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ABSTRACT

Intended to clarify the nature of the curriculum debate and to indicate the issues that need to be considered when formulating curriculum policy, this paper begins with a review of the educational reasons for using the New Information and Communication Technologies (NICT) and the thinking and experience which lie behind them. Ways in which the existing educational infrastructure may be adapted to introduce the NICT are suggested, as well as some benefits of an NICT enhanced education, including the effective achievement of existing goals by computer-assisted learning, the development of information-handling and communication skills or prevocational skills in computer science and technical graphics, and the production of media by the students. A discussion of problems encountered when computers are introduced into the classroom is followed by consideration of the school-level policy and management issues involved in the implementation of such programs. The paper concludes with an examination of national policies for introducing computers into education with a special focus on software development and teacher training. The 105-item bibliography includes some materials in German. (MAB)

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The information society – A challenge to education policies? Policy options and implementation strategies

Report by Professor Michael Eraut
University of Sussex (United Kingdom)

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THE INFORMATION SOCIETY -

A CHALLENGE FOR EDUCATION POLICIES?

POLICY OPTIONS AND IMPLEMENTATION STRATEGIES

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SUMMARY

Introduction

The assessment of the educational potential of various applications of New Information and Communication Technologies (NICT) is a difficult process. There is much experiment and little evaluation; and the situation is changing quite fast. Hence the important debate about priorities lacks reliable evidence on effectiveness. That debate, however, also concerns the relative merits of different educational goals. The argument is partly ideological and partly about predicting the nature of our society in 10-20 years time.

Many of the problems of introducing NICT-related change into education can be predicted from what is already known about innovation in education. But such knowledge is not being fully used in spite of early indications that it is still valid and relevant. What emerges from current evaluative research is the need for planned change towards a future that is yet uncertain, while the relevant evidence is only slowly being gathered. In such circumstances, priority should be given to developing a NICT infrastructure within the educational system which can respond flexibly and with increasing capability and capacity to new opportunities and policy changes. The most important part of this infrastructure is people, especially courseware designers and teachers. It is their training and cdontinuing development which should be given the greatest attention.

Chapter 1

The educational aims advocated in connection with NICT can be conveniently grouped into the following seven categories:

1. The more effective achievement of existing goals by using new methods such as video presentation or computer assisted learning.

2. Enabling new goals to be taught within the current curriculum framework of subjects. For example, the vicarious experience brought into the classroom by television and the information-processing potential of computerised databases and the modelling capacity of new interactive software have significantly changed what can be taught in subjects like science and geography.

3. Learning about society and its technology. The onset of the information society must have a major effect on what is taught in the social science and science/technology areas of the curriculum. One major issue is the extent to which aims in this should have a futures orientation.

4. Learning to use new information and communication technologies as part of a general programme for developing information-handling and communication skills. This can be taught either as a separate subject, or as part of a cross-curricular approach like study skills. The most ambitious claims in this area relate to the use of computers in developing metacognitive or thinking skills.

5. Learning knowledge and skills appropriate for some specialist occupation. This would be a form of prevocational or vocational education. Computer science, technical graphics and office skills are common examples.

6. Learning to criticise the programmes and products of NICT. The purpose is to develop a more critical approach from a variety of perspectives. Media studies has tended to follow the tradition of art or literary criticism, while consumer education has focussed more on technological or economic aspects. The appraisal of computer software could profitably draw on both traditions.

7. Creative use of NICT for purposes defined by the students themselves. The assumption is that students should not be only at the receiving end of other people's communications. They should learn to produce communications of their own, e.g. class newspapers, videos, computer programmes, partly to improve their understanding of the various media and genres but also to develop their enterprise and initiative; and to counteract any monopolistic tendencies in public communications facilities.

It should be noted that these seven categories of aim penetrate into almost every aspect of the curriculum; and include all those aims sometimes advocated under headings like "media education" and "computer literacy". Thus sooner or later the challenge of NICT will have to be treated as a whole curriculum problem. the addition of one or two new subjects into the curriculum is only one approach; and, even if it is preferred, will provide only a partial solution. What is eventually needed is a reappraisal of the shape and scope of the whole curriculum and the balance and emphasis within each part of it.

Chapter 2

In the primary phase, aims in categories 1,4 and 6 are particularly important, but their integration into the curriculum will need further planning and development. Both the quantity and quality of teacher training are a major limitation on the pace and direction of change.

At secondary level, too, strategic curriculum decisions are needed. Three alternative strategies have been advocated.

(1) Incorporation into the traditional curriculum framework through use of NICT in the teaching of the current curriculum subjects.

(2) Insertion into the curriculum for all students of a new subject or subjects. Computer Literacy or Media Education are commonly used names for NICT-oriented subjects, but many other possibilities exist.

(3) Addition of optional courses at the middle or upper secondary level These could be very varied, with titles ranging from Computer Studies or Computer Science to Video Production or Journalism.

In the long term, all three routes may be follows. In the short term, financial considerations alone might suggest a progression from Route 3 to Route 2 to Route 1. But this strategy can also cause difficulty, because to start with Route 3 alone would turn NICT into a specialist subject with its own distinct membership and culture. Once teachers, trainers and managers had become accustomed to this, it would be difficult to change direction. Deciding between the relative merits of Routes 1 and 2 is also difficult, especially for information-handling skills. Finally, the use of school facilities and expertise to improve access for adult and handicapped students is recommended.

Chapter 3

Introducing computers into the classroom causes many problems. These can be ameliorated by good management, teacher support and in-service education. So far, however, the needs of teachers engaging in this radical change in educational practice are consistently underestimated. Apart from getting insufficient access to equipment, they find the available software patchy and not well geared to their curriculum. Classroom organisation and management pose many problems for which they are unprepared; and they receive little guidance on pedagogic strategies, in spite of growing research evidence of their importance.

At school level the developing NICT culture among teachers and pupils conveys hidden messages about access, gender, the character of NICT enthusiasts, the parallel curriculum of the mass media, and the role of NICT in society. School managers need to monitor this hidden curriculum alongside their introduction of INSET into the official curriculum. Each school also needs an ambitious staff development plan, using both external and internal sources of expertise, and to make sure that staff development is properly tuned to the needs of teachers and pupils. Another priority may be the introduction of NICT into school administration. The hardware and software resources have to be managed and expanded according to a financial plan which matches the school's educational priorities.

Chapter 4

National policies tend to be unbalanced with the provision of software and training lagging behind the hardware. There is also a clash between equity and effectiveness, because a 'critical mass' is often a necessary consideration when investing in NICT. Causes of the 'software' famine' are discussed, together with some approaches to relieving the problem. Software development teams are needed to build the necessary expertise; and there is much scope for international cooperation in this area. However, such teams should be broadened into curriculum development teams which can prepare mo .ules comprising both NICT-based and print-based learning materials and tested pedagogic strategies. Otherwise the software will not be well used or properly integrated into the curriculum.

Finally, teacher training needs are discussed. Provision for classroom teachers has been inadequate hitherto, both in quantity and in quality. It needs to give more attention to the implementation problems encountered by teachers, and to include a school-based component. For this purpose, each school needs a NICT coordinator/staff developer who is trained not only in the use of NICT but in staff development approaches and techniques. Other training priorities are head' ;achers, teacher trainers, local support personnel and software designers.

INTRODUCTION

Professor Balle's report discusses how the development of New Information and Communication Technology (NICT) is shaping our future society; and how the decisions of the next decade will in turn affect how NICT is developed and used. The challenge is twofold:-

(1) How can education best prepare for the future information society?

and (2) How can educational thinking contribute to the policy-making process and influence those future developments?

Two important features of the future information society that are difficult to predict are the control of communication channels and the nature of employment. What, for example, will be the eventual balance between the monopolistic, internationalising trend in the ownership of mass media and the new opportunities opening up for local or community channels of communication. Similarly, it is still being debated whether the increasing computerisation of work will lead to more skilled jobs or less. Both issues could be affected by the skills and attitudes of the next generation of youngsters and by the capacity of the adult education system to enhance the capabilities of those already in employment.

More predictable, perhaps, is the continuing influence of the "parallel curriculum" offered by the mass media. This will continue to occupy a large proportion of young people's time and attention; and to provide a marked contrast with the formal curriculum offered by educational establishments. Less predictable is whether computers will also become more prominent in the parallel curriculum than in public education. The evolution of videogames and a "hacking" sub-culture suggests that this is not such an unlikely development; and some children already spend many more hours on home computers than on school computers. Indeed, the very unevenness of this access is already causing concern about gender equity and social equality. While the parallel curriculum need not prevent the evolution of the formal curriculum to a shape and style that is seen both to be more stimulating and more relevant and to retain those traditional goals that are still highly valued, there must be considerable doubt as to whether this will actually happen?

Within education, there is still considerable debate about the most appropriate uses of NICT; and especially about which applications should be accorded priority. The debate encompasses two dimensions, goals and effectiveness. Arguments about goals are partly concerned with forecasting what our future society will be like - a process in which people tend to oscillate from scaremongering to complacency or even wishful thinking; and partly with different perspectives on the relationship between education and society, in particular the balance between conserving the past, preparing for the present and constructing the future. These arguments about goals are complex and value-laden; but so also, contrary to popular opinion, are arguments about effectiveness. For, although there has been much experiment, there has been little replication and little independent evaluation. Moreover, there is no more agreement about criteria than there is about goals.

The more predictable aspects of using NICT in education derive from what is already known about change. Introducing change into education is a complex business, especially when it affects the nature of classroom life. It requires coordination and continuity over a long period of time, combined with the flexibility to modify programmes and strategies in the light of experience. It requires good management at all levels and a substantial investment in both programme development and teacher training. Evaluative research on the use of NICT during the 1980s has already confirmed that these lessons are often ignored; and that NICT-based innovations are far from being immune to the fate of many unsuccessful predecessors.

What emerges from this brief analysis is the need for planned change towards a future that is yet uncertain. Reviews of policy options and implementation strategies will need to become a regular feature of ministerial life, as this report has a half-life of only five years (i.e. half of it will be out of date by 1994). It is argued, therefore, that some priority will also need to be given to developing a NICT infrastructure within the educational system, which can respond flexibly and with increasing capability and capacity to new opportunities and policy changes as and when they arise. The most important parts of this infrastructure are the courseware designers and the teachers. It is their training and continuing development which should be given the greatest attention.

Contents of the Report

This report begins with a review of the educational reasons for using NICT and the thinking and experiences which lie behind them. Thus Chapter 1 identifies several types of educational aim that arise when considering the future uses of NICT. Some are traditional aims, built into current practice, whose pursuit may be aided by the involvement of NICT. Some are new aims which are made possible, perhaps even urgent, by the advent of NICT. The purpose is to clarify the nature of the curriculum debate and to indicate the issues that need to be considered when formulating curriculum policy. Chapter 2 explains the particular form that this curriculum debate is likely to take in primary and secondary education, with a brief additional reference to access by adults. Chapter 3 focuses on implementation, first by reviewing the problems encountered when introducing computers into classrooms, then by considering school-level policy and management issues. Finally Chapter 4 examines national policies for introducing computers into education, giving special attention to software development and teacher training.

