people and structure, the variables being highly interdependent so a change in one (for example technology) is likely to result in changes in each of the others.

A systems perspective leads to the expectation that a change of technology results in changes in tasks and will therefore affect teaching and learning. Two distinct types of effect are discernible: effects on teaching methods and effects on curriculum content.

In some cases, computers are viewed solely or mainly as pieces of educational technology which can enable existing educational objectives to be achieved more efficiently or effectively. In such cases changes within the classroom have been confined to changes in teaching and learning styles, particularly in the use of simulations and data bases, and an increased emphasis on learning individually or in small groups. The use of computer equipment in these modes has generally been very

favourably received by pupils. There is, of course, a novelty aspect of the use of new equipment and new learning modes, but the initial enthusiasm and motivation of pupils shows few signs of diminishing, and the initial fears that enthusiasm was based largely or only on the novelty value seems to be disappearing.

There have been two further substantive benefits reported of changes in learning style. Firstly, much of the best educational software incorporates feedback to the pupil, which can reinforce learning and give the pupil confidence in his own learning. Secondly, individualised instruction can mean that the pupil learns at a speed appropriate to his needs rather than those of the group collectively. Much of the evaluation reported of the effects on learning of the introduction of microcomputers has been based on the professional judgement of individual teachers who have reported their own experiences, rather than being based on systematic research. The weight of evidence seems to confirm the benefits claimed, notwithstanding the tendency for enthusiasts rather than sceptics to report their experiences.

The effects on pupil motivation of the use of computer based instruction, both within computer studies and across the curriculum, has been perhaps the most remarkable aspect of this innovation. In some schools, access for pupils to computing facilities is provided before and after school and at other times outside the normal school day; in such cases there have been very many reports of pupils arriving at school very early or staying very late to make use of the equipment. Most surprisingly, perhaps, the motivating effect has been most substantial in respect of pupils who have previously responded negatively to the educational provision which schools make. The benefits

to both the individuals' self-view and to the schools which these cases represent have been substantial and most pleasing, not least because they were not initially expected.

The use of media-based individualised or small group teaching has effects too on the teacher's role. At the simplest level, it introduces new problems of class management when some pupils are using computer equipment whilst the remainder are otherwise engaged. More fundamentally, it promotes the teacher's role as a manager of learning and diminishes his role as the sole source of knowledge and centre of activities. Although many teachers see such a change as a threat, it has been viewed as a challenge by large numbers too. The admission by the teacher of a lack of knowledge in relation to the new technology can, if handled skillfully, be transformed into a valuable educational experience. One of the most striking features of the innovation has been the enthusiasm and commitment of many teachers who have devoted much of their own time to increasing their skills and in writing computer programs for use in their teaching. Although the computer programs written by teachers for use in their own teaching are variable in terms of quality, the volume of teaching material produced by teachers themselves has been enormous and represents a great commitment by teachers of time and effort.

Whilst the effects on the delivery of the curriculum have been significant, there have also been effects on the content of the curriculum in terms of both new subjects and new topics within existing subject boundaries.

The availability of microcomputers has facilitated the introduction and growth of elementary computer appreciation or information technology courses and the more substantial computer studies or computer science courses. The introduction in schools of courses in microelectronics (which, by incorporating the study of electronic devices other than computers, is more broadly based than computing) or control technology (which may be more narrowly focussed than computer courses) is of even more recent origin. Such developments have caused part of the curriculum to become aligned more closely with industrial concerns by incorporating the knowledge, skills and attitudes to new technology which many employers value.

Such changes in curriculum content are not neutral in terms of the values which they imply. Pena (1983) and Awotua-Efebo (1984) are critical of the importation of technology, particularly educational technology, without a sufficient consideration and recognition of the impact which such technology may have on national or regional culture. Computer technology has been developed mainly in the West, where it was originally used mainly in the mathematical, scientific and engineering domains in applications based on western ideas and ideals of quantification, rationality and objectivity. Although many of the most recent and most innovative uses of computers, particularly in educational institutions, have been developed in areas other than mathematics and the sciences those areas still dominate use in schools, particularly initial use as Tung (1980) and Sakamoto (1981) describe. Such use may, explicitly or implicitly, convey value laden messages to pupils.

