David Woodhouse and Anne McDougall

COMPUTERS

Promise and Challenge in Education

BLACKWELL SCIENTIFIC PUBLICATIONS

COMPUTERS

Promise and Challenge in Education

David Woodhouse

MA DPhil MSc DipEd

Dean, School of Mathematical
and Information Sciences,
La Trobe University, Melbourne

Anne McDougall

MSc MEd

Lecturer in Computer Education,
Monash University, Melbourne

Blackwell Scientific Publications

Melbourne Oxford London Edinburgh Boston Palo Alto

Editorial offices:
107 Barry Street, Carlton
Victoria 3053, Australia
Osney Mead, Oxford OX2 0EL, UK
8 John Street, London WC1N 2ES, UK
23 Ainslie Place, Edinburgh
EH3 6AJ, UK
52 Beacon Street, Boston
Mass. 02108, USA
677 Lytton Avenue, Palo Alto,
Ca. 94301, USA

First published 1986

Typeset in Australia by Davey Graphics Pty Ltd
Printed in Singapore by
Singapore National Printers Pte Ltd

DISTRIBUTORS

USA and Canada
Computer Science Press Inc
1803 Research Boulevard
Rockville, Maryland
20850, USA

Australia
Blackwell Scientific
Publications Pty Ltd
107 Barry Street, Carlton
Victoria 3053

South-East Asia
P G Publishing Pte Ltd
Alexandra PO Box 318
Singapore 9115

Others
Blackwell Scientific
Publications
Osney Mead, Oxford
OX2 0EL, UK

Cataloguing in publication data
Woodhouse, David, 1940–
Computers: promise and challenge in education.

Bibliography.
Includes index.
ISBN 0 86793 160 4.

1. Computer-assisted instruction.
2. Computers — Study and teaching.
3. Microcomputers. I. McDougall, Anne, 1945– . II. Title.

371.3'9445

INTRODUCTION

Changes occur rapidly in computing. This book has been a year in the writing, and has had to be thoroughly revised to keep pace with the new developments of that year. Therefore, to avoid its early obsolescence, we have looked as far ahead as possible. We dismiss as out of date some topics and methods that are still current; and we describe as standard some that are only just emerging. Not being clairvoyant, we shall doubtless be wrong on some counts (perhaps, for example, Prolog will not be the language of the future, after all, but will be overtaken by a new-look Lisp). However, sufficient will be correct for this book to be of use for some time as a teacher's guide to the growing area of computer use in schools.

The book is for all teachers who intend to use computers in schools. It is not about teacher training *per se*, nor is it a general introduction to the structure and use of computers. Rather, it covers the intersection of these two fields of study. The two major topics in this intersection may be categorized crudely as 'learning with computers' and 'learning about computers'. The former topic is the subject of Part I of this book. The nature of the computer as an information processor means that it can be used to enhance teaching and learning processes. The decreasing cost of computing facilities means that it is increasingly feasible to consider them as possible aids to teaching and learning. As such an aid, the computer has its own particular strengths and weaknesses. However, it is potentially a valuable teaching aid right across the curriculum, and all teachers should know sufficient about it to be able to decide whether, and if so when and how, to use it in their teaching. Part I describes the theory and practice of using computers to assist the processes of teaching and learning. This use of computers has been given a multitude of names, including CAL, CAI (Computer Assisted Learning or Instruction), CBL, CBI, CBE (B for Based, E for Education), CSL and CSI (S for Supported). We prefer 'Learning' to 'Instruction', and use the term CAL throughout. We assume that the reader is, or is training to be, a teacher, but we make no more specific assumptions about the reader's area of expertise. Instead we illustrate the range of applicability of the computer by reference to its use in various subject areas. These examples may indicate to the reader ways of applying in his or her own discipline the general principles given.

Not only is the computer applicable, from time to time, in all disciplines across the curriculum, it is also of use to teachers in primary schools (chapter 7) or special education (chapter 8). Therefore, most of the material covered outside these two chapters is also relevant to these areas. Part I does not demand computer knowledge on the part of the reader.

Part II describes aspects of 'learning about computers', and hence is essentially 'methods of teaching computer studies'. For this part, it is assumed that the reader has computer knowledge appropriate for the level s/he proposes to teach. However, as we argue strongly throughout the book, teaching with computers is the best way to initiate teaching about them, and so Part II is in fact relevant to all teachers. It covers courses in computer awareness or computer literacy, as well as senior secondary computer science, together with discussions on computer languages and on what computer science entails. All teachers are therefore encouraged to at least skim through this section, ignoring what they find unhelpful or unintelligible. This part is quite short because, contrary to popular belief, most general educational principles still apply: another reason why everyone can profit from this section. We concentrate on material that is specifically relevant to teaching computing.

