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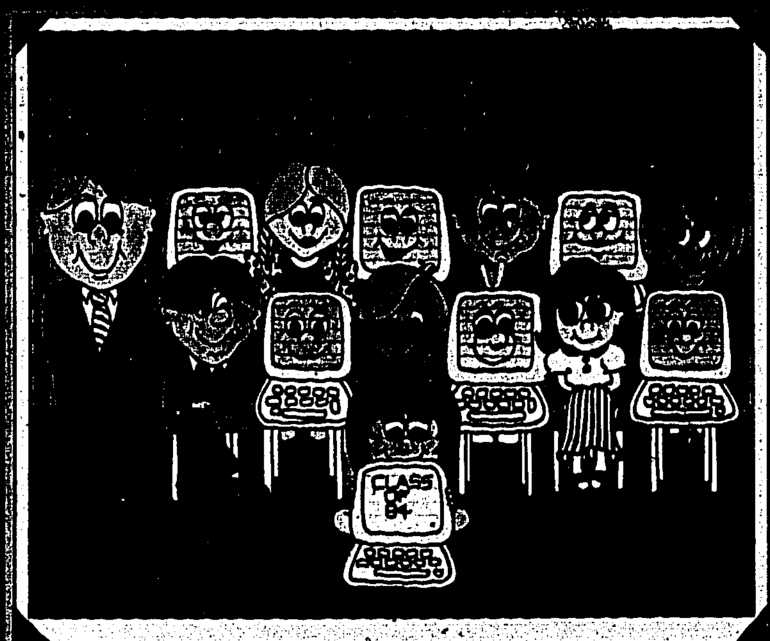
ABSTRACT

Educational applications of computing are reviewed, beginning with a brief introduction to microcomputers and microcomputer characteristics that might be important for school use. An examination of significant models in computer education outside Australia emphasizes projects in the United Kingdom, France, and the United States, including the National Microelectronics Programs in England and Scotland, the British BBC Computer Literacy Project, the 10,000 Microcomputers in School Operation in France, and the Minnesota Educational Computing Consortium. Recent developments at both the state and national levels in Australia are then described. A look at the varied applications of computers in Australian classrooms is followed by case studies of a range of programs, including projects concerned with computer awareness teacher support material, computer studies at the upper secondary level, microcomputers in the primary school, computer-based learning in clinics and classrooms, a school computerized administration system, a statewide computer network, and educational applications of videotex. A concluding chapter outlines some emerging issues in computer education for Australian schools. A seven-page reference list is included. (LMM)

COMPUTING IN SCHOOLS



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An Australian Perspective

Jonathan Anderson

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1 THE IMPACT OF MICROCOMPUTERS

Challenge of the Chip

Little more than a decade ago, hand-held calculators spelt the demise of the slide rule. Other casualties to follow were the mathematical tables used by all students for finding squares, roots, reciprocals, logs, and trig ratios. It is a strange irony that an order placed by a Japanese calculator manufacturer set in motion the research that was to lead the Intel Corporation in 1971 to succeed in producing, on a single chip, the circuitry to perform these arithmetic functions. And so the calculator which had briefly heralded changes in mathematics teaching is, in turn, being supplanted by 'machines that may change the very nature of the educational system' (Clarke, quoted in Maddison, 1983:17).

The first computer on a chip—the Altair microcomputer—appeared on the market in kit form in 1975. By 1977 companies like Commodore, Apple, and Radio Shack in the United States of America had produced their first models of what was beginning to be called the personal computer. Many other companies entered the market in the following years, familiar names like Atari and Texas Instruments in the United States and, in Britain, Acorn (makers of the BBC and Electron microcomputers), Research Machines Limited, and Sinclair. In 1981 the largest computer company in the world, IBM, entered the personal computer market, which indicated the impact microcomputers were having in the business, education, and home fields. Such was the continuing impact that, in January 1983, *Time* magazine nominated the computer as major newsmaker and 'greatest influence for good or evil' for the preceding year.

What has been the impact of the microcomputer in the classroom? Caelli (1979), while noting the implications for education of what he called the microcomputer revolution, reported no revolutions taking place in Australian classrooms. Three years later, Sandery (1982a:1) observed that 'the average Australian classroom is still largely untouched by the impact of the computer'. However, interest in the use of computers in schools and information technology accelerated in 1983–84, to judge from computer-related activities at all levels.