Courses in computing may also have implications for the way in which teaching is organised. Although courses in computer studies, computer science, microelectronics and control technology are often taught by specialist teachers, in introductory computer appreciation or information technology courses the opportunity has sometimes been taken deliberately to treat the course in an interdisciplinary manner with a number of teachers from different subject backgrounds contributing to the course either individually or in a team teaching mode. It has been possible to devise courses such that, for example, teachers of history provide a structured consideration of the development and effects of computer technology in comparison with previous technological changes such as the introduction of printing, rail transport and radio; for teachers of commerce to lead the teaching of the effects of information technology on, for example, banking and retailing; and for teachers of language to relate computer programming to concepts of syntax and semantics in human languages. It is clearly possible for these topics to be accommodated within existing subject boundaries, but in terms of the teaching of computing, some of the most successful courses have been those which have adopted an interdisciplinary approach. The effects on teaching staff of courses which have deliberately been used as a vehicle for breaking down traditional subject departmental boundaries have also been significant and may be more far reaching.

Such changes have minor though potentially important effects on organisational structure. Of more substantial concern in relation to the effects of new technology on structures have been considerations of centralisation or decentralisation. In the schools context, this is of interest in relation to potential changes both within the school and in

the relationship between the school and regional or national education offices.

Much of the research on which conclusions about the effects which the introduction of computers may have on organisational structures, particularly in respect of centralisation or decentralisation, is rather dated and was carried out with reference to the introduction of mainframe computers in commercial organisations two decades ago. The impacts of the introduction of microcomputers within the educational system, which is the focus of the present interest, may be qualitatively different from those relating to mainframes, and the findings of earlier research must therefore be interpreted cautiously. Although many studies have shown that the introduction of computers has been followed by increased centralisation, this has not been an inevitable consequence. The perspective of technological determinism is not generally favoured. It is more common to view the introduction of computers as neutral and enabling or facilitating either increased centralisation or increased decentralisation, the direction of change depending on managerial choice rather than being determined by the technology.

Thus, within a school, it is possible to view a computer based administrative system, possibly incorporating Computer Managed Learning principles, as enabling either a closer monitoring of operations or to a style of more open decision making and management on the basis of the more widespread availability of information. Similarly, the use of a computer could lead to more detailed information concerning each school being available and decisions about schools being made in a more centralised way. Conversely, it could result in a greater devolution of decisions to schools. For example, if it is thought desirable to give

increased responsibility and discretion to schools for certain types of decisions such as financial decisions, that decentralisation may be facilitated if schools have simple microcomputer based accounting systems, as the delegating organisation may have greater confidence in the accuracy of the school's basic accounting records than they might have with a manual bookkeeping method.

A second focus, again deriving from the systems perspective has been the impact which the introduction of computer technology can have on the content of jobs of some individuals and groups. Much of the research on the impact on jobs of the introduction of computer technology has been carried out in the manufacturing sector and service sectors other than education. Computer technology has not been established in schools for a sufficiently long time for research to have enabled conclusions to be established about the effects of its use on jobs. Although in many situations it is not valid to assume parallels between educational and business organisations, in terms of the introduction of technological innovations in administration particularly, it forms a useful starting point for considering the extent to which similar effects may occur within education.

Much of the analysis, particularly at the macro level has focussed on changes in the number of jobs as a result of technological change. In the education sector, it was suggested above that the effects of the introduction of microcomputers on the number of jobs was likely to be less significant than equivalent changes in other sectors of the economy, as microcomputers have so far been used and may be likely to continue to be used as aids to teachers rather than as replacements of them.

In industry and commerce, the effects have not been found to be homogeneous throughout an organisation. An organisation can be viewed as being segmented or differentiated with respect to jobs both vertically and horizontally. In the case of schools, vertical segmentation relates mainly to levels of seniority, and horizontal segmentation to the division into teaching (itself often horizontally segmented into different subject departments) and pastoral and administrative support. The effects of technological change have been found to be very different in different vertical and horizontal segments of the organisation.