Part III deals with some practical considerations that arise whenever the use of computers in schools is contemplated. Selection, purchase, management and the provision of resources are the main topics. In addition other computer uses, which are relevant to teachers, are described (including school administration, library work and computer managed learning). In conjunction with this, the roles of the principal, the librarian and the computer resource person are described.

The Bibliography lists the books and articles referred to in the text. We particularly draw to the reader's attention *Mindstorms* (Papert 1980) for inspiration; *Computer Science* (Woodhouse *et al*

1984) for general background; and the Oxford *Dictionary of Computing* (1983) for reference. For the reader who wishes to learn a programming language, books on Logo by McDougall *et al* (1982, 1984) are available for two models of microcomputer. The Appendix lists useful resources, including people, organizations, journals and the various CAL programs mentioned in the book.

The book is not addressed to the computer consultant, nor to the specialist software writer, nor does it provide a detailed description and comparison of specific machines. The former would have over-extended the scope of the book, while the latter would have become obsolete very quickly.

Developing a new educational environment inevitably entails some difficulties and frustrations. The experienced teacher is unsettled by being once more in the situation of having no bank of personal experience to draw on; and both new and experienced teachers suffer from the absence of an accepted body of tradition or extensive practical results. However, even if only a fraction of the rich and exciting possibilities that the computer promises in the educational sphere are realized, such initial disturbances will prove to have been worthwhile. This book should ease the transition from the first thought of computer use to a smoothly-running, computer-conscious educational environment.

Our thanks are due to Tony Adams for discussions on Logo, Russel Baader for his camera work, Gillian Barclay for the cartoons, Marjorie Clamp for her typing, Owen Hughes, Chris Durham and Jeff Richardson for ideas on primary school use, Peter Edwards for comments on special education, Tony Jones for general discussions, and Margaret Whitstock for information on libraries; to Harvey Cohen, Geoff Cumming, Iain Macleod, John Traeger and the Apple Computer Co. for providing photographs; and to our students who have, both wittingly and unwittingly, provided a lot of help.

David Woodhouse Melbourne
Anne McDougall

CONTENTS

PART I

LEARNING WITH COMPUTERS

Chapter One

Computers in the classroom

The things taught in schools are not an education, but the means of an education

R. W. Emerson (1803–1882)

1.1 INTRODUCTION

In the title of this book, we refer to the promise and the challenge of computers in education. The computer's capabilities promise to improve both the quality and the extent of the learning experience. The challenge lies in using these capabilities to achieve this desirable result. Many teachers are taking up this challenge, or have already done so. Many others feel they should, but are afraid to try. And others again feel that it is not relevant to them.

It is still commonly believed that the computer is a sort of calculator, or that great technical expertise is required to use it. These dual misconceptions have pre-conditioned mathematics and science teachers to consider the possibility and utility of using computers in some way, and conversely, have resulted in many teachers of non-science subjects believing that the computer is not relevant to their work, and that its use would in any case be beyond their capabilities. The aim of this chapter is to show that computers are relevant to all (or almost all) teachers. The rest of this book is intended to assist all teachers to meet its challenge successfully.

1.2 THE COMPUTER AS DATA PROCESSOR

It is certainly true that the first electronic computer was designed for arithmetic calculation. However, within a very short time, it was realized that the computer is a general information or data processor. Data refers to the symbols we use to record facts, ideas, etc. Information is the meaning attached to the data. The computer takes data and processes it to produce new data. Certainly, the computer can process numerical data. For example, the data could be two numbers and the rules for addition, and the computer could produce the sum. The data could be an English–French dictionary and an English word, and the computer could produce the French equivalent. Again, the data could be some words and the rules for writing haiku (a type of Japanese poetry), and the computer could produce a poem using the given words. Or if it was given a specification of some of Schubert's works, it could write a short passage of music in the style of Schubert.

A machine with such a generally applicable capability should presumably be useful in education, also. However, one should not start with the fact of the computer and ask: How can we apply it? Our proper starting point is: What are we trying to do in education? Then: What facilities does the computer offer? Then: Can the latter help with the former? We propose that the computer be used, not just 'because it's there', but, firstly, because it enables some things to be done differently and variety is of great value in teaching; secondly, because it can be used to do some things better than is possible at present; and thirdly, because it allows us to do some things that are totally impossible otherwise.

IF I'D HAD A COMPUTER – I WOULDN'T HAVE HAD TO LEAVE THIS DARNED SYMPHONY UNFINISHED.