As is detailed in the chapters which follow, the Commonwealth Schools Commission (1983a) urged that computer education is vital to

Australia's future; both major political parties made pre-election promises to support the Schools Commission's recommendations; policy initiatives on computers in schools were announced by different States; and major reports were published on computer education: *Computers in Education* (Shears and Dale, 1983), *Computer Education* (South Australia, Tertiary Education Authority, 1983), *Teaching, Learning and Computers* (Commonwealth Schools Commission, 1983b). Other significant events also indicated a quickening of interest in microelectronic and information technologies. The conference of the Computer Education Group of Victoria (CEGV) was conducted as a national conference for the first time in 1983; in the same year the first Australian Computer Congress was held; Telecom was granted the go-ahead to establish a national videotex system in 1984; expanded and new regular features on computers commenced in major daily newspapers; new models of microcomputers were unveiled; and the fortunes of large computer companies fluctuated as increasing sums were spent on computing equipment and software.

The promise of microcomputers for schools, according to some, is very great. The availability of microcomputers in the classroom, it is asserted, will individualize instruction, improve basic literacy and numeracy skills, motivate reluctant students, and help those with special needs. In contrast to these views, there are others who wonder whether this new excitement is not a little familiar. Were not similar promises made for the teaching machine and for programmed instruction? Therein lies the challenge of the chip. Is it a tool ushering in new modes of learning, changing the very way learners think, or is it another educational innovation, a fleeting enthusiasm, in time to be relegated to the shelf? Are schools and teachers prepared for this new educational tool? Will the presence of computers tend to widen divisions in the educational community?

One to warn of a backlash against computer education is Scriven (1983). The possibility of such a backlash poses perhaps the greatest challenge of the chip. Already there are more microcomputers in students' homes than in the schools these students attend and, while much of education is the victim of fashion, current technological change guarantees the computer a role, for 'microelectronics technology has the potential to permeate, to some degree, almost all fields of human endeavour' (Australia, Committee to Inquiry into Technological Change in Australia, 1980:13). Any backlash against computer education, then, runs the risk of putting schools even further out of step with what is happening all around.

Anatomy and Promise of the Micro

What was developed by Intel Corporation in 1971 was a large-scale integrated circuit etched on a tiny silicon wafer or chip. To this central processing unit (CPU), popularly called a microprocessor, were soon added memory circuits or chips to hold the program for driving the CPU (Bessant et al., 1981). The interconnection of these chips on a printed circuit board, called a mother board, with input/output connections for attaching peripheral devices like monitors, disk drives, or printers, makes up today's microcomputer.

What essentially distinguishes microcomputers from larger computers (minicomputers and mainframes) is that the single chip CPU for the microcomputer is smaller and cheaper. Because this is a general purpose chip, it can be mass produced with the result that microprocessor chips may be purchased for just a few dollars. Today's microcomputers in schools are based on a few popular microprocessors: the Z-80 (for the Microbee and the TRS-80, Models II and III), the 6500 series (as in Apple, Atari, BBC, Commodore, and Vic 20), or the 8088 (for the IBM-PC). What makes for differences in microcomputers is how these microprocessors are combined with memory components and other input/output circuitry—in other words, their architecture.

Like any other computer, this general purpose electronic machine, the microcomputer, can operate in three phases at extremely high speed: input: information is entered; processing: the information is modified; output: part, or all, of the modified information is displayed.

A microcomputer normally comprises separate components corresponding to these basic operations of input, processing, and output. Thus there is a keyboard for input, microprocessor and associated memory for processing, and a monitor or TV screen for output. Other devices can be connected. Common are a disk drive or cassette recorder for additional storage, and a printer to provide hard copy, as it is called. Disk drives use flexible disks, often referred to as floppy disks, on which information can be stored or retrieved in a similar way to sound patterns on records. A valuable guide to microcomputers generally, and more specifically to microcomputer systems available in Australia, is Webster's (1983) *Australian Microcomputer Handbook* (updated regularly).