The most extensive analysis has been applied in relation to point of production or service level jobs. There is a widespread belief that computerisation, and automation more generally, will eliminate many of the routine and monotonous elements of such jobs and enable people to engage in more creative work, and that increased efficiency can lead to a shorter working week, longer vacations and an increase in leisure time. In contrast to this view, many research studies report adverse effects on job content. Amongst the effects identified, singly or in combination, are declining manning levels, fragmentation, polarisation of skills, de-skilling and alienation. The findings are not, however, consistently pessimistic. A number of studies have shown significant improvements in some clerical jobs, largely as a result of the computer removing some of the repetitive and less interesting aspects of the job.

There are reasons for not expecting the major discontinuities found in some jobs resulting from new technology to apply to the same extent within the education sector. If one considers work in education institutions to be horizontally segmented into teaching and the

supporting administrative and clerical work, the same expectations may apply in respect of both segments. The most direct parallels of previous research are with administrative jobs in education. The administrative, clerical and secretarial functions, whilst important, are not sufficiently voluminous or homogeneous to allow the easy fragmentation of such work. It is likely that new technology will affect clerical jobs but that the technology will be used intermittently rather than continuously and the effects will to that extent be less dramatic than in some other sectors.

Similar expectations may apply to the teaching function. If microcomputers are used as a support to teachers rather than to replace them, and also are used intermittently rather than continuously, the effects again may be less dramatic than in jobs in which the relevant technology is used continuously. There is little evidence, so far, that the introduction of computer assisted learning has led to de-skilling of the teacher's job. The thesis that technology can lead to polarisation of skills might, however, give rise to expectations of the more widespread use of teaching assistants supported by microcomputer technology, with access to more highly qualified, experienced and senior teachers acting in a consultancy, advisory or supervisory capacity.

There is little agreement about the effects of technological change on senior management jobs. Kanter (1972) distinguishes between traditionalists, who feel that senior managers will continue to operate with a high degree of independence from technology with a mode of operation which will be essentially unchanged, and futurists who feel that the availability of accurate, reliable, comprehensive and timely information will enable senior management to control the organisation to

a greater extent. Such an analysis leads to a consideration of the effects of computers on organisational centralisation or decentralisation, as discussed above. It has been claimed by Mumford and Ward (1968) that the more extensive use of computers will be the first technological change to affect the management structure of organisations and with it senior managers because it is the first technical change affecting the basic commodity with which senior managers deal - information.

Consideration of the effects of technical change on middle managers tends to be derived from assumed impacts at senior management level. Where the assumption has been that changes in information technology will lead to substantial changes in middle management roles the focus has commonly been on the supervisory aspect of such jobs.

Where the assumption has been one of increasing control being vested at senior rather than middle management level, this has been associated with the assumption that monitoring, evaluation and control will increasingly be dependent on computer based information and that middle management jobs will to that extent be de-skilled. Conversely the consultancy aspect of middle managers jobs has sometimes been seen to increase in importance. It is significant in the context of educational organisations that the middle management role has commonly been seen in terms of team leadership rather than or as well as a monitor and controller; to that extent information technology may be expected to have a less significant impact on middle management roles in educational organisations than in some industrial or commercial sectors.

It is perhaps significant also, in the educational context, that a large proportion of people entering teaching have achieved middle management positions as their careers have progressed, or a least have expected to do so. The thesis developed in industrial contexts that technical changes can lead to job polarisation with consequent diminished promotion opportunities may be expected to apply to a lesser extent in educational organisations but to change career patterns to a greater extent if it does apply.

Future scenaria

If some or all of the effects discussed above occur, what might schools be like in the future? Hawkridge (1982), in one of the most rich and thoughtful analyses of the use of microcomputers and other information technology in education, considers three scenaria relating to the year 2000: an optimists forecast, a pessimists forecast and his personal forecast. He emphasises, as futurologists sometimes but not always do, that the scenaria are concerned with what education might be like, rather than what it will be or should be like.