CHAPTER 1 EDUCATIONAL REASONS FOR USING NEW INFORMATION AND COMMUNICATION TECHNOLOGIES

1.0 This chapter discusses the range of educational aims which can be promoted through the use of New Information and Communication Technologies (NICT). As the list below indicates, some are existing aims pursued by the current curriculum, some require an extension or transformation of existing aims, and some suggest entirely novel curricular goals. All the aims have strong advocates, and most are the subject of pilot projects or developmental research in several European countries. The challenge to education is how to decide priorities between these and other aims and how to accommodate these new opportunities within a curriculum that is already perceived as too crowded.

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It should be noted that these seven categories of aim penetrate into almost every aspect of the curriculum; and include all those aims sometimes advocated under headings like "media education" and "computer literacy". Thus sooner or later the challenge of NICT will have to be treated as a whole curriculum problem. The addition of one or two new subjects into the curriculum is only one approach; and, even if it is preferred, will provide only a partial solution. What is eventually needed is a reappraisal of the shape and scope of the whole curriculum and the balance and emphasis within each part of it (DES, 1989).

This chapter, therefore, will attempt to characterise and examine each of the seven groups of aims listed above, to assess relevant findings from pilot projects and research, to highlight significant issues and to indicate those factors which curriculum policy-makers will need to consider. The situation is complex because the decision-making process involves:

- deciding what priority should be given to each curriculum goal
- choosing between different curriculum approaches to achieve the selected goals
- assessing how much can be achieved by a particular approach in any given context.

These are interdependent rather than sequential judgements and the available evidence is limited.

Before discussing these matters in greater detail, two major problems should be noted. First, curricular goals are rarely tackled one at a time, nor would it be economical if they were. So in pursuing one goal, a teacher is likely to take advantage of the opportunity to contribute to others. In particular, teachers will claim to be developing a range of general knowledge and skills while focussing on much more specific areas of content. Thus students may learn about computers or acquire general information-handling skills while primarily focusing on the study of a particular topic in a particular subject. There is little evidence, however, to indicate the extent to which such general knowledge and skills have been acquired in this way (see Section 1.4 below).

Some would argue, for example that much of this learning is a natural part of a pupil's intellectual development and relatively independent of formal teaching.

The second major problem is closely related. Most assessment techniques were developed to measure achievement in the traditional goals of education:- basic skills, comprehension and the simple application of concepts and algorithms in highly predictable ways. Hence, although the Assessment of Performance Unit in the UK and the International Association for the Evaluation of Educational Achievement (IEA) have expanded the testing repertoire in language, mathematics and science, there are still many educational goals for which valid methods of assessment have yet to be developed. Assessment is also a highly politicised aspect of education, with scores on public examinations and tests of basic skills being treated as major public indicators of standards. This makes it difficult to change curriculum priorities, as Alan Bennett noted in his play "Forty Years On":

> "But don't you think, Headmaster, that your standards are out of date?"
>
> "Of course they are! They wouldn't be standards otherwise!"

Thus, partly because of technical limitations, partly because of limited time, partly because of political pressures, and partly because of the uncertainty surrounding the attribution of cause and effect in the development of general skills, evaluations of pilot projects have tended to focus on measuring achievement of traditional goals alon .

1.1 The more effective achievement of existing goals

The longest running tradition in evaluation research is the comparative study, in which one method of teaching is "tested" against another by comparing gains in student achievement over a period of time. For thirty years this approach has shown that in a large proportion of such experiments there are no significant differences between one method and another. Most evaluators have become disenchanted with this approach for a variety of reasons, including the following:

- Where either or both 'treatments' involve teachers, the variation between teachers exceeds that between methods. Indeed even when teachers are absent, within-class variations can be considerable.
- The quality of the message is at least as important as its mode of delivery. Many comparisons are made with programmes that educators consider to be of low or medium quality.
- The idea of using a single method alone for a long period of time is pedagogically naive. One should be looking for the best mix.
- Even when one method is shown to be "superior" for one topic, no educator would seriously consider using it all the time.
- The cost factor is often conveniently omitted.

Media research proceeded along similar non-productive lines until researchers finally concluded that media selection is more appropriately considered at the level of the individual learning activity (Heidt, 1985; Levie, 1985). Only then can the most appropriate combination of attributes be selected for the particula kind of information being communicated and the particular kind of learning that is expected to occur. Other studies have shown that the main factors affecting the classroom use of audiovisual media are

(1) flexibility of use and ease of operation under normal classroom conditions

(2) availabiity of good audiovisual materials

(3) the pedagogic knowledge and media experience of the teacher

(4) cost.

Flexibility has significantly improved with the arrival of videocassettes, and will be further enhanced by videodiscs. The introduction of videodiscs will finally solve the main technical problems, but may be considerably delayed by economic problems. The availability of suitable software, for example, will depend on the development of a specifically educational market. In the long term, the teacher factor may prove to be the most significant; and that will be further discussed in Chapter 4.

With computers a rather different picture has emerged. The Kul'ks' (1987) meta-analysis of 200 comparative studies in the U.S. showed an average Effect Size of 0.31 standard deviations, i.e. examination scores were raised by about 6 percent. Nea.ly all these studies involved courses or sections of courses, situated in computer laboratories with one work-station for each student, and using drill and practice or a didactic tutoring mode of instruction. What then is the objection to everyone installing computer laboratories for this purpose? The arguments centre round Cost, Pedagogy and Uncertain Effects.

The cost-effectiveness of computer assisted instruction is still subject to considerable debate. Levin (1986), for example, has argued that peer group tutoring offers better value for money at primary level; and that in mathematics, a substantial reduction in class size would also yield better results. He also showed that in the school context the hardware accounted for only 11% of the total expenditure. So, although hardware costs may fall, the total cost of laboratory-based CAI will not decline much further.

It is often stated that it is the interactiveness of computers that [illegible] responsible for their superior performance in these ...parative studies.

Yet the main pedagogic criticism is that typical CAI is not interactive enough. Critics, often from within the computing fraternity, argue that CAI comes close to coaching students for tests which inadequately sample the subject domain, drilling them only in the more easily replicated surface features of a subject. To refute this accusation would require a detailed review of the software and the assessment instruments, neither of which is adequately described in the public research.

Against this background of pedagogic debate, there is very little evidence from process studies to suggest the reason for the apparent success of CAI. Even the Kuliks argue that more research is needed on this issue. Until we understand rather more about how and what students learn from CAI, few institutions are likely to invest in it on any significant scale.

The advent of microcomputers was responsible for the rapid diversification of computer-based learning away from the laboratory model, although that model still remains dominant in a large number of schools and countries, especially for courses in computer science or computer literacy (see Sections 1.4 & 1.5 below). During the 1980s computers have been increasingly tried out in normal or slightly modified classroom settings, where evaluation has been much more difficult. Comparative experiments are of little use when the computer is rarely given responsibility for the teaching of a whole topic, and interactions between student and computer are typically quite short. Moreover the variations between contexts and patterns of computer use in classrooms have been far too great to characterise any one pattern as being "the experimental treatment". Research into this multitude of classroom-based experiments has been limited. It has necessarily focussed on independent observations of process and product; and has rarely sought to intervene with special tests or examinations.

Nevertheless, researchers and other observers of the newly developing classroom-based computer scene are agreed on a number of points.

1) Only a few teachers have managed to integrate use of the computer into their normal programmes of classroom work.

2) Some teachers are engaged with their pupils on a voyage of discovery about computers.

3) There is much bad practice with students wasting time or engaged in relatively meaningless activities.

4) Much more teacher preparation is needed for effective classroom use of computers.

5) For a variety of reasons, there is still a desperate shortage of good software.

6) The potential of computers for aiding learning is still largely unexplored.

7) What is known is still relatively unexploited.

8) Large numbers of positive experiences continue to motivate teachers and students alike.

More detailed accounts of this classroom evidence will be given in Chapter 3. Here it can be noted that, although greater time and effort needs to be given to implementation, there is still much to encourage the further development of computers as aids to achieving many current curricular goals.

The other major change in computer assisted learning has been a move away from the tutorial mode of computer-learner interaction towards more learner-centred approaches. In the Tutorial Mode the designer retains the initiative throughout, and the user responds as asked: user choice is confined to selecting an option on a menu, constructing an answer to a question or calling for repetition or help. The least sophisticated forms involve drill and practice exercises with facts, spellings or arithmetic - sometimes presented in interesting diagrammatic formats or as games. The most sophisticated involve what is commonly referred to as ICAI (intelligent computer-aided instruction) or just as 'intelligent tutoring'. In theory, it is said to build a tutoring system around knowledge of the subject, knowledge of the student and knowledge of how to help the student learn (Sleeman and Brown, 1982). But major problems immediately arise. How is knowledge of the subject to be represented? How is knowledge of the student to be obtained and used? How is knowledge of how to help the student learn to be raised above the current level of ad hocery? Some commentators (e.g. Self, 1987) believe these aims are unachievable. While the ordinary tutoring mode can make a useful contribution, especially to distance learning, we should not be deluded into thinking that enormous improvements in design technique are "just round the corner".

More learner-centred approaches start from two premises: that learning goals are defined by the users rather than the software; and the role of the computer is to assist users to achieve these goals. In the Inquiry Mode (see Table 1) the assistance may take the form of a calculating facility or providing information from various databases; or the student may be allowed to interact with a simulation or consult an expert system. The computer retains the role of knowledge provider, but the users decide what knowledge they want and how they will use it. In the Constructive Mode, however, even the knowledge provider role is abandoned. Both the goals and the relevant information come from the users; while the role of the computer is to enable them to record, manipulate, organise, retrieve, present and

MODE OF USE / TYPE OF INFORMATION	Tutorial Mode System Knowledge, System Goals	Inquiry Mode System Knowledge, Student Goals	Constructive Mode Student Knowledge, Student Goals
Facts Pictures Drawings Algorithms	Drill and Practice	Data Bases (Other data) Calculation	Data Bases (Own data) Programming
Diagrams Outlines Displays Tables			Electronic Notepad Graphics Package Design Aid
Questions Answers	Tutoring	Information Retrieval	Word-processing
Prose			Writing aid
Models		Simulations	Modelling
Organised Conceptual Knowledge Expertise	Intelligent Tutoring	Expert Systems	Desk-Top Publishing
Control of Peripherals			

Table 1 Student Use of Computers: a typology of modes and applications

The underlined terms are broader in scope than the others, and cannot be located in a single position in their columns.

communicate that knowledge. The simplest examples are the use of a word-processor for writing, a graphics package for presentation, or a database for organising evidence from surveys. More subtle software includes electronic notepads, writing aids, design aids and programmes for desk-top publishing. Then at the most sophisticated level students may engage in constructing their own programmes for computer-controlled devices or their own models of complex phenomena and their inter-relationships.

While some of the work in the Inquiry Mode and the Constructive Mode falls within existing curricular goals, their exploration is increasingly causing teachers and researchers to realise that important new goals are now becoming attainable (see Section 1.2 below). Indeed the proper balance between existing goals and new goals is becoming a matter for considerable debate. Recent discussions can be found in Cerych and Jallade (1986), Gwyn (1986), OECD/CERI (1986) and especially the 1987 OECD/CERI report on Information Technologies and Basic Learning: reading, writing, science and mathematics.