The microcomputer has been described as an 'imagination machine' or an 'almost anything machine' (Computer Solutions, 1981:2-2). Toong and Gupta (1982:89) draw a memorable analogy:

> If the aircraft industry had evolved as spectacularly as the computer industry

over the past 25 years, a Boeing 767 would cost $500 today, and it would circle the globe in 20 minutes on five gallons of fuel.

The promise of further developments, not in the next 25 years but in the next few, may be as dramatic. The race to produce the first megabit—a chip to hold a million bits of computer memory—is nearly run, which means smaller, even more powerful computers. For schools, other developments have the potential to transform the learning environment more radically. One such development will be the availability of portable, battery-powered microcomputers, which students will be able to use at school and at home. Another will be the general use of videodiscs in conjunction with microcomputers. Already the Minnesota Educational Computing Consortium has produced courseware based on the Apple microcomputer and the Pioneer Laser Disc system (Kehrberg and Pollack, 1982). Yet another development will be printers that can provide copy of any of the 54 000 frames on a videodisc, thus offering the prospect of storing and retrieving vast quantities of textual and graphical information easily. Developments in networks, too, will provide increased opportunities for communication, both with distant databases and with students in other countries. A further development is likely to be computer voice recognition. All these developments will bring changes to the kind of interactions between teacher and student, and between student and student, compared with those in non-computer or pre-computer environments.

Choosing Microcomputers for Schools

Many schools are considering the purchase of microcomputers and there is a bewildering selection of competing machines and models from which to choose. 'Which to buy?' is a question often heard. Unfortunately there is no simple answer. What is important to note is that microcomputers are not like television sets, cassette recorders, or projectors, in that performance criteria used for purchasing these kinds of equipment are not as applicable when buying microcomputers. Software or courseware is the more important consideration. Realization of this means that the question schools should really be asking is 'What computer software is wanted?' And to answer this question, the prior consideration is, 'How are computers to be used in schools?' Answers to those two questions will nearly always narrow the choice of a microcomputer to a short list. A good rule of thumb is to decide on applications first, equipment second (Anderson, 1983a).

This review of computing practice in Australian schools focuses mainly on applications—for example, the major programming languages in use (BASIC, LOGO), the use of word processors, simulations, access to databases, and the many other uses of computers in schools. Applications are, of course, not independent of equipment, as the listing of factors reported by teachers as important shows (Billings and Gass, 1982). These included:

- memory (certain applications—for instance, word processing and LOGO—need a certain minimum memory to run);
- keyboard (some keyboards differ from a standard typewriter—seen to be essential for business studies and most school applications);
- graphics (certain microcomputers have better resolution than others, an important consideration for art students);
- colour (not available for all microcomputers—again important for art students, for many simulations, and for business applications);
- languages (if programming is to be taught, particular languages such as LOGO or Pascal may be required—not available for all microcomputers);
- sound/music (varies across machines, sometimes not available at all, which might be a limitation for certain applications);
- screen display (refers to size of screen and upper-case/lower-case capability—important for word processing and reading applications);
- peripherals (for example, whether a disk drive is an option—essential for mass storage and rapid retrieval, as in word processing or business applications).

A useful overview of popular microcomputers and software in use in schools, at least in the United States, is contained in Williams and Shrage (1983). More useful for Australian schools is a paper, 'Choosing your school's microcomputer', issued by the Elizabeth Computer Centre (1983) in Hobart.

Structure and Scope of Review

The major title of this review, 'Computing in Schools', is meant to reflect the dual emphasis adopted. Firstly, the focus is on computing: that is, on applications rather than on computers as such, since computer software or courseware is more important for schools than computer hardware. Indeed, for most educational applications, users need never be aware of a particular machine's configuration. Secondly, the computer applications described are ones in use in classrooms around the country, and this is partly reflected, too, in the sub-title of the review.

This first chapter provides a very brief introduction to microcomputers, what a microcomputer is and what characteristics might be important for school use. The remaining chapters focus more on the uses of computers in schools. For the use of microcomputers in special education, reference may be made to Green et al. (1982) and, for their use in educational research, Johnson (1982) provides a comprehensive survey.