The optimistic scenario assumes that substantial resources are devoted to information technology in education, such that each pupil would have access to computer facilities. Hawkridge does not suggest (as some forecasters in this area do) that the widespread use of computer assisted learning will lead to deschooling. He suggests rather that schools will continue to exist in broadly the same form as at present, with classes of approximately the present size, but with much less teaching of the class as a whole and a greater emphasis on pupils working individually and in small groups. Although books to be written in and to read will still be used they will be less important than at present, with much of the pupils own work stored on his own magnetic disc. These developments will have two effects. The increased emphasis on individualised learning will mean that pupils are likely to progress at different speeds (or at least that pupils working 'out of step' will present fewer problems of class management to the teacher). Secondly, the use of computer assisted learning with diagnostic processes, particularly in respect of basic arithmetic and language skills, will

mean that the teacher personally will need to spend less time on the repetitive teaching of basic skills and can become more concerned with developing pupils' social skills.

It is suggested that the effects of information technology on learning will be at least as significant outside the school. The technology will facilitate increased access by adults to education for both formal courses of general or vocational education and for informal learning. There may also be increased access to devices incorporating both computers and other media to facilitate learning in the home or in various community facilities such as libraries, which will further foster the learners independence and responsibility for his own learning.

Hawkridge contrasts that optimistic forecast with a pessimistic scenario based on assumptions of a relative decrease in the funding of education, which becomes increasingly dominated by private interests. An elitist rather than egalitarian policy results in increasing inequality of educational opportunity. For the majority, considerations of utilitarian training will be dominant over those of education, and the control of information technology for educational purposes will remain largely in the hands of bodies with little interest in or knowledge of the educational process. This will result in the production of a large quantity of software of a type which will make the education of the majority more narrow rather than broadly based. The concern, based on a model which assumes that learning is linear and can appropriately be modularised, will be to find efficient means of increasing scores on standardised tests, rather than to use the new technology to support a variety of styles of learning.

Hawkridge discusses these two deliberately polarised views before presenting his own forecast of increased access to rich learning paradigms based on relatively inexpensive information technology and the selective rather than universal and indiscriminate exploitation of new technology. He suggests that education will not be deinstitutionalised, but is rather pessimistic about the influence of large multinational corporations, and the effects of that influence on equality of access to learning opportunities.

Issues raised by microcomputer use in schools

In the short term as well as in the longer term scenaria outlined above, there is wide agreement that the use of microcomputers in schools can confer significant benefits. There is equally wide agreement that their introduction can result in further, different problems.

Whilst the trade-off between benefits and costs of various kinds will be different in different local and national circumstances, there are a number of issues which are likely to arise if the possible use of microcomputers in schools is being evaluated. It is useful to consider such issues at the level of both the Ministry of Education and the individual school.

(a) Within the Ministry of Education

Clearly, the issue of funding is of central importance. Although in some countries in the Asia and Pacific region the cost of a microcomputer may be only a small proportion of the average annual salary costs of teachers, in most countries in the region it would represent a much greater proportional cost. Whilst the cost of the equipment has fallen rapidly, the cost of providing only one microcomputer to each school would consume a significant proportion of the education budget. Further, the experience has been that the arrival of one microcomputer is quickly followed by requests for more to enable different things to be achieved.

Consider the cost of funding the provision of computer equipment and programs in a country in which there are 5 million pupils who attend

school for 8 years. At a resource level of one microcomputer per 100 pupils (which is the current level of provision in some European countries) this would give access for individual use for an average of only 3 minutes per pupil per day or 80 hours during the total period of school education. With a school population of 5,000,000 pupils, a total of 50,000 microcomputers would be needed. With each computer system costing about US$1000, the total cost would be $50 million which, written off over a period of 5 years equates with an annual cost of $10 million. For 5 million pupils, the cost will therefore be US$2 per pupil per year.