1.2 New goals within current curriculum subjects

This section reviews some of the new learning experiences now becoming available for inclusion in the curriculum as a result of NICT. While some are clearly directed at new curricular goals, others come closer to supporting existing goals but are still regarded as making a novel contribution to their subject. Indeed, deciding whether or not a particular application falls within old or new territory depends not only on the country but also on the criteria being used. The curriculum may be formally defined in terms of aims and content, informally defined in terms of expectations and tradition, and operationally defined in terms of textbooks and examinations. These new experiences often place a strong emphasis on inquiry skills and conceptual development.

The most easily appreciated advantage of NICT is the access it will bring to new kinds of information. The key developments here are in electronic communications and videodisc technology. Electronic communications have already arrived. It is possible for schools to get up-to-date information from a wide range of external data sources, allowing the continuing analysis of such phenomena as economic trends, current affairs and weather patterns to bring a sense of immediacy akin to that so prevalent in the "parallel curriculum" of the mass media. Electronic mail partnerships can also be used to develop students' communication skills and enhance understanding of peers in other countries, a boost to international understanding that has yet to be fully developed or evaluated.

Videodisc technology, as suggested earlier, ought to help make the use of audiovisual materials far more flexible. It allows smooth and flexible transitions from still pictures to moving picture sequences, the facility to freeze or repeat, fast search and retrieval and the opportunity to follow-up unforeseen needs for information. When more software becomes available, teachers will be able to use a much wider range of visual evidence, and to use it much more flexibly. One major limitation will be the teachers' skill and imagination. Another will be the quality and appropriateness of the discs. One can foresee the interconnected use of maps, photographs and diagrams in geography; the reference in history to archaeological evidence, portraits and manuscripts; the viewing of dangerous or difficult experiments in science; comparisons of dramatic performances in literature; and an enormous range of audiovisual experiences to support the teaching of foreign langauges. Most of these things can be done with today's technology, but the time and effort involved is too great for most teachers. When those difficulties are lessened, wider and more integrated use of audio-visual material will follow, with consequent demands on resources.

The other major advantage of NICT lies in the tools it puts at the command of the learner for writing, calculating, information-processing and problem-solving. While writing forms a central part of the traditional curriculum there is evidence that changes in attitude and approach are being achieved by the introduction of word-processors. Writing is being professionalised for children, not only in the quality of the final presentation but also in the way the task is being approached. The multiple drafting process is welcomed as it becomes less troublesome; and the criteria by which writing is judged are becoming more explicit, more widely shared and more meaningful (Broderick and Trushell, 1985; Marcus, 1984; Miller, 1986; Pearson and Wilkinson, 1986).

Mathematics can also be transformed by using the computer as a tool, not only because of its calculating facility but also because of the range of methods of data representation. This opens up the possibility of making greater use of numerical data right across the curriculum, for numerophobes and numerophiles alike. Mathematicians have suggested that the use of computers should enable greater attention to be given to iterative numerical techniques, statistics and probability, procedures and algorithms (including programming), geometrical topics facilitated by having a computer graphics facility, and matrices and vectors (which are used both for storing data in computers and for getting computers to draw pictures and representations of three-dimensional objects)(Ball et al. 1986). More radical still is the approach of Papert and his followers who advocate a programming/problem-solving approach to learning. Most of their work has been in the field of mathematics, where they have pursued an entirely different kind of mathematics curriculum (Feurzeig, 1986). Independent evaluations of LOGO have been very varied, suggesting that more attention needs to be given to the context, purpose and pattern of use (Ennals, 1986; Govier, 1988; Hughes et al., 1985; Hoyles and Sutherland, 1989).

The information-processing facility of computers is also used in databases which may be used in either the Inquiry or the Constructive Mode. according to the purpose. In primary schools they are used to develop classification and inquiring skills in a variety of content areas; and in secondary schools they are used in history and geography. Combining the database facility with the numerical data-processing facilities allows many aspects of the social science curriculum to take on quite a different character, with greater attention to data analysis, and inquiry methods than would be possible in a computerless curriculum. Simulations are equally popular in these subjects, with the additional computer facilities allowing a more sophisticated and more numerical approach than would otherwise be possible (Kent, 1986; Wild, 1988). Again, many would argue that this kind of work gives learners a different view of the discipline and a deeper understanding of certain key features of its subject matter. In the natural sciences, for example, students can engage in simulated experiments in which they manipulate the variables, using the computer to perform any necessary calculations. Some of these experiments might be impossible to carry out in real life, as for example with a simulated ecological system; while others might be extremely lengthy to perform once, let alone ten times under a range of different conditions.

Similar arguments are presented by proponents of the use of the computer to support problem-solving or thinking behaviour (Pea, 1985). Appropriately directed programming often has this aim (Papert, 1980; Gwyn, 1986; OECD, 1987). Papert's concept of designing a 'microworld environment' in which children can solve problems by developing appropriate programmes is one approach (Lewis, 1988). Another is provided by programmes designed as tools to assist pupils to develop mental models of a knowledge domain (Bliss and Ogborn,1988). Introducing work of this kind into the curriculum would give much greater attention to students developing their own theories and testing them out,in accordance with the increasing emphasis by some cognitive psychologists on the importance for learning of children's own informal theories.

Finally, there are a range of peripheral devices which computers can be used to control, ranging from lathes, through looms and robots, to electronic keyboards (SED, 1987).

To conclude this section, it should be noted once more that the question of whether a goal is new or not will often be difficult to answer, because some curricular goals have rather ambiguous status. For example, curriculum documents may contain references to problem-solving or inquiry skills, which are pursued by only a small minority of teachers. Yet these goals are precisely those given the greatest emphasis by advocates of using computers in the Inquiry or Constructive Modes. The most promising development is that the use of database and modelling software and programming environments like LOGO is making inquiry and problem-solving processes more explicit; and hence more easily incorporated into the curriculum experienced by pupils, rather than only the paper curriculum of educators' aspirations.

1.3 Learning about society and its technology

One of the principle aims of education is to prepare future generations to take over from those currently making our society work. The complexity of even today's society, the increasingly rapid pace of change and the already foreseeable challenges that lie ahead in such fields as energy, environment, development and international relations make this a daunting task. But as Broudy (1986) has asserted, "the central civic activity of the citizen is to participate in decisions concerning the public good". We now have the capacity to educate future generations better than their forebears. But will we use it to prepare them sufficiently for the tasks that lie ahead? And will they emerge from schooling with a sufficiently positive attitude towards education to want to participate in periodic continuing education thereafter? The context of this paper makes it particularly apposite to ask:

- What will school leavers in the 1990s know about the society we live in, particularly about the role of information within it?
- What will they know of the mathematical, scientific, economic and technological knowledge that underpins the way information is organised, stored, distributed and achieved?
- What will they know about the interactive relationship between information technology, information control and society?

Although some lonely voices were heard long ago, it was not until the late 1970s and early 1980s that the onset of a future post-industrial information-dominated society began to be widely discussed. As a result few of our teachers or curriculum policy-makers are able to participate in a properly informed debate about its role in the curriculum. Hence there is a propensity to deal with the issue by creating new specialisms rather than reforming the current curriculum in such areas as the social sciences and citizenship education. To deal with the information society only in courses in 'computer literacy' or 'media education' is to separate it from mainstream discussions about the nature and future of our society. The Carnegie Commission on Education (Boyer, 1983) commented on the problem as follows:

> "The great urgency is not "computer literacy" but "technology literacy", the need for students to see how society is being reshaped by our inventions, just as tools of earlier eras changed the course of history. The challenge is not learning <u>how</u> to use the latest piece of hardware but asking <u>when</u> and <u>why</u> it should be used."

This problem has already been encountered in science education, where such matters as the impact of science and society and science policy have traditionally been treated as 'extras', while the scientific and technology dimension has been so lacking from most history books as to give an entirely false impression of the nature of historical change.

This argument leads me to three conclusions. First that the role of communications and technology needs to be properly integrated into the study of the past, the present and the future. Second that the rapidity of change is such that more attention needs to be given to the study of the present and the future than has been customary in most nations hitherto. Third, and possibly more contentiously, I would argue that much study will not lead to sufficient understanding of the issues if it cannot be based on a good grounding of economic awareness and understanding.

The conclusions present a considerable challenge curriculum developers. How are they to make accessible to pupils the central concepts and issues discussed in important documents like the MacBride Report to UNESCO Many Voices, One World: Communication and Society Today and Tomorrow (1979) or the Friedrichs and Schaff Report to the Club of Rome, Microelectronics and Society, For Better or For Worse? (1982) And if this material is to be discussed in the upper secondary school, what foundations will need to be laid for it in the lower secondary curriculum? However, comprehension may not be the only problem. A careful course has to be steered between a technological determinism, which treats change as inevitable and beyond social and political influence, and a wilful neglect of trends and phenomena which will have major effects on our society (Taylor and Johnson, 1986). More difficult still is the pedagogic skill required of teachers in areas where there are political pressure groups and value differences can be highly politicised. But this is equally true of other areas of the curriculum, where properly professional approaches to handling value issues in the classroom have been developed. It would also be a mistake to overestimate the likelihood of teachers having any effect at all on the values of upper secondary students. Opportunities to clarify values and discuss important issues are welcomed, but the imposition of a teacher viewpoint is always rejected.

Finally, I wish to draw attention to the problem of how much understanding of computers should be included in the technology component of the curriculum. The pedagogic challenge is that of linking pupils' concrete experiences of computer use to generic knowledge about such matters as programmes, computer architecture and even expert systems that will provide them with some background to follow the changing technology and better understand the impact of computers in daily life (Neuwirth, 1986). The widely quoted syllabus prepared by the Association for Teacher Education in Europe (van Weert, 1984) suggests pupils should study the societal impact of NICT, the applications which are making the impact, principles of programming and principles of software and machine architecture. This was conceived as part of a proposed "computer literacy" cours.. t', however, more integrated approaches have also been considered, and the new national curriculum in England and Wales is concerned to build these particular aspects of NICT into a foundation Design and Technology component for all pupils from 5 to 16. This will enable NICT to be integrated with other technologies in a general problem-solving approach to design and technology which involves designing, making and evaluating artefacts and systems (DES, 1988).

1.4 General information-handling and communication skills

For some time, advocates of student-centred learning have argued that students need to develop information skills. This phrase can include aspects of what are sometimes called 'library skills', 'study skills' or even 'reading development' (Marland, 1981). An extension to include the interpretation and use of a whole range of graphical modes of representation would also seem appropriate. It can then be argued that the use of computers can play a significant part in facilitating the development and use of these skills, though it also adds to the "syllabus" the additional skills required to use the computer itself in a range of applications. Carter and Monaco (1987), who studied computer usage in ten schools from an information skills perspective, report that "the introduction of IT into schools does not appear to require pupils to acquire information skills which differ significantly from those required to utilise all media." Moreoever the use of IT was the least of the pupils' problems. Far more important were lack of understanding of what they were doing and the inability to visualise the information in a different way. More appropriate use of IT could help tackle some of these problems. This suggests that IT applications can be profitably learned and practised as part of the development of information skills.