1.3. WHAT ARE WE TRYING TO DO?

Firstly, we must answer the question: 'What is it that we are trying to do in education.' This is not an easy question to answer. In the first place, the answer depends on your philosophy of life, and in the second place, it depends on your starting point. The former may be illustrated by reference to a commercial organization, where the aim of those in charge is likely to be to maximize profit; and the use of computers, or any other tool, is directed towards achieving this goal. This singleness of purpose is possible because the organization was founded for this purpose, is under unified control, and has no external forces pushing it in some other direction. Employees have accepted the profit motive, as this has also been to their advantage. However, they are increasingly seeking 'quality of life', 'job satisfaction', etc., and to this end want some control of the running of the firm. Thus there are different groups, with conflicting ideas, each feeling they have the right to a share of the decisions.

Education exhibits similar characteristics to this new, confused, commercial environment. Politicians, administrators, councils, teachers, parents, students, and academics may all have different views, and also feel that they have the authority and right to influence all decisions that are made. Often, the different views are contradictory, leading to arbitrary decisions, conflicting actions, or long delays while differences are resolved. In particular, any one of these outcomes can apply in the matter of introducing computers into a school. Thus, as in all aspects of teaching, each individual chooses (or accepts) a particular ideology, and then bases his or her teaching activities on it.

Even assuming a particular point of view or educational philosophy, the question 'What are we trying to do?' can be answered at various levels, depending on how far back one wishes to go, what one is willing to assume as a starting point, and how much one is willing to change.

Some possible answers, in increasing order of generality, are as follows.

1 We are trying to implement a particular lesson plan. Can we slot the computer into an existing lesson plan to do a particular task?

2 We are trying to achieve a particular goal. Can the computer be used to permit a different presentation aimed at achieving this existing goal?

3 We are trying to achieve a particular aim. Can the computer facilitate the presentation of a different course to achieve existing aims?

4 We have other aims in mind, that have so far been unrealizable. Can the computer be used to extend existing courses to achieve these new aims?

5 We have a new style of education in mind. Can the computer be used to promote a new approach within existing structures?
6 We espouse a new educational philosophy, different from that which has evolved to date. Can we take advantage of the advent of a radically new machine to implement radically new policies?

Whichever level of change is sought, there are problems. Many people are very busy now: any change involves extra time, and this is often a sufficient deterrent. This, together with the cost of computer use, leads to an unwillingness to change again once the effort has been made, and tends to ossify computer supported activities. Therefore if one has not gone far enough down the above list for a start, one may be committed to an increasingly irksome philosophy, or even a specific syllabus. But starting a long way down the list will be more time-consuming, and might delay computer use unacceptably.

However, just as the ability to drive a car is worth the effort involved in learning, so the ability to use computers apropriately and with confidence in one's teaching is well worth the effort involved in coming to grips with the task.

1.4 THE SCHOOL AS MICROCOSM

While it is clear that the purpose of teaching a subject in school is not to make all students experts therein, nor to train them for a career in that discipline; nonetheless the school curriculum should be influenced, in both content and method, by the current activities of practitioners in the field, and by the likely imminent developments in professional practice. This is not an entirely new insight. Document work is central to the activities of the practising historian, and so it has been accepted that history students at upper secondary levels should be involved in some document work. However, in many disciplines, this connection has not been made. Science students have done well-defined, rather artificial, stereotyped experiments. Mathematics students have been set tractable problems with straightforward solutions. French students have been taught grammar and vocabulary, with no literary or cultural context. In the last 20 years, this has changed, with the new mathematics, discovery learning, project work, a wider interpretation of foreign language studies, and so on. However, no professional or academic area stands still. All disciplines are developing, and so the school curriculum must change too, if it is to maintain its close relation with practical content and method. In particular, the computer is now being used in many disciplines, and so the teachers of the corresponding school subjects should take cognizance of this and act appropriately.

One example of this is in the production of architectural and technical drawings and blueprints. The whole design process is being increasingly automated, with the designer using a computer terminal with keyboard and screen, in place of a drawing board, with a file stored in the computer being the result of the design process. The computer can then produce plots directly from the file. In this situation, what should be taught in technical drawing classes at school? While there is still need for an appreciation of accuracy and perspective, it is totally unrealistic to act as if the outside world of draftsmanship had not changed. Clearly the syllabus needs to take account of computer applications, and the method needs to involve computer use.

The subject of the social scientist's study is people, and people are so varied in their nature, motives and actions, that the sociologist can easily amass enormous quantities of data — and needs to do so in order to obtain representative results. However, the more data s/he has, the more need there is for computer storage (because of its capacity) and computer analysis (because of its speed). Such large quantities bring their own problems of scale, and it is quite unrealistic, and unconnected with contemporary social science, to set the student only the restricted sort of problems that can be handled without the help of the computer.