A similar calculation can be carried out in respect of the provision of computer programs. Based on the assumption that for each pupil to gain access to computer assisted learning for 80 hours during his schooling, a total of about 300 hours of programs may be needed to allow for differences in the curriculum followed by different pupils and for differences in learning ability. Again, assuming that software is replaced after about five years, the annual cost could be about $10 million, or a further US$2 per pupil per year. Based on these calculations, the cost of about $4 per pupil per year for equipment and programs might represent rather less than 2% of the country's total education budget.

A number of sources of funds can be used, singly or in combination. In some cases schools have purchased microcomputer equipment from the discretionary funds provided by local or national educational administrations. The opportunity costs for the school are clearly substantial. In some countries funds have been provided from government specifically for the purchase of microcomputer equipment, commonly

initially on a pilot basis in a small number of schools with a view to the extension of the scheme on a wider front. Funding sources outside the education system itself have also frequently facilitated the purchase of equipment. Parents and the local community have in some cases been willing to raise funds specifically for the purchase of computer equipment. Fund raising activities which have as their target the purchase of a specific item are frequently more successful than those which are obtaining funds for the day-to-day running costs of a school, and if the acquisition of computer knowledge and expertise is seen by parents as instrumental in terms of their children's future employment prospects, this may result in the generation of funds for the purchase of computer facilities either outright or in combination with funds provided through the normal educational funding channels. Manufacturers and suppliers of microcomputers have frequently offered favourable terms. The education market is potentially a large one and negotiated prices are likely to reflect that; further, as discussed above, manufacturers and suppliers have an interest in the future generation of computer users becoming familiar with their make of microcomputer rather than that of another manufacturer. Such motives, as well as those of altruism, mean that the price of microcomputers for educational use may be significantly less than it would otherwise be. They also mean that considerations about purchase and about funding from commercial interests must take account of factors beyond those which are solely educational. Concerns about "technological colonialism" are real, and such concerns as well as economic factors, relating for example to the balance of trade, are significant in considerations of the source as well as the extent of equipment purchase.

In countries such as India, where the computer manufacturing industry is expanding rapidly, there are clear benefits in using equipment which has been produced within the country. Such a purchasing policy reduces the import burden and assists in the development of local industry, but it also provides important benefits within the educational system itself in access to expertise and in terms of national self-view.

Although the cost calculation presented above was based on a single machine at a particular price, there is a choice of equipment, with an increasing number of models of microcomputer available at different prices and with different facilities. If a policy of some standardisation of equipment is introduced nationally or regionally, or indeed if schools make their own choice of equipment, the choice at each level of funding is essentially between a small amount of relatively sophisticated equipment or more rather less sophisticated equipment. The preferred alternative depends substantially on the planned use of the facilities. If the microcomputers are to be used mainly for advanced courses correspondingly sophisticated equipment may be needed; if it is to be used for introductory courses, less sophisticated equipment may be satisfactory.

The successful use of computers depends on obtaining suitable software (computer programs). It is likely that teachers of computer studies will themselves wish to write a proportion of the software which they use in their own teaching. In respect of computer assisted learning and administrative applications some of the most successful and innovative applications are those in which individuals have written their own software which meets their own needs and is suited to their own teaching style or administrative methods.

However, if the potential benefits of microcomputers are to be realised in more than a minority of schools it is necessary for computer programs to be obtainable from sources external to the schools. Whilst some commercial computing companies may be interested in the provision of educational software, and may develop and market some such software at their own initiative, the price is unlikely to make it attractive to schools individually, and some educational software from such sources has been criticised in terms of its quality and the educational assumptions on which it is based.

It is likely to be necessary then for an initiative to be taken at Ministry of Education level to facilitate the production or acquisition of software and its dissemination. Thus far there has been little transfer of software between countries, and whilst some software is specific to the syllabus and educational culture of the country in which it was developed, there is possibly scope for a more widespread dissemination across international borders of information about the availability of software. If it is felt desirable for at least some software to be acquired from the commercial sector it is important that considerations of software are not isolated from those of hardware. Problems are likely to arise if hardware choices are made in the expectation that appropriate software is available or will become available; such problems can be mitigated if hardware is considered in conjunction with software rather than the two decisions made in isolation from each other.