Chapter 2 examines what are seen to be significant models and influences in computer education overseas, particularly developments in the United Kingdom, France, and the United States. What is happening in these countries provides a backdrop to Chapter 3, which presents an overview of recent developments in Australia, at both the state and national levels.

The theme of Chapters 4 and 5 is how computers are used in schools, whether for learning about computers or learning with or from computers. Chapter 6 continues this theme by considering a range of applications encountered in schools across the country. There is the danger, in presenting these case studies, of portraying a picture of a hive of activity in computer education. There are certainly exciting on-going developments, of which the ones selected are a sample, but in many schools the activity is yet to take place.

The final chapter outlines some emerging issues in computer education, or schools computing as it is often called. As far as the use of microcomputers in schools is concerned, there are many more questions than answers that can be pointed to, and the organization of Chapter 7 is an attempt to highlight the most pressing of these questions.

During the course of the review, it was possible to visit and see at first hand developments in some, but not all, Australian States and Territories. A particular difficulty encountered throughout the review is that the field is changing so rapidly that it has been rather like trying to photograph a fast moving target. Nevertheless it is hoped that the pictures presented of current practice will be useful to teachers, administrators, and others with a professional interest in schools computing.

2: SCHOOLS COMPUTING: OVERSEAS MODELS AND INFLUENCES

There are several developments overseas that have had a discernible influence on schools computing in Australia. Of those that might have been selected, five particular programs were chosen for inclusion here. Each represents a significant development in its own right; between them, they encompass a variety of models that either have already exerted some influence on Australian developments, or have the potential to do so.

For the most part, specific programs or projects are described rather than attempting to outline computer education for a country as a whole. Thus in the United Kingdom, the focus is on two microelectronics education programs, the Micros in Schools Scheme, and the BBC Literacy Project; while, in the United States, the case studies presented emphasize, on the one hand, developments in one school district and, on the other, developments across a State. The exception, perhaps, is France which, as Shears and Dale (1983) point out in their useful survey of overseas developments, to a greater extent than either Great Britain or the United States can be seen to have a national educational computing policy of long standing, even if only put into practice to a limited extent initially. In each case, the portrayals are described in terms of their impact, or potential impact, on schools computing in Australia.

Throughout the review, where the developments described are reported in the journal literature, reference details are given in the list of references; otherwise, where appropriate, names of institutions and addresses are provided in the endnotes so that those interested may seek further information.

National Microelectronics Programs in England and Scotland

In the United Kingdom there has been, and continues to be, strong support for computer education in schools. In view of developments in schools computing at the national level in Australia, the policies and programs that have evolved in Britain are of considerable interest, both because of our historic links and because of the innovative developments there in microelectronics and information technology. Detailed below are two nationally funded microelectronics programs and the micros in schools scheme. The focus of discussion is on software development, teacher education initiatives, and the relationship of information technology to education.

Microelectronics Education Programme (MEP)

The British Prime Minister, Mrs Thatcher, in introducing the Microelectronics Education Programme (MEP), said:

> Britain's greatest natural asset has always been the inventive genius of its people. This is the asset which we must tap if we are to profit from advances in technology. In microelectronics and information technology, we must do everything to encourage and train people with the ability and skills needed to design systems, write software, and develop new businesses and products. (Cited in Inchley, 1982:3)

Thus in 1980, the British Government launched MEP in England, Wales, and Northern Ireland, to prepare students 'for life in a society in which devices and systems based on microelectronics are commonplace and pervasive' (Great Britain. Department of Education and Science, 1981:1). The program, scheduled to run until 1986, has a projected total budget of £20m.

The major aims of MEP are, first, to investigate the most appropriate ways to use computers as an aid to teaching and learning; and, second, to introduce new topics into the curriculum (e.g. microelectronics in control technology, word processing, use of computers for information retrieval) either as part of existing subjects or as new disciplines. Initially the priority was for developmental work in secondary schools but the program was soon extended to include primary schools and special education.

A highly innovative organization was developed, steering a path between a purely national operation on the one hand, and decentralized activities based on existing Local Education Authorities (LEAs) on the other. It was decided that two-thirds of MEP activities should be regional and one-third national. To implement regional activities, the 109 LEAs in England, Wales, and Northern Ireland were divided into 14 regions. This rather ingenious stratagem had the effect of respecting the autonomies of LEAs, and at the same time by-passing them. The administration of the national aspects of the program is provided by the Council for Educational Technology (CET) and six national co-ordinators, with assistance from the Schools Council.

