

AN INTRODUCTION TO EDUCATIONAL COMPUTING

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The Purpose of this Series

This series of books is intended to provide readable introductions to trends and areas of current thinking in education. Each book will be of interest to all educators, trainers and administrators responsible for the implementation of educational policies and programmes in higher, further and continuing education.

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This, the first book in the series, is written by Nicholas Rushby of the Imperial College Computer Centre, London where he directs a project concerned with the use of computers in education as a resource. Until last year he co-ordinated a major project as part of the National Development Programme in Computer Assisted Learning.

Titles of other books in the series that will be available shortly are given on the inside back cover of this book.

Currently available is the second title in this series *Preparing Educational Materials* by Duncan Harris of the University of Bath.

P. J. Hills.
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It would be difficult to compile a list of all those people who have contributed, directly or indirectly, to the writing of this book, for such a list would include the names of everyone I have worked with for the last eight years and many more whom I have met or whose work I have studied. I have tried in this book to portray all the facets of the subject, the disadvantages and the limitations of computer assisted learning as well as its benefits and possibilities. Inevitably in doing so, my own views have been influenced by others. I have also called on some of the scepticism of its critics.

However, some friends and colleagues deserve special mention — Edward James, my longtime mentor who first aroused my interest in the subject, Richard Hooper who was the Director of the UK National Development Programme in Computer Assisted Learning, all our colleagues in the many educational and training institutions working in CAL projects under the aegis of the National Programme, and staff from CAL projects in Europe, particularly in France, Holland and Germany. To all these people I owe my thanks for their time and patience. The responsibility for my perceptions — and my possible misconceptions — of their work lies of course with myself.

Finally it is customary, and in this case very appropriate, to record my thanks to my wife and family for their tolerance. Writing the book has not been easy — least of all for them.

Nick Rushby

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PREFACE

In both education and training, teachers are faced with many and varied problems relating to their teaching and their students' learning. Highly structured courses to meet the particular needs of individual students pose problems of instruction; modular course structures with more sophisticated assessment methods pose problems of student management; student centred courses pose problems of resource management; necessary practical experience may be time-consuming, expensive or impossibly dangerous. Educational technology, in its widest sense, provides teachers with methods and tools which, properly applied, can alleviate some of these problems. The computer is one of these tools, offering some possible solutions — but with some limitations too.

This book is concerned primarily with the use of the computer as a resource and as a manager in education and training; in other words, teaching with computers, rather than teaching about computers. However, as we shall see later, it is often difficult to distinguish between these two activities. Inevitably the use of computers in the teaching process helps the student to appreciate their capabilities and to dispel the aura of mystique which surrounds them. Further, it is very difficult to teach students about computers without using the computer itself.

The text has been written for practising teachers in all kinds of education and training environments, for students of education, and for administrators responsible for the implementation of educational and training policies and programmes. It is primarily a book about the potential and the use of a technology to help the teacher and trainer, rather than about the technology itself. Certainly, although it assumes some preknowledge about education, training, and the ways in which we teach and learn, it does not presume that the reader knows any more about computers than that these machines exist.

To avoid verbosity, the term education has been used in the text to mean training as well as education at all levels. Similarly, the word student should be taken to mean pupil, student or trainee, while lecturers, tutors and instructors are referred to collectively as teachers. Finally, as is customary, masculine pronouns have been used throughout; the avoidance of words like she and her is an attempt at brevity rather than an assumption that there are no women students, pupils, lecturers, tutors, teachers,

trainees or instructors in education or training.

An Overview

It is important to realise that an in-depth knowledge of computers and their operation is not an essential prerequisite for using them to assist in teaching and training. There seems no good reason why a teacher should know any more about computers than about any other machine that he uses in his teaching, for example an overhead projector. Success in using an overhead projector depends on the way it is used and on the quality and relevance of the graphics rather than on an understanding of its design. The role of the computer as a mediator in the flow of information between the student and his learning environment is discussed in the first chapter, on education and information. A model based on the different kinds of information flowing in the learning process provides a means of describing, if not defining, the differences between computer assisted and computer managed learning.