Amongst the most substantial of the issues at Ministry level is that of teacher training. Whilst still significant, the lack of teachers able to teach computer studies as a main subject is diminishing in a number

of countries as computing has become established as a legitimate part of the school curriculum and as teaching therefore becomes more viable as a career for computer studies graduates. The problem of teacher training is in those cases no more difficult in principle than that for teachers of any other subject. The more extensive teacher training problem relates to training teachers of other subjects in the use of computer assisted learning approaches within their own subject. Training programmes for existing teachers need to be developed to enable teachers to become aware, competent and confident in relation to the use of microcomputers in their subject.

There is considerable dispute about the appropriate content of such familiarisation training, and specifically about the relevance of the inclusion of computer programming. Some argue that it is impossible or unnecessary for teachers of subjects other than computing to be able to write programs and that their use of computers will and should be restricted to the selection and intelligent use of computer assisted learning materials from other sources. Others argue that teachers cannot treat computers as 'black boxes' and need to be familiar with how they work and such familiarity can be obtained only through programming and/or that computer assisted learning will be most successful when the teacher can develop materials suited to his own needs and style of teaching and that can occur only if teachers can write their own programs or at least modify those obtained from elsewhere. Surrounding such arguments are the logistical questions of how such in-service training should be provided - what should be the duration of the course, should it be full-time or part-time, what role can universities and commercial computer agencies have in this provision, and so on.

Whilst in-service training may be the most immediate of the training needs, equivalent issues arise in relation to pre-service teacher training, and if teacher trainers are not themselves familiar with computer assisted learning this in turn gives rise to a need for training the trainers.

Training issues arise also in relation to the use of microcomputers in school administration and management. The provision of training for school principals in the use of microcomputers in school administration and in the management of educational computing within the school as an innovation in terms of the factors discussed in the section below may form an appropriate part of the training activities of institutions such as the Sri Lanka Staff College for Educational Administration, the Institute for Development of Educational Administration in Thailand, and similar organisations throughout the region.

The requirements for equipment, computer programs and training are formidable, and their cost will be considerable. In principle, some explicit or implicit cost benefit analysis is appropriate as part of the decision making process about whether and on what scale to introduce microcomputers into schools. Whilst some writers stress the inevitability of the growth of use of microcomputers in education on a global scale, it is probably both more useful and more realistic to reject the 'technological imperative' and assume that as both the potential benefits and the opportunity costs will be viewed differently in different circumstances, that the decisions made will similarly differ. Considerations beyond the educational will be important, and in some cases dominant, particularly in respect of the opportunity costs of substantial capital and revenue expenditures and in most countries the

effects on the import burden and the influence of (often foreign) commercial interests in the country's education system.

(b) Issues within the school

Within the school also, there are decisions of a cost benefit nature to be made, where costs include not only financial costs but also costs in terms of the time needed to become sufficiently familiar with the equipment to use it appropriately, and in the generation or acquisition of suitable software.

One of the earliest and apparently most simple of the decisions which have to be made within the school, but which can have far-reaching consequences is that of who shall be responsible for the computer equipment. In many cases it has seemed natural to locate responsibility for the equipment within the school's mathematics department as one of the mathematicians has often been the first person in the school to develop an interest in computing. Where computer studies is taught this has also commonly been, at least initially, by members of the mathematics department and this has been a further argument for locating computer responsibility within that department. This can have two deleterious consequences. The identification of computing with mathematics by staff within the school can mean that their potential in computer assisted learning across the curriculum is not exploited in full, perhaps partly because access to the equipment by teachers of other subjects is not as easy as it might be. Secondly, the identification by the pupils of computers with mathematics encourages in them a restricted vision of the range of applications of computers and a

false impression that they are suitable mainly for the processing of numerical data.