By the end of 1983, MEP had reached the half-way point of what is now planned as a six-year program. The Director, Richard Fothergill, in an interview with *The Guardian* (October 1983), is reported as saying that a major purpose of MEP has been achieved with more than a tenth of the total teaching force having completed courses under its aegis (approximately 40,000 teachers), and many of the others being influenced by the presence of microcomputers in schools. He noted, however, that preservice education for teachers was lagging far behind.

Another major achievement, according to Fothergill, has been the development of good software. By July 1984, it is estimated that 1 000 software packages will have been produced within MEP. Publishers, too, have been encouraged by MEP to enter the educational field. A particularly interesting development has been the change in the kinds of computer programs produced. Early programs did little more than check students' responses to a limited range of questions. Then came simulations (inspired principally by the work at Chelsea College, University of London) which allowed students to manipulate variables and to note the resulting changes in the systems being modelled. The currently approved programs are more of the type where students formulate their own questions. Looking to the future, the MEP emphasis on software development is reported as likely to make greater use of languages like LOGO where students learn by teaching the computer.

There is close liaison between MEP and other schemes, such as the Scottish Microelectronics Development Programme and the Micros in Schools Scheme, as well as with the BBC Literacy Project.

Scottish Microelectronics Development Programme (SMDP)

SMDP grew out of initiatives of the Scottish Education Department commenced in 1979. In 1980 when MEP was announced, the Education Department in Scotland announced a similar but independent program. To acknowledge its earlier origins, it is referred to as SMDP (Phase 2).

While the main aims of SMDP parallel those of MEP in broad outline, the major emphasis of SMDP, as noted by Inchley (1982), is on the development of educational software. A 'two-tier' bank of computer software is being progressively built up at the headquarters in Glasgow. The top tier consists of supported programs, developed by SMDP staff or purchased from commercial suppliers. The programs at this level are judged to be valuable educationally and as meeting certain criteria of documentation and technical expertise. The bottom tier contains programs donated from any source. These are not supported, and no guarantees concerning them are made.

Inchley (1982) takes the view that the contributed library model may not be a useful one for state education departments (specifically Victoria), because much of the contributed software is of dubious value and its distribution takes up professional resources. A contrary viewpoint, partly reflected in the French approach to teacher education, is that it may be useful for the professional development of teachers to contribute programs and to aim for the criteria of supported programs at the top level.

The Micros in Schools Scheme

The British Department of Industry announced its Micros in Schools Scheme in 1981. Under this scheme, funds were made available to LEAs to assist secondary schools to acquire microcomputers. Schools were given the choice between two British machines, the BBC.Acorn B and the Research Machines 380Z (Maddison, 1983).

In October 1982 the scheme was extended to primary schools. Schools could purchase on a pound-for-pound subsidy one of three British-made microcomputers: the BBC Acorn B, the Research Machines 480Z, or the Sinclair Research Spectrum (Education Digest, 1983). The Prime Minister, Mrs Thatcher, again announced the scheme, thus indicating the priority afforded to microelectronics by the British Government:

> I hope this scheme will mean that, by the end of 1984, every primary school has its own microcomputer and will be giving young people the experience they need with the technology of their future working and daily lives. (Cited in Education Digest, 1983:i)

One of the conditions of support is that two teachers from each school should undertake inservice training provided [illegible] MEP (Inchley, 1982).

Education and Information Technology

The Council for Educational Technology (CET), noted above as providing administrative support for MEP, has the charter to promote the application and development of educational technology in all sectors of education and training. Thus CET is concerned with a broad range of applications including computers, the use of radio, television, and telephone, and the role of libraries. One of the current activities of CET is to explore the potential of all aspects of videotex, and in particular British Telecom's Prestel system.

The BBC Computer Literacy Project

The impact that the BBC Computer Literacy Project has had and is continuing to have in Britain makes this a development of which computer educators elsewhere should be aware. As Maddison (1983:79) notes:

> The wide range of activities, resources and transmission scheduling being devoted by the BBC to public education in microelectronics and especially computer awareness makes the Corporation's long-term commitment in this field the most extensive enterprise of the kind to be undertaken by a major broadcasting organization anywhere in the world.