The applications studied by Carter and Monaco, mainly databases, word-processing and teletext, are often taught as part of a general 'Introduction to Computing' course. They would argue that this is likely to divert attention from information skills per se onto computer operating skills alone; but this would depend on the kind of activities pursued. Theoretically, it should be possible to develop information skills within any curriculum area. Other applications commonly included in such courses are the use of spreadsheets and simple calculations and graphics. Here the additional facilties provided by the computer could profitably be used to extract meaning from print-based media such as books and newspapers; and hence to develop a much more critical approach to graphically-displayed information and statistics. Sometimes programming is also included in such courses, but it does not really belong in this category of aims.

Other media which might usefully be included in a course on information and communication skills are photography and sound recording. They are particularly well suited to work with young children and vividly illustrate how information is always selective and sometimes deliberately misleading. Sound can be used to develop listening and speaking skills, and photographs to stimulate or illustrate written communication. The use of more complex media is discussed below in Section 1.7.

Finally, this is probably an appropriate place to examine the claims of Papert and others that programming enhances general cognitive skills. On the whole these claims have not been substantiated. In those few cases where positive evidence was obtained, there was considerable intervention to provoke reflection and metacognitive analysis while children were at work. Salomon and Perkins (1987) conclude from a penetrating review of the issue that computer programming is no more effective in achieving this aim than other specially designed procedures for developing problem-solving skills. As with information skills, the thinking is the key and that takes place in the mind of the thinker, whether or not the stimulus is a computer programme.

1.5 Prevocational or Vocational Education

The strategic argument about the relative merits of a "computer literacy" course for all, incorporating many of the goals outlined above in Sections 3 and 4, and a "computer studies" course for a few will be taken up in Chapter 2 Meanwhile it is useful to consider "computer studies" as a prevocational or vocational course; recognising that such courses may be offered in the later stages of compulsory education, in post-compulsory upper secondary education or in technical/vocational colleges.

Jallade's (1984) review of NICT and technical education defines four groups of NICT users:

(1) Specialists at three levels: (a) high-level specialists who receive university training in NICT and become designers of systems, designers of applications and specialist teachers of NICT; (b) middle-level specialists who receive 'short cycle' higher education plus in-company training; (c) maintenance and service personnel, who obtain technical/vocational qualifications and also receive in-company training.

(2) Professional 'appliers' who combine professional qualifications with an additional qualification in NICT.

(3) NICT users 'on-the-job' whose jobs now require fairly routine use of NICT: this is being built into a large number of technical/vocational qualifications, and is also a major concern of in-company training.

(4) NICT users 'off-the-job', for whom NICT training is about uses of NICT in the home and community.

Evidence suggests that the recruitment of high level specialists does not depend on the presence of 'computer studies' in the school sector, but rather on strong and appropriate science education at the upper secondary level. Maintenance and service personnel receive their vocational training either in upper level secondary education or in technical colleges; but there are signs that much of this work will soon be at "higher technician level". In either case the requirement from compulsory schooling is not an early specialism in computer studies but a good general education in mathematics, science and technology. Some prior experience in working with computers would seem to be an important element in career choice but that should be offered within the core curriculum, with an emphasis on the general development of thinking and problem-solving skills.

This same theme is echoed by a recent OECD (1988) report on human resources in one major group of IT users, the banks and insurance companies. This reported that the new skill requirements of middle-tier workers seem to place a premium on "liberal arts" education at the secondary and even early post high school level; and quoted a bank official as follows: "The bank can train anyone in becoming proficient in the use of specific techniques and procedures; the bank cannot train individual workers in thinking for themselves, in being at ease with broad and complex environments." Bertrand and Noyelle continue with the following comment:

"Most firms regard such training (in the use of new technologies) as quite trivial when compared with other training needs. In the long run, also, it is widely assumed that the new generation of workers will graduate from high school and college proficient in the use of the new tool."

From this analysis it appears that the main challenge for vocational education will be not the creation or continuation of separate computer studies programmes, but the transformation of existing vocational programmes to take the developing role of NICT more fully into account. As with modern languages, competence in NICT is likely to become an additional requirement of many existing occupations. Though, at some stage in the future, vocational courses may be able to assume that their students arrive with some computer-related skills already acquired. Another point stressed in a useful review by Hunter (1986) is the need, when considering computer applications, for an increased focus on the cognitive aspects of tasks, such as analysis, decision-making, troubleshooting and problem-solving. This is particularly urgent in business education/commerce courses.

The arguments above should not be applied to optional courses which allow students to develop their interests and talents. These allow the use of NICT for personal and community purposes to be explored in a context free of purely vocational considerations. Such opportunities should apply across the full range of NICT and not be focussed primarily on computers. Video-production, for example, could be equally valuable; and this is more fully discussed in Section 1.7 below.

1.6 NICT Criticism

While the general study of the role of NICT in our society was discussed in Section 1.3, one aspect, the criticism of particular programmes and products, needs separate consideration. Claims and assumptions about the quality of programmes need to be properly substantiated; and this is a prime goal for media education, in whatever curricular form it appears. Historically, an aesthetic approach has tended to dominate, but from a wide range of viewpoints. Many teachers have traditionally treated the mass media as an undesirable influence against which children have to be protected. Others have challenged this "high culture" perspective by treating programmes as forms of popular art and helping children to discriminate between good and bad examples of each genre. Given the range of mediated messages this poses enormous problems of priorities. A recent UNESCO conference (Masterman, 1986) suggested that this be resolved by reference to the primary aim of developing critical autonomy in pupils. The acid test of any media education programme is for students to have the confidence, experience, skills and maturity "to apply critical judgements to media texts which they have not yet seen" and to be "critical in their own use and understanding of the media when the teacher is not there."

To achieve this purpose, media education has to move beyond the exchange of opinions to a deeper understanding of how media structure and represent information (UNESCO 1984). Mediated messages are not neutral, transparent, windows on the world but constructed by particular people with particular goals and assumptions for transmission to particular audiences. Moreover these audiences are not passive but actively make their own meanings and interpretations of what they receive. Such an approach combines the concerns of the literacy critic with the construction and personal impact of texts with the social scientists' concerns with public meanings, the control of communications and ideology. Both humanists and social scientists are agreed on the need to understand how mediated messages are constructed in order to properly appreciate and criticise them; though their subsequent judgements may be made according to rather different sets of criteria. Some of this understanding can be developed by including discussions of media images in a range of traditional subjects. History and geography are particularly important in this regard because so much knowledge in this area is acquired outside school. But more detailed study will depend on the teachers themselves being adequately trained in media education (Masterman, 1988).

Another theme that falls within this section is that of consumer education, where aesthetics, economics and technology may be brought together to assess the relative merits of various consumer products. Again it could be argued that some background knowledge of industry would be helpful, as suggested in Section 1.3 above. This is also an area where the information skills described in Section 1.4 should be used to find useful paths through the maze of consumer guides. In this context, we are primarily concerned with NICT-related products, such as players, receivers and recorders of audio and audiovisual messages - many of which are bought by students of school age. Attention should also be given, however, to computer software. Though such consumer education involves quite different areas of knowledge and expertise, it could still be based on the same primary aim as that adopted by media education, namely development of a critical autonomy.

1.7 Creative use of NICT for student-defined purposes

Several reasons have been advanced for giving students facilities and space within the curriculum to construct images, programmes or products for their own purposes. One reason follows from our discussion about critical autonomy. The argument is that first-hand experience of constructing a photograph, a video, a newspaper or a computer programme is central to understanding the central concepts of structuring and representation of communication. Another argument is more instrumental, suggesting that having to construct a communication develops a deeper understanding of the content of that communication, partly by developing motivation and enthusiasm for the task and partly from the learning that comes from engaging in groupwork, when ideas that might be passively accepted from a teacher or a textbook can become the centre of prolonged and searching discussion. Yet a third argument sees such creative work with NICT as a natural extension of expression in written text, in art, in music or in technological design.

For me the most powerful argument of all, comes from an analysis of the role of NICT in society. Control of communication is not only a matter of political and economic power, it is also a matter of confidence, determination and perception. NICT can be u i for personal purposes and to empower local communities, provided people develop the skills and motivation to make NICT serve their own interests as much as other people's. Moles (1984) discusses the role of the self-media in communicating from oneself to oneself over a period of time. In addition to diaries and snapshots, we now have home videos and electronic notebooks. Then at community level the arrival of cheaper sound and video equipment of near broadcast quality, of increased channels for electronic communication and of desktop publishing has transformed the potential for quality communication. Apart from the enormous enthusiasm such work engenders in students and the concomitant development of their communication skills, this aim must surely be justified as central to the emancipatory role of education. Those very a ects of education which some people fear will be eroded by NICT could become the areas where it has some of its most positive impact.

CHAPTER 2 INCORPORATING NICT-RELATED AIMS INTO THE CURRICULUM

This chapter takes the seven types of aim described in Chapter 1 and assesses their significance for curriculum policy in primary and secondary schools. the presentation is intended to clarify policy options and critical issues for policy making, through discussing not only priorities but also the curriculum formats in which the various aims may be pursued. A final section then looks at access to school-level provision by adults and by children with special needs.

2.1 The Primary Phase

Many European nations have deliberately not introduced computers into primary schools but other new technologies, notably television, usually play a significant role. One distinctive feature of primary education in some countries is the greater flexibility of organisation both of the classroom and the curriculum. This makes it possible for a good primary teacher both to use a television programme as a stimulus for a series of activities with a whole-class thematic focus and to use a microcomputer with two or three children working on their own. Most would like to have at least three such computers but do not necessarily need many more. This adaptability has led many observers of the British scene to comment that computers have been better used in primary than in secondary schools. However, primary teachers have not found it easy to integrate computers into the curriculum; and typical practice lags well behind that reported by the enthusiasts (see Chapter 3).

The best use of NICT in primary education has possibly been in language development, perhaps because teachers feel most confident in this part of the curriculum and have been quickest to see the potential. Audiovisual media have been used to capture children's imagination and hence stimulate language production in speech and in writing - a use that is highly dependent on the skill of the teacher. Adventure games on computers have now begun to be used in a similar kind of way; while sound is used both to stimulate and to record children's own stories. The impact of word-processing, however, appears to be of quite a different kind. Although the exploration of its potential is still in its infancy, already there are signs that it could have a dramatic effect on children learning to write. Not only is the improved appearance of the product motivating, but the ease of redrafting and discussion of drafts brings within most children's reach the kind of attention to language structure and audience that linguists have always considered desirable but difficult to achieve in practice. It has the power to transform writing from a physical chore to an exciting metacognitive activity (Dunstan,1988).

Applications in mathematics may eventually prove equally exciting but await improved access, more and better software, and increased teacher understanding before their potential is realised. However, the prevalence of thematic or topic work in the primary curriculum creates information handling demands which computers are well suited to meet; in addition to offering opportunities for introducing information in a variety of media forms. This kind of use is less demanding of regular access to equipment and therefore more readily introduced. What frequently happens, though, is that topic work is claimed to be developing language and information skills when it is presenting little real challenge to the children. Making the process more visible may alert teachers to the realisation that such things have to be taught.