In relation to the use of computers in the administrative work of the school, similar considerations apply. The manual processing of the school's administrative work has normally been the responsibility of one of the school's senior staff, perhaps a deputy headteacher, to whom the clerical staff may report. If the computer is to be used in the administrative work of the school it may be appropriate for teachers with computing expertise to have a role in relation to administrative computing. There have in some cases, however, been problems when the introduction of computer based administration has resulted in the transfer of significant responsibilities from a senior and experienced member of staff to someone who has relevant technical expertise but who may have much less seniority and experience than his colleagues.

For both of these reasons it is increasingly common for the responsibility for computing for instructional or for administrative use to be located in schools neutrally, perhaps with a senior non-departmental member of the school staff, for example a deputy headteacher, or in a resources department. Such considerations are normally less problematic in primary schools, which are typically less departmentalised and where there are fewer pressures than in secondary schools to maintain rigid departmental boundaries.

Related to the issue of the location of responsibility may be the physical location of the computer equipment. If the equipment is physically located within a department, for example the mathematics department, that will have a significance similar to the location of

responsibility discussed above. If a school has a number of microcomputers the decision as to whether they are all located together in a computer room or whether they are distributed around the school will facilitate some developments and inhibit others. The location of one or two microcomputers in each of a number of departments can facilitate their use in computer assisted learning whilst the establishment of a computer room can facilitate the development of computer studies but may not encourage use across the curriculum. Although some microcomputers are portable, even when associated data storage and output devices are attached, security considerations and the geography of some schools militate against portability as a solution to the issue of the physical location of equipment in some cases.

The initial location of responsibility for computer use, and the physical location of equipment, have been found to have a considerable influence on the subsequent pattern of development of computer use in an organisation. Rowan (1982) discusses industrial and commercial examples in which the initial location of responsibility within an accounting department has been followed by a pattern of use of the computer predominantly for accounting applications, and superficially similar firms in which the initial location of equipment and responsibility within a production control department has led to the use of the computer predominantly for production related applications. Lamb (1972) reaches similar conclusions in analysing local government use of computers.

Mumford and Ward (1968) conclude that although it may be convenient in the short term to give little consideration to the physical location of equipment and the location of managerial responsibility for it, the lack

of such consideration can lead to increased difficulties at a later stage of the development of the innovation.

There is general agreement in the literature, then, that if the computer is to be restricted to a single area of the organisation's activities, it may be acceptable for it to be located there, but if the facilities are to be used in several areas of the organisation then it is appropriate to take a more formal view of the location of responsibility and of the equipment itself. Within a school, the balance of use between computer assisted learning and administration may similarly be expected to be influenced by the location of responsibility for computer use in respect of who has responsibility and whether different people have responsibility for those two aspects of use. In terms of the balance of use between computer studies and computer assisted learning across the curriculum, the same considerations may apply.

It is useful to consider responsibilities for computers not globally but separately in terms of decisions about:

(a) how the computer is to be used, the applications to be undertaken and the balance between teaching and administrative uses (i.e. a concern for strategic matters) and

(b) day to day responsibility for the computer (i.e. a concern for tactical matters).

The most consistent and emphatic message in the literature on computer applications concerns the relationship between the success of computer applications and the involvement of senior managers in planning and directing those applications. One of the major firms of management consultants (McKinsey and Company, 1968) concluded that the key to

computer success was strong leadership from senior management in directing the applications of the computer, and that where computers were ineffective it was generally because senior management had not accepted responsibility. Lamb similarly suggested that:

"Policy for computer development should be determined at senior levels, and priority in operation, development and equipment selection should not necessarily be controlled by a major user" (Lamb, 1972, p230).

Stewart agrees:

"It is most important that management should not abdicate in the belief that it cannot understand or that it can safely leave computer development to the specialists" (Stewart, 1971, p206).

The implications for the headteacher of the school and his senior staff are clear.