The BBC Computer Literacy Project is significant for schools computing in two respects. First, because the microcomputer adopted for the project has been recommended for use in schools by several States, Australia now has more BBC microcomputers in schools than any other country after Britain. Second, since the television series which made the BBC microcomputer so well known in Britain has been screened by the ABC, and the publications and computer courseware associated with the project are also becoming available, this project along with other concurrent developments is achieving the same effect, as in the United Kingdom, of raising community understanding of computers.

The major features of the BBC Computer Literacy Project, as they relate to computing in schools in Australia, are discussed briefly below.

The Television Series

Precursors to the television series that provided the major focus of the Computer Literacy Project were the BBC Horizon program 'Now the Chips Are Down' and the three-part series 'The Silicon Factor', both of which were shown on ABC television and are reasonably widely known.

Screened in all States during 1983 was the first of two ten-part BBC television series 'The Computer Programme' (Note 1). The ten programs comprising the series (It's Happening now, One Thing after Another, Talking to a Machine, It's on the Computer, The New Media, Sounds and Moving Pictures, Let's Pretend, The Thinking Machine, In Control, Things to Come) are designed for several audiences. First, there is the wider community, represented by the commentator, Chris Serle, who with the help of computer professional, Ian McNaught-Davis, discovers the basic concepts of microcomputers, the ways they are affecting our lives, and how to program them to perform simple tasks. But the producers also had schools very much in mind, and were aware of the necessity for properly prepared teachers. Hence, a second target audience comprised teachers, and the ten 25-minute programs were thought of as being useful for an introductory computer awareness topic for preservice or inservice courses with teachers at all levels. Programming in BASIC is introduced without viewers needing to have direct access to microcomputers. In Australia, the ABC chose to include 'The Computer Programme' as part of its programs for schools, and this may well have been a misjudgment in view of the wider, mainly adult audience for whom the series was originally directed. The series is to be re-screened during 1984 in the evenings.

The second ten-part television series called 'Making the Most of the Micro', although available in Australia for video recorders, has yet to be shown on television. This second series, presented by McNaught-Davis, aims to encourage hands-on experience with microcomputers. Again the BASIC programming language is featured, the particular version being extended BASIC as used with the BBC microcomputer, but users of other microcomputers are catered for with a variety of machines being demonstrated. Although it is evident that the producers were aware of questions raised in some quarters about the value of programming for students, their approach emphasizes learning about computers through using them. The titles of the separate programs which comprise 'Making the Most of the Micro' give something of the flavour of the series: The Versatile Machine, Getting down to BASIC, Strings and Things, Introducing Graphics, Keeping a Record, Getting down to Business, Sounds Interesting, Everything under Control, Moving Pictures, and At the End of the Line.

The BBC Microcomputer

An important part of the BBC Computer Literacy Project was the selection of a microcomputer so that users could be offered hands-on experience. Computer companies were invited to submit designs and the contract was awarded to the Cambridge company, Acorn. The BBC microcomputer system (Note 2) consists of two models—a standard model (Model A) comprising 6502 microprocessor, 16K of RAM, and 32K of ROM with BASIC and the machine operating system; and an enhanced model (Model B) with a further 16K of RAM high resolution graphics and additional interfaces. The Model A is no longer available in Australia; a new microcomputer, the Electron, was released in late 1983. During a recent visit the British Minister for Industry and Information Technology announced plans for manufacturing the BBC microcomputer, or Beeb as it is often called, in Australia. Manufacture is expected to commence in mid-1984.

A strong feature of the BBC microcomputer, as far as many schools are concerned, is that Acorn has an interface to its Econet local area network. The network enables a number of microcomputers (theoretically up to 254) to communicate with each other and to share disk drives and printer, thereby affecting economies and allowing a certain measure of control. Other features are the ROM based software (including word processing and programming languages), the selectable graphics modes, and the second processor option. The BBC micro may also be fitted with facilities to access the British Post Office's Prestel system (given in further detail in Chapter 5), as well as teletext information transmitted by the TV networks. Towards the end of 1983, for instance, the BBC launched its new telesoftware service, thus allowing users with teletext adapters to download free software from the airwaves. It is expected that this will include software provided by MEP.