Chapter 2 looks at 'Computer Assisted Learning' (CAL) from an educational viewpoint and examines four broad areas of use. In the first form, which owes its origins to the techniques of programmed learning, the computer is used to provide a tutorial dialogue in which the student is systematically led through the course. The focus of attention is on the subject material which the student must master. In the second form, it is the student who is the central feature and the computer is used to provide information about a particular situation or simulated system so that the student can explore it and learn about it. The third form of CAL supports the student while he forms and tests control of the learning process, sometimes devising his own models and programming the computer accordingly. The fourth area is concerned with reducing the unnecessary labour of learning by helping the student to carry out tedious calculations or extracting relevant information from large quantities of data.

Computer assisted learning is one, but only one, of the tools that the teacher can use in his teaching. Certainly it is a very charismatic tool, but to be effective it must be applied appropriately. Chapter 3, on 'Using Computer Assisted Learning', considers the strengths and weaknesses of a number of different media: books, tape slide, educational television, computer assisted learning — and live teachers too. This leads to the idea of a learning package, which consists of one or more contributions to a specific subject topic using a number of different media. One of these may be a CAL program.

The problems of managing modular courses and course structures, and handling information on students' performance and progress are

covered in Chapter 4 on 'Computer Managed Learning' (CML). The length of this chapter reflects the extensive nature of the facilities that can be provided by a CML system. While CAL concentrates on the student and his learning, CML is concerned with helping the teacher and the student by relieving them of some of the routine, time-consuming management processes. These include the tasks of assessment, test analysis and item banking, guiding students through modular courses and beyond into their choice of career, the maintenance of student records with the attendant problems of privacy and accuracy, and reporting on the performance of students, the assessment methods and the course, to the students, their teachers and the education or training management. The chapter concludes with a brief description of the administrative applications of the computer in education and training, particularly for timetabling and resource management.

Chapter 5, on 'Informatics and Education', addresses the problem of what we should teach our students, and know ourselves, about computers. Should we teach our students how the computer operates and how to program it, or concentrate on its impact on society, its possibilities and limitations. In addition to the obvious link that the use of the computer in CAL and CML breeds familiarity rather than fear, there is a second connection, because part of the study of computing concerns a systematic approach to problem solving which can often be successfully applied to the problems of education and the educated.

To be effective, CAL and CML must be used appropriately. To be practicable, the technological and educational resources required must also be deployed appropriately. Educational computing brings together three interrelated kinds of resources: the provision of computing machinery, the development of computer programs, and the production of educational materials. Chapter 6, 'Technological Aspects', considers the cost of providing the technological resources and how this may be reduced.

The final chapter, 'Managing the CAL Innovation', examines the problems of promoting and organising the appropriate use of this technology in a number of institutions in different national educational systems. It discusses ways of managing the production of educational course material and the supporting computer programs, and the factors influencing and inhibiting the innovation.

Other books, papers and reports referenced within the text are included in an annotated bibliography of key works in educational computing. The final section of the book is a glossary which gives brief definitions of key terms in educational computing and in computing itself.

Computers in Education and Training

The use of computers in education and training has been greatly influenced by the history of their introduction into universities, colleges and industry, and by their use in applications other than education and training. Many of the earliest recognisable computers were developed and operated in universities on both sides of the Atlantic. Since those early days, the computer has grown in importance as a research tool so that now it would be unthinkable, in many subject areas, to carry out research work without access to a computer. Next, the effective, large-scale use of computers requires a cadre of trained staff to design and support computing systems and to help potential users who may not be skilled programmers. Teaching people about computers uses a substantial amount of computer time and, traditionally, research and teaching computing together account for most of the computing activities in higher education. At secondary level, where the research aspect is absent, computer education is dominant.

More recently, first in North America and then in Europe and elsewhere, teachers have realised that the power of the computer as a machine for storing, organising and processing information can be applied to teaching and learning. The computer may be used as a classroom resource, as a calculator, as a model of some real-life situation or as a means of producing animated visual aids. Alternatively it may be used in the background to help with the classroom management, keeping records of the students' performance and carrying out other supportive functions.