Finally, one should stress the real potential for introducing media criticism and production into primary education. Children are already receivers of mass communications and enjoy critical discussion and especially developing mediated messages of their own such as newspapers, radio programmes or photoplays. Such work is often easier to organise at primary level because timetables are less rigid and motivating cross-curricular themes considered to be a bonus (British Film Institute, 1989).

2.2 The Secondary Phase

There are three routes by which NICT can be incorporated into the secondary curriculum:

(1) Incorporation into the traditional curriculum framework through use of NICT in the teaching of the current curriculum subjects.

(2) Insertion into the curriculum for all students of a new subject or subjects. Computer Literacy or Media Education are commonly used names for NICT-oriented subjects, but many other possibilities exist.

(3) Addition of optional courses at the middle or upper secondary level. These could be very varied, with titles ranging from Computer Studies or Computer Science to Video Production or Journalism.

In the long term these three routes are not competitors, because one can envisage all three being followed at once; and it is certainly difficult to imagine the first route not being part of any future strategy. However in the short term, the extreme shortage of what is still very costly equipment (in the context of public education budgets) and of teachers trained to maximise the potential of NICT, the three routes appear as alternatives. This is particularly true for computers, which have arrived on the educational scene rather more suddenly than television, and with stronger community expectations for immediate responses from schools.

Route 1 is increasingly favoured by educators, as it makes the technology the servant rather than the master of the curriculum. This argument welcomes Routes 2 and 3 alongside Route 1, but opposes the segregation of NICT implied in pursuing Routes 2 and 3 alone. However, Route 1 is also the most ambitious and expensive approach. It requires as much hardware as Route 2 and considerably more software; and, above all, it requires that all teachers become confident users of NICT. Whereas Routes 2 and 3 require that only specialist teachers are trained. From a purely financial viewpoint there is an obvious progression from Route 3 to Route 2 to Route 1 as each transition involves a step-up in funding. But there are strong arguments against regarding such a progression as easy.

Treating NICT as a specialist area of knowledge will establish it as a separate subject, both distinctively technical and threatening to other subjects' resources and "territory". This will create a psychological barrier for many would-be NICT users; and make it more difficult for teachers of other subjects to take up NICT later when Route 1 is finally pursued. Even the transition from Route 3 to Route 2 is fraught with difficulty; because research in curr-ulum history has shown that subject communities play a very powerful role in determining how knowledge is conceptualised and which educational goals have been given priority (Goodson, 1983). If one defines a new subject in terms of specialist expertise, then one is giving the pioneers of that subject, on whom one will have to rely for its future development, a particular kind of occupational identity. To switch at some later stage from Route 3 to Route 2 is likely to make the kind of course offered in Route 2 similar in emphasis to the original specialist provision. Because to start with a specialist option is to develop a subject community whose attitudes and predilections are oriented towards specialist goals.

Another danger in pursuing Route 3 on its own is that different groups of students will take advantage of it to different degrees. Girls, in particular, are less likely to choose specialist options perceived as technological. Hence, although British curriculum policy has now endorsed Route 1, the effect of the increase in comptuer studies courses at school level over the last ten years has been to lower the proportion of women taking computer science degrees (Large and Bradbury, 1989).

These comments are not meant to imply that Route 3 would not be the most appropriate choice in some national contexts. That would depend on the existing location of prevocational and vocational courses. Where vocational training is primarily located outside the upper secondary school, it would seem anomalous to have such options within the school sector; though, as discussed in Chapter 1, it is still possible to have NICT-related options that do not have a primarily vocational orientation. Within the vocational course sector, there is also the danger highlighted by Hunter (1986) that provision will be dominated by preparation for specialist NICT jobs at the expense of the growing NICT-related requirement of a large number of traditional occupations.

The introduction of new NICT-related subjects into the common curriculum offered to all children (Route 2) also requires careful consideration. Let us begin by considering the long term situation. If NICT becomes sufficiently available for use by all secondary school teachers to support teaching and learning in every area of the curriculum, will these new NICT-related subjects still be needed? For the sake of this argument, I shall assume that the role of NICT in society and some understanding of its technology will have been fully incorporated by then into the core curriculum in the social sciences and technology (see Section 1.3). The debate then hinges around the most appropriate way to pursue the aims of information-handling skills (Section 1.4), criticism of mediated communications (Section 1.6) and programme/software production (Section 1.7).

Let us begin with information-handling skills. Since this has been taught in some schools since the pre-computer era, there is relevant experience to build on. Evidence from UK schools suggests a genuine dilemma over whether it is better to have a separate subject or a cross-curricular approach. One argument is the impossibility of teaching skills without content; and if there is to be content why should it not be content taken from the normal curriculum? If the content is not seen as important by the children, then the whole process can become self-defeating. A second argument is that of transfer. Will the information-handling skills acquired on a separate course be reinforced and further developed in the rest of the curriculum? The third is the converse of the second: if information skills are to be taught through a cross-curricular approach will there be sufficient coherence and progression? Indeed, will some aims ever get implemented? There is good evidence that very few schools have successfully translated cross-curricular rhetoric into actual practice. These arguments focus around two main issues.

(a) Within any particular information handling task, how much of the initial know-how can be ascribed to generalised information-handling skills and how much to content-specific knowledge and methodology?

(b) Will teachers in general become sufficiently learner-centred to see developing pupils' approaches to learning and inquiry as a major part of their task?

The first is an essentially curricular issue, the second a challenge for teacher training. I would be surprised if any nation was able to reach a consensus on either!

One rather complicated strategy that straddles these two alternatives would be to devise an information skills curriculum, which was taught by teachers from several subjects on a modular basis, each teacher using their own subject content in their allotted module but also being responsible for liaison between their own subject and the information skills team. A strategy similar to this is used in Sweden (Makrakis, 1988). Certainly, there is a good argument for locating at least the initial teaching of information skills with one person, in order to avoid duplication. Though in some countries, that may have been already achieved in the primary school.

While some aspects of the criticism of mediated communications clearly ought to be incorporated into the teaching of the subjects concerned (UNESCO, 1986), a substantial part of this work falls within the area of communications. As such it is capable of being treated as a separate subject, as part of the social studies curriculum or as part of the first language curriculum. In Britain decisions of this kind have usually been made at school level, taking into account the interests and talents of the teachers available. This strategy probably works better when this is an option rather than compulsory element in the curriculum. In the latter case, staffing can be a problem. Unless all first language or social studies teachers become media educators (not a bad long term strategy) but difficult in the medium term) there will be teachers reluctant to take on this responsibility in some schools to counterbalance the enthusiasts in others. But if media education becomes a special subject, will one not be creating a cultural bifurcation between print and not-print that ill seem increasingly anachronistic?

The programme/software production aims would logically fit alongside the criticism of other people's products. However other strategies are equally worth considering. A case can be made, for example, for making production an optional course whilst criticism remains part of the compulsory curriculum. In some schools it currently appears not even as an option out as an extra-curricular activity. Yet another strategy arises when schools depart from their normal timetables for a few days in the year in order to pursue special activities intensively. This is particually well suited to activities like videoproduction, which cannot be easily fitted into the short period structure of a standard timetable. This is also an area of the curriculum where it might be possible to import help from experts and enthusiasts in the local community, rather than making it a teacher-led affair.

Route 1, the direct incorporation of NICT into the traditional curriculum frameworks, best achieves the subject-based aims discussed in Sections 1.1 and 1.2 above; and we have just argued that it is the most appropriate route for discussing the role of NICT in society. It is also a possible, but not necessarily preferable, strategy for information handling, criticism and production. Being the most ambitious strategy, however, it requires the most complex planning and the greatest level of resourcing. We discuss this further in the later chapters, but meanwhile we should note that progress would be greatly facilitated if there was at least one teacher in each subject who was prepared to take a leadership role in introducing NICT, and who was in turn able to receive support from a NICT specialist located either inside the school or in its immediate locality.

2.3 The Widening of Access

Cerych and Jallade (1986) refer to the danger of developing a division in our society between those who are "computer literate" and those who are not, the most likely divisive factors being age, class, gender, ethnicity and handicap. However, even if the schools succeed in delivering an appropriate level of competence to all their students, a large population of disadvantaged adults will remain. Not only do a very large proportion of adults need to acquire some NICT-related skills to adapt to the changing nature of employment, but NICT has an extremely important role to play in making educational opportunities available to adults. The acknowledged success of the open universities is probably only the beginning of a more general transformation of the means by which adults gain access to learning opportunities (Graebner, 1989).

The resources, facilities and expertise available in schools could play an important role in supporting this transition. Because some adults find it easier to get to schools than other education centers; and joint use of resources and facilities is likely to be cheaper than separate provision for adults. Indeed it would be wasteful to make future plans for the use of NICT in schools which did not also take into account parallel plans for adult education.

One should also note the great potential of NICT for making the curriculum accessible to children and adults who have difficulties in receiving it because of distance, physical handicap or some other form of disability (Geoffrion, 1983; Hawkridge, Vincent and Hales, 1985; Morocco and Newman. 1986; Weir, 1987).

CHAPTER 3 IMPLEMENTATION PROBLEMS WHEN INTRODUCING COMPUTERS INTO SCHOOLS

3.1 Computers in the Classrooms

This section focuses on classroom issues that arise in connection with the introduction of computers into the teaching of traditional school subjects. The rather different context of courses in computer literacy or information technology is discussed in the following section. Then the chapter concludes with a review of the innovation problems facing school management. Four main types of classroom problem are discussed: incorporation into the curriculum, classroom organisation and management, the teacher's role during computer aided learning, and the impact of the innovation process on teachers' attitudes towards using computers.

3.1.1 Incorporation into the Curriculum

Teachers are acutely aware of the strong community expectation that schools will make increasing use of computers. They also find that as a result of a variety of decisions made by others they have inherited a motley collection of hardware and software. They may have been on a short computer awareness course; and even have a colleague who is a bit of an expert. But they probably have had very little advice on what they are expected to do, apart from using the computer and having some good stories to tell about it.

If they are working to a tightly prescribed curriculum, teachers are likely to find that the software does not match it too closely; or that the software covers half a topic but also goes well beyond the objectives, so they have to decide whether to use it at the expense of skimping or omitting something else. Even if the curriculum is loosely structured, teachers still have the problem of how to develop a unit which combines computer-linked activities with other activities in a coherent and manageable way. Neither of these planning tasks are impossible, but they are time-consuming and demand considerable knowledge ^ the software and its effects on learning.

Large gaps are reported in many countries between the use being made of computers in the 'good practice situations' reported by the enthusiasts, and that observed in the majority of schools. This is true of British Primary schools even though they have been reported as among the best adopters of computers. Govier (1988) summarises research reporting that the insertion of a computer rarely affects either the curriculum or normal classroom practice: its use is assimilated to existing pedagogic assumptions. Many teachers still regard the computer as a distraction in the classroom and do not believe it has yet had positive effects on pupil learning (Hall and Rhodes, 1986). My conclusion is not that the accounts of the enthusiasts are wrong, though some might seem a little uncritical, but rather that good practice has not been very widely implemented.