A particularly significant issue as many schools begin to use microcomputers is that relating to the source of software. There are currently four main sources of software. The first is within the school itself, where some teachers may have the requisite programming skills and enthusiasm to produce software. Particularly if this is to be for use in areas other than the software writer's own subject, issues of professional support and the provision of requisite resources (of which the time needed is often considerably underestimated) arise. When a 'critical mass' has been attained and there are sufficient individual schools in which software is being developed, its acquisition from other schools becomes a second possible source, though the information networks through which the existence of such software becomes known vary considerably in efficiency. A third source is the commercial market, which is particularly relevant in respect of some administrative programs such as word processing and accounting packages, but in respect

of computer assisted learning materials available from the commercial sector the educational assumptions upon which some of that software is based are questionable. Finally organisations have in some cases been established to disseminate and possibly produce software on a local or national basis.

Schools which were pioneers in the development of educational computing relied, of course, mainly on the development of their own software but acquisition from sources external to the school is much more significant for the majority of schools.

There are a number of aspects of computer use within schools for which it is appropriate for contingency plans to be made. In particular, contingency plans relating to the breakdown of equipment, the departure of key staff, and the loss of or damage to data storage media should be made.

Although microcomputers of the present generation are much more reliable than their predecessors it is nevertheless possible that they will fail at some time, and rather more likely that the mechanical parts of either printers or data storage devices will fail. It may therefore be helpful if a reciprocal arrangement can be made with another local school with the same make of equipment so that access can be maintained in the event of system failure. This, of course, is one of the benefits of a policy of equipment standardisation regionally or nationally.

In a number of schools, knowledge of the operation of the microcomputers is limited to a small number of people; the writing of computer programs tends to be carried out by an even more restricted range of people, so the production, maintenance and operation of particular programs can be

severely disrupted if those members of staff leave the school. It is prudent, then, to ensure that a number of people within the school are familiar with each application and that the documentation of programs written or amended within the school is adequate.

Contingency plans incorporating basic computer operating procedures are also appropriate. If the disc or cassette on which data or a program is stored is damaged or lost and a copy has not been kept, the consequences can range from inconvenience to disaster. It is therefore worth instituting a systematic copying routine such that a copy of each program and data disc or cassette is kept, preferably in a room some distance from that in which the working discs or cassettes are stored. It is sometimes suggested that two copies are kept. I recall an installation in which the master data disc was damaged and the data on the copy disc accidentally erased on the first occasion on which it was used; more than one back-up copy has since been kept in that office!

Within the school, then, a large number of issues ranging from the substantial and the strategic to the seemingly more trivial and operational issues are relevant for consideration. Whilst it is possible to institutionalise the technological developments discussed in this paper by giving only a superficial consideration to these matters, experience shows that a thorough analysis initially of the issues discussed above can produce significant benefits in the longer term.

Conclusion

The potential benefits of using microcomputers in the educational process are likely to be different in magnitude, and may be different in kind, in different countries or regions; the opportunity costs of doing so will certainly be different. Although, in principle, decisions of this kind are amenable to cost benefit analysis or similar treatment, it seems to be the case, perhaps not surprisingly, that where ever substantial resources have been committed to educational computing those commitments have been made in the absence of a formal analysis of a cost benefit type.

Research (e.g. Lucas, 1975) on the reasons for the failure of computer based information systems which have not been successful suggests that problems commonly arise from the absence or inadequacy of feasibility studies and/or from a concentration on the technical aspects of the innovation with insufficient consideration being given to the organisational, behavioural and managerial issues discussed in this paper.

As the introduction or expansion of the use of microcomputers is contemplated in countries within the Asia and Pacific region there are, then, a large number of such issues to be addressed both at the level of the Ministry of Education and at the level of the individual school. In any sequential decision making process, decisions taken at an early stage to commit resources to one aspect of a development rather than another can substantially affect subsequent decisions by opening particular further avenues of development and making others less

accessible. In those countries in which microcomputers have been used in education for some time (and three or four years is a vast amount of experience in this rapidly changing area) there is a feeling that educational computing is established and has a significant role in the future. There is, however, a concern that the momentum of the development has resulted in some decisions having been taken quickly and on the basis of insufficient thought and that developments might have been more beneficial if some of the issues addressed above had been considered more thoroughly.

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