In industry and commerce, the original reasons for installing computers were to support the every-day processes of the organisations; to carry out the calculations for payroll and invoicing, to process stock control information, to model the financial behaviour of the company and its environment, to control production lines and processes, and recently for more sophisticated applications such as airline reservation and operating systems. As teachers came to realise that computers could be used to support their teaching, so their colleagues in industrial training saw that the computers already in their organisations could be used to help in the training process.

Whether in education or training, teachers are faced with many and varied problems relating to their teaching and their students' learning.

Highly structured courses to meet the particular needs of individual students pose problems of instruction; modular course structures with more sophisticated assessment methods pose problems of student management; student centred courses to meet the particular needs of individual students pose problems of resource management; necessary practical experience may be time-consuming, expensive, or impossibly dangerous. Educational technology, in its widest sense, provides teachers with methods and tools which, properly applied, can alleviate some of these problems. The computer is one of these tools.

Education and Training Systems

Education and training involve complex systems which concern students, teachers and parents, resources such as schools and colleges, educational or training administrators, society and industry. This system is subject to pressures from a number of sources. In particular, three pressures, political, technological and social, can be seen as exerting considerable influence on it. These pressures are discussed in more detail in Chapter 7.

In discussing the use of computing in all levels of education and in training, we must recognise that there are both significant differences between the two, and also common problem areas to which this technology may bring common solutions. These distinctions are perceived in different ways, by the practitioners who think in terms of outcomes, and by the educational or training technologists who think of the processes needed to achieve those outcomes.

One difference which is seen as significant by many teachers and instructors is that, while the main aim of the educational process is to benefit the student, in training it is the organisation that hopes to benefit by acquiring a more skilled person. The managers of educational and training systems have different expectations of their students' success. The aim of the training process is to ensure that as many as possible of the students achieve all the course objectives and hence complete the training successfully. Most education systems, by accident or design, operate by a process of periodic culling, so that only the most successful students at the end of each stage may pass on to the next.

The process of education tends to focus on the student as someone to be guided through his learning and encouraged to widen his aspirations so that he can fulfil his potential in society. Education is perceived by its participants as a democratic process while training, in contrast, is usually more prescriptive. Training tends to concentrate on the student's learning of the subject matter so that he acquires the necessary abilities and skill to carry out his role in the organisation. Clearly this is an over-

simplification, because many training courses encourage students to extend their learning beyond mastery of the specified objectives, while much of education, particularly at the primary and secondary level, is concerned with the teaching of basic skills, such as arithmetic, and thus by the above definition is really training.

This difference in approach is also seen in the methods which are used to assess the students' performance and progress. Training commonly uses criterion-referenced testing[†] which seeks to establish whether the student has achieved specified objectives. Assessment in education has also a qualitative flavour, and examines not only whether the objectives have been mastered, but also the degree of excellence achieved and how well each student has performed by comparison with his peers.

There are also considerable differences between the aims and processes of education at different levels. The shift in emphasis away from skills training to more abstract forms of knowledge in secondary and higher education is one obvious difference. A less apparent distinction is the change in the locus of control of learning as the student matures and moves from secondary to higher education. For the first part of his formal education, the student expects to be told what he must do in order to learn. Later, it may be desirable to wean him from this dependence on his mentor so that he can learn to learn by himself and, hence, continue to learn effectively after the end of his formal education.

Behind these different teaching and learning methods and objectives lie the common problem areas listed earlier: problems of individualising instruction to meet the particular needs of particular students; problems of managing students and resources; problems of providing particular learning experiences. For these problems computer assisted and computer managed learning offer some possible solutions — but have some limitations too.

Students and Information

The milieu of educational computing abounds with Lewis Carroll-like phrases which authors use to mean just what they want them to mean, nothing more and nothing less. The literature is confused with near synonyms such as computer aided instruction and computer aided learning[†] which are sometimes used interchangeably, but for some authors have subtle differences of meaning. Certainly there is a difference between the processes of learning and instruction; instruction is not a necessary condition, and is seldom a sufficient condition, for learning.

[†]Words or phrases marked with a dagger are to be found in the Glossary at the end of the book.