Where there has been long-term well-supported use, and changes in practice are noteworthy, the problem of the relationship between the new practice and the regular curriculum is repeatedly raised. Olson and Eaton (1986) regard this as generally healthy, because it leads to teachers reappraising the curriculum. Hawkins and Sheingold (1986) are more ambivalent, pointing to the difficulty of using computers to introduce problem-solving skills that were not in the regular curriculum and could not easily be monitored or assessed. Teachers felt uncomfortable when they could not judge the success of their work and did not know what kind of standard to expect. This, together with much of the pedagogic evidence cited below, leads to the conclusion that it is not just more and better software development that is needed. It is curriculum development with computer aided learning built in. Then new goals and assessment, computer-based and computer-free learning experiences, and pedagogic guidance for teachers can all be developed in an integrated manner. A tightly-structured package might be inappropriate but more support is needed than that provided by isolated pieces of software.

3.1.2 Classroom Organisation and Management

Much work with computers is carried out under considerable practical difficulty, due to circumstances beyond the teachers' control. First, there is the problem of access to equipment. The introduction of computers into schools is good public relations; and apparently large sums of money are seen to be spent. But what is provided may amount to only 20 minutes access per pupil per week (Becker, 1984). While recent evidence from the US (Congress, 1988) suggests that pupil users now have an average access time of 60 minutes a week, this is unlikely to be reached by many European schools (except in vocational courses). It also falls short of the 20 minutes a day regarded by many educators as a minimum for proper exploitation of computers' potential. To use computers profitably with such low access times requires close integration with non-computer-based activities and users who are already familiar with the software.

Second, there is the problem of location. If computers are moved around, then classrooms constantly have to be reorganised. But the alternative strategy of moving classes to a computer room raises other difficulties. For the computer work to be properly integrated with other activities, learning resources such as reference books and practical apparatus will need to be available. There may even be pressure on the teacher to organise the work to maximise computer usage rather than achievement of learning goals (Johnson, 1985).

Teachers feel threatened by computers because it forces them to organise their classrooms differently, reduces their control and makes their normal approach to monitoring progress difficult to implement. Discipline is rarely an overt problem with children working at computers, because their motivation is high. However, this only reinforces the common practice whereby teachers leave pupils at computers to more or less look after themselves. Though this enables the teacher to give more attention to the rest of the class, it also serves to isolate computer-based activities from the "official curriculum" and gives them an ambiguous status. Teachers gain the opportunity to practise an apparently more pupil-centred pedagogy within this isolated setting of a class within a class, and to acquire a modern image. But they also feel bereft of influence, unable to monitor what [goes] on and uncertain about their proper role (Olson, 1988).

This points to yet another management problem for teachers. Not only do they have to plan for computer-based activities to lead into and develop out of non-computer based learning experiences (longtitudinal planning); but they also have to plan for computer-based and non-computer-based activities to take place at the same time (lateral planning), though not necessarily as part of the same topic. Coordinating and sharing the work of the different groups may also be advisable from time to time; and this demands careful thought about when and how to return to a whole class focus. No wonder the Scottish Inspectors reported that "the skills required by the teacher in using the computer are predominantly pedagogical rather than technical" (SED, 1987).

3.1.3 The Teacher's role during Computer Aided learning

Not only do many patterns of computer use require the teacher to plan an integrated series of activities but there is increasing evidence that educational benefits are diminished by the common practice of leaving children working with computers entirely alone. Olson and Eaton (1986) found that not being able to diagnose and respond to pupils' problems quickly was a major concern of teachers, only remediable by careful monitoring and close familiarity with the software. Carter and Monaco (1987) note that information-handling skills cannot be assumed but have to be taught to children using NICT. Robert (1984) reported that children using LOGO tended to adopt "a proper experimental approach" only when appropriately guided by adults. Children may also need teacher coaching on how to work collaboratively. Indeed most researchers seem to be agreed that the teacher has a crucial role to play during computer aided learning if higher order thinking is to be developed.

Hawkins and Sheingold (1986) summarise the challenge to teachers as follows:

> Teachers may be managing pairs or groups of students rather than conducting the more typical whole-class or individual activity. To manage and support such work effectively requires observational skills different from those teachers normally apply and new intuitions about when and how to intervene in student-based activities, as well as raising questions about how to monitor the progress of individual students.

3.1.4 Impact on Teachers

Heywood and Norman (1987) suggest two major causes of low or zero use of computers by teachers - competence and confidence - and they are closely related. However, teacher anxieties are not, as is often assumed, based primarily on the technology but on their own ability to use it for good educational purposes in their classrooms. This is often accompanied by real doubts about the extent to which their pupils will benefit. The heart of the problem lies in curriculum and pedagogy, for these will determine whether or not the innovation is beneficial for their particular class. So it is only when these practical concerns are addressed that their anxieties are likely to be assuaged.

In reading accounts of the introduction of computers, one is constantly reminded of research into other earlier educational innovations in curriculum or educational technology. Gross's (1971) account of curricular innovation in a primary school suggested that "lack of clarity" was a major cause of failure. Teachers were prepared to support the rhetoric of what was being advocated but found themselves unclear about precisely what was meant to happen in practice. Often the introduction of computers into a school shows a similar lack of clear educational purpose; and the proponents of change fail to appreciate the magnitude and difficulty of the necessary change in pedagogy. The lack of integration with the regular curriculum is also reminiscent of the fate of many 1960s experiments in educational technology.

More recent research into curriculum implementation has suggested that the initial adoption of an innovation has to be followed by adaptation and refocussing, if the innovation is eventually to become institutionalised as part of normal practice (Berman, 1981; Hall and Loucks, 1978). Similarly Wright (1987) has noted that even regular users of computers in primary schools tend to reach a plateau after one or two years. She argues that this is because their practice is based on somewhat haphazard trial and error with little time for reflection. Further help is needed if they are to go beyond that point "to develop their understanding of microtechnology's capacity to transform certain aspects of primary school curriculum."

From this and other accounts it is possible to identify at least three different teacher responses to the introduction of computers into schools. At one extreme there are those who are extremely fearful of any technical innovation and any possible disruption to their established classroom practice. At the other extreme are the enthusiasts who adopt the use of computers unintentionally and are always pursuing the latest new development. In the middle are teachers who having overcome their initial anxiety become excited by the capacity of computers to motivate their pupils. They then reach a point where the novelty is less, and begin to consider the costs and benefits. Where and how should computers fit into the curriculum and the life of the school? These are the true educators and it is their contribution which must be further developed and expanded if NICT is to realise its potential.

3.2 Teaching Computer Literacy and Information Technology

This section refers only to courses taken by all pupils, not to specialist options Introducing such courses is probably the easiest response to external expectations that schools should use computers, but external pressures do not often provide any clear objectives. Hence courses of this kind carry a variety of labels and vary enormously in length, from 10 to 200 hours. Sometimes, considerable thought has been given to the selection of the content at national or district level. Sometimes, teachers are put in the position of "having to make it up as they go along". Even when carefully planned, it is common for courses to attempt to cover far too many of the aims discussed in Chapter 1; thus becoming superficial rather than challenging and patchy rather than coherent.

In a few countries these courses are taught by teachers specially selected and trained for the purpose: these teachers are likely to have backgrounds in computer science, physics or mathematics, and to be predisposed towards a mainly technocratic approach. In other countries, teachers may be either enthusiastic volunteers or conscripts who have spare time on their timetables, according to local circumstances. The enthusiasts will actively seek training, the conscripts may not. All teachers of this new subject are likely to have problems in developin; and sustaining an occupational identity; because they have no prior curriculum tradition or group of experienced teachers to follow. Their place in the school is uncertain, and even the future of their subject is unclear. As Chapter 2 indicated computer literacy may be incorporated into the curriculum in a variety of ways, ano separate courses may be only a step on the way to a more integrated form of provision. Those teachers who have painfully developed a new identity may find themselves having to change yet again (Petch, 1988).

Many of the problems discussed in Section 3.1 above also apply to teachers of computer literacy or information technology. Since pupils will expect regular access to computers, shortages of equipment will pose greater difficulties than for teachers of other subjects. The curr ılar and pedagogic problems will still be significant, and the role of the teacher a matter for considerable concern. There is a natural temptation in such circumstances to keep pupils fully and enthusiastically occupied with a series of computer applications or programming tasks, without giving serious attention to what is being learned, to important information-handling skills, and to wider discussions of relevant social and values issues.

3.3 School Level Policy Making and Management

Research on educational innovation has confirmed that the role of the head-teacher is crucial, even in a centralised system where he or she is given relatively little devolved authority (Fullan, 1982). This has been acknowledged in the innovation strategies adopted by some districts (Peper, 1986). However, in many schools the development of NICT has by-passed normal school management decision-making to a remarkable degree. Both in the US and in the UK the policy and practic found today is almost a historical accident, resulting from the interests and preferences of school personnel and a variety of interactions with the district authorities and the local community. Few schools have had either the expertise or the decision-making time to develop, let alone implement, coherent whole school policies. The results, as Walker (1986) reports are:

1. slow, haphazard, and scattered acquisition of equipment (because there is no budget for this purpose);
2. use by a few enthusiastic teachers who become specialists (because there are no plans for staffing, in-service education, or staff development);
3. use in isolated individual courses (because adoption throughout a department or curriculum component would require an institutional commitment);
4. improvisation, year-to-year adjustment (because strategic planning requires an institutional commitment);
5. highly variable quality (because individual users will not assert a right to pass judgement on the quality of what another may do, and the institution, having washed its hands of the matter, will be powerless).

The enterprise tends to be run by local 'experts', teachers who have acquired knowledge about computers, and are networked with other 'experts' outside the schools. They retain the tacit approval of headteachers, for whom the prospect of having to make independent judgements about school computing policy is often quite threatening. So policy may be implicitly determined by (1) the curiosity and drive of a small band of enthusiasts whose developing peer culture leads them away from today's children towards tomorrow's utopia; and (2) the availability of free or subsidised hardware and software of many kinds (usually incompatib and variable in quality). The need to bring this situation under critical control is increasingly recognised (SED, 1987); and this is clearly a priority area for headteacher training.

Before proceeding to discuss more specific aspect of school policy, it is useful to reflect for a moment on the wider implications of the introduction of computers into schools. A school is a microcosm of society, which both reflects the norms and values of society and provides some of the new perspectives which will influence the future. There are grounds for thinking that this is particularl. true for NICT. The experience of NICT in school during the 1990s will help to shape the role of NICT in our wider society during the twenty first century. Every school contains elements of a NICT related culture from which children absorb and acquire views about issues such as:

- whether NICT is a technocratic or humanistic influence
- whether it enslaves or emancipates individuals
- whether it is more for men than women
- whether it constrains or enhances personal thinking
- what kind of people tend to be high NICT users
- how to relate to the parallel curriculum
- whether they will be able to influence decisions about the future or merely sit at the receiving end of a technological imperative.