The historian is in a similar position. Increasing amounts of historical data are being discovered and generated. Whether it is documents relating to the role of organized labour in the Spanish Civil War, or an on-going record of known aboriginal middens, the quantity is likely to be such as can only really be used if it is computer based, and gathered into a data base designed to facilitate the addition of information and the posing of various questions. This is part of the world of the historian in the 1980s, so some concept of it must be part of the world of the history student in the 1980s.

1.5 EDUCATIONAL TECHNIQUES

Some topics which are already in the curriculum can be much better taught, and hence more readily learned, if computers are used appropriately as part of the educational environment.

1 *Biology*. If a biology teacher wishes to give concrete experience of genetics and hereditary characteristics, the normal approach involves the rearing of generations of fruit flies. However, the techniques of feeding, handling and inspecting fruit flies and keeping them alive are not essential to the understanding of transmitted characteristics. The alternative approach is to program a computer to simulate the production of generations of fruit flies, given the relevant genetically determined characteristics, and the probabilities of their occurrence in successive generations. One well-known PLATO (see Chapter 2) simulation does this, and also draws pictures of the various fruit fly variants on the terminal screen. This approach not only omits the irrelevant part of fruit fly rearing, but permits many more families and generations to be studied. Simulation is covered in detail in Chapter 6, where it is also observed that practice in handling experimental equipment is also necessary, but that it can profitably be distinguished as a distinct skill for the beginner to learn separately.

2 *Nutrition* (in physical education or home economics). Appropriate nutrition depends on many factors. These include the amount of various essential nutrients in the diet and their contribution to energy, body maintenance and resistance to infection; the activities carried out and their corresponding energy requirements; personal details such as height, age, sex; and medical conditions, such as diabetes. Adequate teaching of nutrition and dietetics requires the calculation of many example diets for particular individuals, and the assessment of many proposed recipes. This can be extremely tedious, detract from the essential learning, and limit the number of examples which can be covered. To overcome this, a number of computer programs are available, which can quickly perform the desired analyses and the corresponding calculations. One such program is the *Dietary Planning, Health and Fitness Program* (Ima Computer Co. Ltd, Melbourne), while another is *Diet* (Cambridge University Press).

3 *History. The First Fleet Data Base,* prepared at the Elizabeth Computer Centre, Hobart, contains information on the 777 convicts who sailed in 1787 on the first fleet to Australia (Fig. 1.1). An associated query language allows students to carry out historical research by interrogating the data base. How many convicts were female; what age were the convicts; what were their crimes; what trades were represented? Such questions may be of intrinsic interest, but also lead to wider considerations, such as the criminal population, attitudes to crime and punishment, relative severity of different assizes, and trades which are now extinct. Students are able to form hypotheses and test them against the data.

Fig. 1.1

4 *Social studies*. The investigation of the *First Fleet Data Base* readily leads to questions of society, such as the problems of satisfying basic needs in the Port Jackson settlement, the probable life span of the colony, problems of the very old and the very young, and comparison of twentieth and eighteenth century societies. Note that many associated activities, such as role plays, further research, and mapping, are not computer centred. This program has been used successfully from Year 2 upwards.

5 *Grammar*. The biggest problem in teaching English grammar is motivation: "Why should we learn words like 'participle', and phrases like 'adverbial phrase': we can talk without knowing such words and phrases. And anyway yous can still catch us drift, even if we don't talk real good." McDougall & Adams (1982) show how an oblique approach has the desired effect. As in much of the Logo environment (see Chapter 5), the student is put in the driving seat by being asked to 'teach the computer' to do something — in this case, to teach it to write sentences. To do this, the student must provide lists of words, and simple output statements. The output produced will probably be so far from satisfactory English, that the student will be moved to group the words into classes to achieve, first, grammatical and next, meaningful, output. The rules which the student gradually builds into the growing program, are exactly the rules of English grammar!

6 *Foreign languages*. Similar concepts were used in a number of programs designed by S. Zammit of St Catherine's College, Melbourne, to assist in the teaching of French. A program for beginners codes French words using a variety of substitution ciphers. A more advanced program generates a large number of sentences, using the students' basic vocabulary. As the students' vocabulary increases, the computer-based dictionary is augmented, and the number of possible sentences grows. Another program involves the children in understanding complicated street directions to navigate from point to point on a town plan. These programs were written by the teacher — a language specialist, but not a programmer — not for the children to operate, but to enable the teacher to provide extra variety in the lessons.

7 *Commercial studies*. In this area it would be natural to use a computer to assist the learning of typing. In all other activities, the computer terminal is only representing something. If a program simulates the breeding of fruit flies, for example, pressing a key may