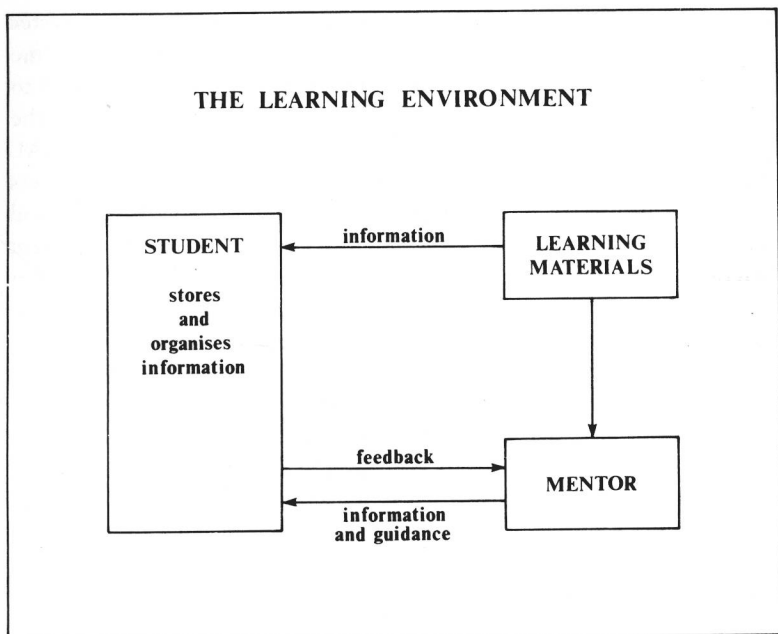
The difference between computer assisted learning (or CAL)[†] and computer managed learning[†] (or CML) is more significant but difficult to define. Traditionally, the distinction has been that in computer assisted learning the learning material is presented to the student through the computer, while in computer managed learning the computer is used to direct the student from one part of the course to another and the learning materials themselves are not kept in the machine. So in CAL the student receives some detailed tuition from the computer whereas with CML he and his tutor get information about his performance and progress. However, many CAL systems also carry out some management functions. Similarly, some CML systems present tutorial information which would usually be associated with computer assisted learning. The difference between the two is therefore somewhat blurred.

In a simplistic view of the learning process, the student acquires knowledge by receiving information from his surroundings and organising it so that he can then retrieve specific items, make generalisations and extrapolations. The speed, and perhaps the quality, of some learning may be improved if the student works with structured learning materials and is given some individual guidance by his mentor on his selection of a route through the modules. This implies that the student will supply information about his progress, problems and preferences. Hence there is a two-way flow of information with facts and guidance coming from the environment to the student, and feedback coming from the student. This is illustrated in Figure 1.1.

Clearly this is but a crude and oversimplified model of the very complex processes which constitute learning; processes which we do not fully comprehend. It can be argued that until we have developed a better understanding of the learning process it is difficult to advance our use of educational technology. Perhaps — but then there are many teachers who are able to help their students to learn although they too lack a clear and complete theory of learning and it seems reasonable that we should proceed cautiously in advance of the theory.

This pragmatic view provides a convenient description of the various types of educational computing. The computer can be seen as a mediator of the two-way flow of information between the student and his learning environment. We have seen that there are various kinds of information, facts, feedback and guidance. There are also quantitative and qualitative differences in the information, depending on the scale at which the learning is examined. At the micro level, for example when the student is working in a small seminar group or is reading a book, the information is highly detailed and changes very rapidly. It is difficult to

Figure 1.1: The Student in His Learning Environment



record and store all the information which is passed around during a lively discussion seminar, yet this is only a small part of each student's learning activities during a course which lasts for several weeks, months or years. In the longer term, this level of detail is unnecessary and a summary of the flow is more relevant. So there is another scale at which the learning process can be viewed, where the information is rather less detailed and changes less rapidly. This might be at the level where the student's activities are seen in terms of modules which take perhaps two or three hours to complete. Progressing further, this information can again be summarised to provide details of the learning process on a timescale which spans months, terms or years. Again there is less detail and a slower rate of change of information. This range of information detail and change is shown in Figure 1.2.

We should remember that the basic information considered in the model is the same throughout the range; it is the level of detail that is changing. At each stage the information is summarised and so reduced in quantity before being passed onto the next stage. So at the detailed end of the range there is a vast amount of information relating to each