These attitudes will be influenced by formal decisions about access to equipment, the content and ethos of NICT-related courses, and the selection of teachers to work in the area. But they will also be affected by the attitudes and behaviour of teachers during daily school life, and by the developing NICT-related peer group culture (Diem, 1986; Turkle, 1984). Not only does a school need to be aware of its subtle influence on its pupils, but it will need to raise issues of this kind with the local community. It is important to keep educational issues on the agenda when people are responding to NICT in a mood of "technological panic" (Jamieson and Tasker, 1988; Sloan, 1984).

This naturally leads us to those areas of school policy for computers which most directly affect the way NICT is perceived, the curriculum and staff development. The curriculum actually received by pupils will carry hidden messages about NICT as well as overt learning objectives; and the balance and emphasis will vary considerably from one teacher to another, and according to the resources available. Hence the importance of good staff development if curriculum implementation is to proceed in the desired direction. To achieve this school managers have to make good use of external courses by selecting wisely, sending the most appropriate teachers, and organising in-school follow-up. In addition, a great deal of in-school staff development will be needed, almost certainly an ongoing programme (Anderson, 1987). This problem is discussed in greater detail in Section 4.3 below.

The use of NICT for school administration will also be a management concern; and if it is organised in a manner that engenders a negative response from teachers, the view of humans as victims of the inexorable march of a hostile technology will prevail. The effectiveness of both administrative and curricular usage will depend on resource management. On the hardware side this means a coherent purchasing policy, reliable maintenance, and the optimum deployment of equipment; on the software side, arrangements for searching out, evaluating and purchasing need to be combined with cataloguing, good access and storage. There is also the problem of converting spaces to improve usage and the perennial problem of security. These activities have to be delegated to appropriate teachers or technicians, who then need to be given clear policy briefs and properly managed, not just left alone.

Problems have often arisen when a single teacher with computer expertise, or sometimes only enthusiasm, has been given responsibility both for managing the computing facility and for staff development without regard for whether he or she has the skills needed for either job. In some schools, this problem has been resolved by creating two distinct roles: a system manager with responsibility for managing the computing facility and its hardware and software resources and a NICT coordinator to oversee staff development and take responsibility for the curricular implications of NICT. The former requires technical expertise and administrative skills, the latter pedagogic expertise and interpersonal skills. Whatever the arrangement, teachers will need training for these management tasks; and will benefit from the regular exchange of experience with their counterparts in other schools. It is particularly important for schools to have a long-term policy, so staff development can be planned ahead, key people given some incentive and direction, and special offers of equipment and/or advice can be accepted or rejected according to proper policy criteria (SED, 1987).

Further management issues arise when the school is also used as a resource for adults or a centre for adult education. NICT facilities might be important for the adult programme, which would have to be carefully meshed with other aspects of the school's work. One can also envisage situations where parents bought equipment for the school, which they then want to use in the evenings or during weekends.

CHAPTER 4 NATIONAL POLICIES, SOFTWARE DEVELOPMENT AND TEACHER TRAINING

4.1 National Policies

An extensive and helpful review of policies in OECD countries was published in 1986; and more recent and detailed information for Council of Europe nations is provided in the National Reports for this conference. In order to avoid duplication, this section is confined to a few salient points. First, special attention is given in the two following sections to Software Development and Teacher Training. This is not because these are the only important aspects of a national policy, but because they are the least appreciated by policy makers. Their attention is repeatedly drawn to hardware, partly because it is indispensable and visible, and partly because of concern for each nation's own information technology industry. Yet expenditure on hardware does not provide the desired positive effects on pupils, unless software development and teacher training are given an equivalent priority. The discussion of NICT implementation in Chapter 3 above highlighted several issues relevant to developing a balanced policy.

(1) A certain 'critical mass' of equipment is needed to support specific educational policies.

(2) Software development needs to be closely integrated with curriculum development; and is lagging behind hardware provision.

(3) Pedagogic issues are vital to the effective use of computers, yet neglected in training.

As the OECD report noted, hardware policies usually favour equity rather than efficiency; and this problem is compounded by the 'software famine' and inadequate teacher training.

All these points are highlighted by the few published evaluations of national policies. However Makrakis' (1988) case studies of Sweden and Greece was a doctoral thesis rather than a commissioned evaluation; while HM Inspectors' report on the Microelectronics Education Programme in England and Wales (DES, 1987) was much too late to be useful. Only Norway, to my knowledge commissioned an independent evaluation (OECD, 1987b) to guide its policy-making process. Given the level of investment and the degree of uncertainty surrounding both innovation strategies and classroom implementation, this lack of policy evaluation seems extremely unwise. When an OECD report (1986) suggests that "One way to look at the present situation is to see education as engaged in a vast exercise of trial and error", one has to ask how much and how effectively are we learning from such an expensive experience.

We should also note at this point that, although it is important for major policy issues to be widely debated in democratic societies, there is a danger that the public are particularly ill-informed about some of the issues raised at this conference. Three recommendations follow. First, more realistic estimates of cost need to be available and in a form that makes the question of 'value for money' more easily discussed. System and training costs should be included, not just expenditure on hardware; and pupil access time should be used as a simple indicator of the level of implementation, not pupil/machine ratios. Second, the curriculum aims outlined in Chapter 1 need to be rationally discussed and prioritised, in a mood free from either salesmanship or technological panic. Then third, much closer attention needs to be paid to the side-effects of various innovations and policies, on attitudes towards NICT, on career choice and on equality of opportunity.

4.2 Software Development

Several factors contribute to what most writers perceive as a 'software famine' (Smith, 1989)

- the educational software market is small in comparison with either the commercial software market or the textbook market
- small linguistic groups are especially disadvantaged
- software is tied to hardware, which reduces the market still further, limits cross-national transfer and shortens its lifetime because the technology is changing so rapidly.

- software is expensive to produce
- software development expertise is in short supply
- mechanisms for finding and evaluating software are inadequate
- software is available only as an isolated item, not as part of a coherent curriculum package
- good quality software is still exceedingly scarce.

The size of the market may be increased (1) by having more users, i.e. increasing access to equipment (2) by standardisation which reduces the number of operating systems and user interfaces (3) by reducing the quantity in favour of quality. However, even in the large North American market software manufacturers tend to play it safe. Thus a recent policy review (Congress, 1988) reported "substantial concern for the long-term quality and diversity" of commercial products; and recommended further underwriting of software research and development.

This is an area where European cooperation could make a significant difference, not only through standardisation but also through organised coproduction (the parallel development of similar software between two or more countries) and through joint activities (such as exchanges and workshops) for the further development of expertise. Some such arrangements already exist among the Nordic countries. These ideas were further developed at a recent conference organised by the Commission of the European Community (CEC, 1987), which also provided a useful review of national software policies.

Most reviewers of the software situation see an important continuing role for software development teams, where special expertise can be developed (Cerych and Jallade, 1986). Several such teams are described in Moonen and Plomp (1987), in which several contributors also discuss software evaluation. To produce the best results, such teams need an understanding management which can find a balance between productivity and quality, very close links with schools and an independent formative evaluation facility. Nevertheless there is still a danger that they will produce software, which is not accompanied by good pedagogic advice and is not sufficiently integrated into a larger curriculum package.

This highlights a problem that is central to any national policy for NICT, its relationship with other educational policies. Most of the problems identified in Chapter 3 concern management, curriculum and pedagogy; and none of them can be resolved within an exclusively NICT-based framework. Software development teams probably ought to be expanded into curriculum development teams for whom software is only part of their remit; and such teams should also be closely involved in the development and evaluation of pedagogic strategies.

4.3 Teacher Training

Practically every issue raised in this report has implications for teacher training. At every level and in every country further training is needed both to extend training to people who have not yet received NICT-related training; and to continue to improve the capabilities of those who have been trained. Chapter 1 has identified the curricular goals which teachers may have to deliver, and Chapter 2 the extent to which these are likely to be the responsibility of specialist teachers or teachers of traditional school subjects. Chapter 3 then demonstrated that, in addition to the more obvious needs for competence in using the appropriate NICT software, there were vital training needs relating to curriculum implementation, classroom management, pedagogic approaches and monitoring of student progress.

This section is organised according to the tasks which a teacher may be expected to perform. First, the training of specialist teachers of computer studies is considered, and that of semi-specialists who teach computer literacy. We then discuss the training of all other secondary school teachers and primary school teachers. Next training needs are suggested for sc. dbased management roles such as NICT coordinator, system manager and headteacher; then finally those for out-of -chool personnel such . dvisers, administrators, NICT trainers and software developers.

4.3.1 The training of specialists and semi-specialists

Those countries introducing computer studies or computer literacy as a new curriculum subject face the problem of recruiting and training sufficient specialist teachers. These may come (1) direct from the diminishing cohort of secondary schoolleavers., or (2) from the highly demanded group of computer science graduates or (3) by conversion training for teachers of other subjects. This section will only cover their needs as teachers. Further needs resulting from the expectation that these specialists will also assist other teachers, deliver in-school training, and generally spearhead the innovating introduction of NICT, will be dealt with in Section 4.3.3 below where we examine the needs of NICT coordinators. The teaching role will itself present many problems. Those teachers with computing experience are likely to find school equipment somewhat inferior to that to which they have become accustomed. There will be considerable pressure to keep their knowledge constantly up to date. Above all they will be pioneering the teaching of a new subject, in which there is no established pedagogy and few teacher educators with any substantial teaching experience.

In order to teach computer studies, a computer scientist will need a combination of practical in-school experience with courses in education and on the teaching of the subject. In most countries this introduction of graduates into teaching takes several months. A conversion course, on the other hand, would have to cover a wide range of specialist knowledge, courses in subject pedagogy and practical experience in teaching computer studies. This would take at least a full year (OECD, 1986). Most countries have now developed and successfully delivered the computer science components of such a course, but hitherto the equally important pedagogic aspects have received much less attention. This is hardly surprising since a new subject pedagogy is still in the process of creation, only limited expertise is available for incorporation into training. Given sufficient priority, this problem ought to diminish over time.

These pedagogic problems are greater still for teachers of computer literacy in lower secondary or primary schools. Their training is less, their equipment is often worse, their students are less mature, not necessarily volunteers, and their curriculum is usually less well defined. I have used the term semi-specialist, because these teachers rarely receive specialist training. Yet they still have to forge a new subject identity, often on the basis of minimal experience and expertise. The knowledge base appropriate for this group of teachers will depend on the breadth of the Information Technology Syllabus. While the model suggested by the Association for Teacher Education in Europe (Van Weert, 1984 is broader than many current courses in computer literacy, it still leaves out some of the goals discussed in Sections 1.3 and 1.4 above. In particular, it fails to put the use of computers into the wider context of information skills and communications or to consider algorithmic procedures as but one approach to thinking and problem-solving. Also, the evidence of Chapter 3 suggests that the methodology or didactics course would need to be more substantial than the others if it was to include sufficient practical teaching experience. Olson and Eaton (1986), for exmaple, suggest that such a course should include (1) discussio of the competencies and understanding pupils should be expected to achieve, and how their development can be monitored, (2) exploration of a range of pedagogies including whole-class teaching with a computer, groupwork and appropriate off-line learning activities, and (3) practical study, experiment and reflection on the teacher's role in various IT teaching contexts. It is difficult to imagine these goals being achieved by a course of less than 200 hours.

Specialist training in media education presents a rather different set of problems. First, the curriculum debate in many countries has left media education in a somewhat ambiguous position; and arguments for media education currently command less political support than those for computer literacy. Second, there is a substantial knowledge base required for teaching about the media and engaging in media criticis, even if this is not always recognised. Third, on a more positive note, the pedagogic skills required are fairly similar to those already possessed by many teachers of literature and social studies, and therefore present less of a problem. As a result, specialist training in media education is more easily delivered by distance learning, except for the area of production skills which like many computer-based skills requires practice with feedback and coaching.

4.3.2 The training of teachers of other subjects

The magnitude of this task was aptly described in a report from OECD/CERI (1986):

> "We face the need to train, as rapidly as possible, the entirety of the teaching profession to use the new technologies. Given the rapid evolution of the whole NIT area, it is scarcely any exaggeration to say that the whole profession would need, by some means or another, to be placed in semi-permanent retraining. There are many reasons why it is wildly impracticable to think in these terms ; not least a lack of trained trainers, economic constraints, insufficiently clear agreement on the directions to be followed. The logistics of such an exercise, too, would be overwhelming. Yet this is, in fact, the fundamental task facing the various agencies of teacher in-service training and its seriousness should not be ignored."

Some countries have made a substantial start, most notably the Nordic Countries, France and the United Kingdom. Denmark has just completed a five year programme to train all of its upper secondary teachers. Not only have 95% of teachers at this level completed both a 20 hour local course and a 40 hour regional course (partly differentiated according to subject), but three teachers from each school have completed 200 hour courses. An evaluation of this programme would be extremely useful.

Typically, introductory courses have been much shorter than those in Denmark, and evidence is reported that their impact has been extremely variable (Vickers, 1987). Several reasons for this have been reported. First, training has not been closely coordinated with access to hardware and software in schools; so some teachers have received training and found themselves without any opportunity to implement what they had learned, while others were given access without any training opportunity. Second, some teachers were given longer training courses the expectation that they would later assist and train their colleagues, but then found themselves given no release time from teaching to carry out these additional duties. Third, some courses were too short and possibly too insensitive to overcome teachers' initial lack of confidence. Fourth, some courses focussed only on technical aspects and gave little time to curricular or pedagogic matters. Indeed, even the basic task of familiarising teachers with relevant software was sometimes ignored in favour of the teaching of programming. Fifth, it is now increasingly recognised that short courses need a period of school-based follow-up in order to have a maximum effect. Unless the schools have the will and the capacity to do this much of this course is likely to be wasted. This problem is not necessarily solved by making courses school-based because teachers will still need individual support and coaching at the follow-up stage.

The lessons of this experience should be carefully noted. They point to a need for improved liaison between trainers and schools, for proper management of training and follow-up within the schools, for more relevant courses; and for greater attention to what is already known from research into educational innovation and in-service training (Bolam, 1987; Eraut 1988).

The Vickers Report also draws attention to another important problem the extent to which the important pedagogic expertise, stressed in Chapter 3, is not readily available outside the classrooms of leading practitioners.

> "It is the teachers themselves who are pioneering new approaches to practical pedagogy. What is needed is not just subject knowledge, but knowledge about how students might learn that subject in computer enhanced environments. Knowledge about how these environments work is only slowly being developed; it is being created at the classroom level by teachers who are acting as researchers, analysing the actual effects of different software packages, and experimenting with alternative ways of using them."
>
> (Vickers, 1987)

There is a major management problem in capturing this expertise for training purposes and continuing to develop and update it, without taking all the best teachers out of the classroom.

What then does the training of a subject teacher have to accomplish? First it has to overcome inhibitions about the hardware and achieve a degree of machine competence. Second, it has to establish sufficient familiarity with a range of software appropriate to the subject to give the teacher confidence in using it. Third, it has to enable the teacher to critically evaluate software in terms of its assumptions about knowledge and pedagogy, its implicit values and its impact on pupils (Johnson, 1987). Above all they need to become aware of a range of pedagogic strategies, to observe 'good practice' at first hand, to be able to experiment under guidance and to discuss the relative merits of different approaches. Such training will probably need to involve some formal sessions, and some guided visits and classroom experiment. While the former could be provided out-of-school, the latter will almost certainly require school-based support (Ellam and Wellington, 1987).

Such school-based support may be provided either by teachers within the school who have greater experience of NICT or by advisory teachers who visit the school and work alongside teachers in their classrooms. Both strategies are further discussed below. Another need is for teachers to hav. sufficient access to machines and in their own personal time for them to gain greater confidence as users and begin to explore new possibilities. The policy of New Hampshire, the American state, which has funded the purchase of computers for achers' personal use, might seem unduly charitable; it could be an excellent investment if accompanied by appropriate training.

So far this section has concentrated on the needs of secondary teachers, though most of the comments would also be pertinent at primary level. The differences will be greatest in those countries where primary teachers take a single class for all subjects. These teachers will need to be familiar with a wider range of software, but will nevertheless find that much of their experience can transfer across subjects. Primary teachers often have the opportunity to use computers more flexibly, but are likely to have less machines available.

While it is relatively easy to organise new computer studies courses within pre-service training, it is still difficult to meet subject-specific needs and to make such courses sufficiently relevant to classroom. One reason is because the task of retraining subject-based teacher educators has not been seriously tackled in most countries. Another is that appropriate pedagogic expertise is scarce in teacher training institutions and it is difficult to find appropriate school experience for trainee teachers.

4.3.3 Training for School-Based Management of NICT

In section 3.3, we briefly discussed the distinctive roles within schools of the 'system manager' and the 'NICT coordinator'. The system manager has responsibility for the purchase, distribution and maintenance of the equipment, and possibly also for the management of software. This requires a clear policy brief and close liaison with school management to ensure that the facility best serves the needs of the students. Administrative skills are needed and often technical expertise as well; though the technical side of the job will depend greatly on the help and advice available from outside the school and the quantity and quality of technician support inside the school. People with the appropriate skills for this task may not be well suited for the NICT coordinator role, yet they are essential for keeping the system running. Teachers abandon unreliable systems very quickly indeed, so attempting to innovate without a reliable facility is a total waste of time. System managers need training that enhances their existing technical expertise and includes detailed study of the relevant administrative issues; access to information and advice from outside the school, opportunities to meet counterparts from other schools and regular updating.

The NICT coordinator role is primarily concerned with curricular and pedagogical issues and NICT-related staff development. Such a person needs the same kind of basic training as the semi-specialist teachers of computer literacy (see Section 4.3.1 above), plus some knowledge and awareness of the more specialist needs of the various school subjects. As a coordinator they should not be expected to be the sole possessor of expertise, but rather to act as the channel through which it may be made available; for example through organising access to subject-specific training or a consultancy visit from an appropriate external expert. This requires good interpersonal and networking skills. The other kind of knowledge required by NICT coordinators relates to staff development, in-service training and the management of change. They have to assess staff development needs and find appropriate ways of meeting them, and to be a general source of pedagogic advice. They will also need to contribute to schools' policy for NICT and its impact not only on the curriculum, but on teachers and pupils and the general school milieu. This kind of training is available in the UK on the more practice-oriented advanced post-experience courses, usually for masters degrees; but is less common in other European countries.

Finally, we should consider the headteacher whose support, neutrality or opposition is crucial for introducing any innovation. Their training is now a recognised priority in many countries, but has not usually included familiarisation with NICT. Apart from the need to become personal users, they need to be more aware of the educational issues discussed at this conference, to be familiar with a range of possible school policies, and to be able to conceptualise what the proper management of NICT within a school involves. They will then be properly prepared to oversee the policy development process in their schools, to delegate the various NICT-related responsibilities to appropriate members of staff and to see that they get proper training to do their jobs well.

4.3.4 Training of Out-Of-School Personnel

The main out-of-school roles to be considered are training and advisory work, administration and software development As suggested earlier, the acu lack of suitably prepared trainers is a major barrier to rapid progress. Because curricular and pedagogic knowledge relating to NICT is still in its early development and largely created in schools here has to be some kind of partnership between trainers and pioneering classroom teachers. But there also have to be limits on the recruitment of these teachers into training roles, if their creation of new pedagogic knowledge is to continue. Hence the initial build-up of a cadre of trainers is likely to be quite slow, although it will be possible to accelerate later. Subject knowledge of NICT is more widely available, though much in demand outside teacher education. Finally, there is a danger of ignoring expertise in teacher education itself. People appointed as trainers have much to learn about the planning, design and delivery of courses, about how to provide advice or follow-up training, and about the knowledge and skills required by change agents. They will need to be familiar with the literature on the management of change and in-service education, and to develop an appropriate range of interpersonal skills. Thus training the trainers involves the communication of training knowledge and know-how in addition to the necessary subject knowledge and pedagogic expertise.

The long-term need, however, is not just for specialist trainers in NICT, but for the intergration of a NICT component into all other forms of teacher training. Unless this is achieved fairly soon, the greater part of initial and re-experience teacher training will continue either without a NICT component or, more probably, with a NICT component that is purely technical and separated off from the other p ical forms of training. This need applies not only to trainers of teachers but also to trainers of headteachers and administrators. In the short term, NICT specialists will be able to organise conferences and prepare special briefings for headteachers and administrators; and in the medium term it may be possible to recruit at least one trainer to each training team, who has some competence in NICT. Not many NICT specialists will be able to take on such a task, so the recruitment and preparation of suitable members of training teams will need to be carefully planned.

The planned development of teams is even more important for software development, where it is generally acknowledged that teams are needed: both to bring together a sufficient range of expertise and for the additional quality that their interaction is believed to stimulate. Earlier, I recommended that some software development should be embedded within a larger curriculum development brief, in order to tackle sizeable chunks of curriculum, to integrate computer-based and non computer-based activities and to give greater attention to pedagogic issues. If this policy was accepted, then a wider range of expertise would be needed and teamwork would be even more important. All members of such a team should have some knowledge of NICT, though only some would need to be NICT specialists. Expertise would also be needed in curriculum development, instructional design and the appropriate subject pedagogy. Recruiting such teams and continuing to develop their expertise is an important function of any national policy for NICT in education.

4.4 Research and Evaluation

NICT is an area of rapid development and high investment. There is therefore considerable need for continuing research to see that the education sector both meets the challenge of NICT and derives maximum benefit from new developments. Alongside this research, ongoing evaluation of current developments must surely be prudent. Policies need to be continually adjusted in the light of evidence about how they are working out in practice. My main concerns in this area are threefold.

(1) Research on NICT in education must be sufficiently broadly based. There is a danger that it will focus too narrowly on hardware and software development. Such matters as the organisation of NICT in schools, user interfaces and pedagogic strategies also need urgent attention. Curricular patterns need

to be tried and evaluated in order to ascertain how best to incorporate NICT-related goals in the education system.

(2) Evaluation projects needs to be mounted which provide constructive feedback to developers, trainers and policy-makers. Innovation in NICT sometimes comes dangerously close to "the blind l ng the blind".

(3) More notice needs to be taken of previous research, particularly that relating to innovation and the management of change. The well-documented mistakes of the 1960s and 1970s are in danger of being repeated in the 1990s.

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