The version of BASIC used on the BBC microcomputer permits many of the features of what is called structured programming, with such extensions as local variables, passing parameters between procedures, recursion, IF ... THEN ... ELSE and REPEAT ... UNTIL.

Associated Publications and Software

Several publications were especially prepared for the BBC project (Note 3). Principal among these was *The Computer Book* (Bradbeer, DeBono, and Laurie, 1982), produced in conjunction with the television series, which provides a useful introduction to computers and computing. A general course in the BASIC programming language is given in *30 Hour BASIC* (Prigmore, 1981). A third major publication is *The Friendly Computer Book* (Inglis, 1983), a beginner's guide to the BBC, Sinclair ZX Spectrum, and RML 380Z microcomputers.

Several software packs were also produced for the project to demonstrate the potential of the BBC microcomputer. The following is a listing of the introductory package of programs, available on cassette or disk and with accompanying handbooks:

1 The Computer Programme Programs 1
(12 programs from the Computer Programme)
2 The Computer Programme Programs 2
(8 more advanced programs)
3 Early Learning (5 maths and spelling programs)
4 Drawing
5 Music
6 Painting
7 Games of Strategy (4 programs)
8 Fun Games (4 programs)

Informatique: Computer Education in France

The approach to computing in schools in France is worthy of note by Australian educators for several reasons. First, the French educational authorities have made a firm commitment to computing in schools, a commitment which goes back as far as 1970. This commitment is part of the French Government's general support for computers and information technology. Second, the French education system is highly centralized, not unlike that pertaining in some States of Australia, and this has influenced the implementation and organization of computing in schools. Third, the integrated approach to the place of computing in the curriculum, called 'informatique', is quite distinctive, differing from approaches generally adopted in other countries.

The 58 High Schools Project

L'Experience des 58 Lycées, the project involving minicomputers in 58 high schools throughout France, lasted for virtually all of the seventies. Although the present review focuses mainly on microcomputers, the French minicomputer project is significant in several important respects. Most important perhaps, as Shears and Dale (1983) report, is 'the French belief that the teacher is the central factor in the success or otherwise of the use of computers in education particularly in the school' (Shears and Dale, 1983:72). A two-pronged approach was adopted. First, some 500 teachers from all subject areas were released over the duration of the project to undertake intensive university courses. Second, a further 5.000 teachers undertook correspondence courses from the National Centre for Distance Teaching with two or three days practical experience at one of the 58 high schools. Another important feature of the French national project was the computer language especially designed for use in education (LSE—Language Symbolique d'Enseignement). Yet another feature was the decision to use computers manufactured in France.

An evaluation of the 58 High Schools Project was reported by the French National Institute for Educational Research in 1981, the main findings of which are summarized by Maddison (1983). Among the positive aspects highlighted were the significant numbers of students and teachers who had begun to use computers confidently in all subject areas, the positive attitudes engendered, the extent to which teachers tried out new methods and broke down traditional subject barriers, and the central bank of computer programs developed. There were negative aspects too, including the fact that a majority of teachers still had never used computers, that progress in some subject areas was slower than in others, and that shortages of software and equipment meant that most students had less than eight hours direct access to computers per year. Another problem highlighted by Hebenstreit (1983) was the tendency for many teachers to regard actual programming as more important than defining educational objectives. 'The net result', Professor Hebenstreit reports, 'are some packages of little real value because their objectives are trivial or could be achieved with pencil and paper or in book form'.

The 10 000 Microcomputers in Schools Operation

More recently, the French Ministry of Education has commenced L'Opération des 10 000 Microcoordinateurs (the 10 000 Microcomputers in Schools Operation) which attests to the enthusiasm for schools computing by the French authorities. The aim is for 10 000 microcomputers to be in schools by 1986. As in the High Schools Project and the national programs in the United Kingdom, the decision is for computer equipment to be produced in France. Again the emphasis is on teachers producing most of their own materials. While this might result in both quality and quantity being less than if professional programmers had been employed, Zinn (1981) notes that 'the gains in acceptance of the computer studies program in local schools will more than compensate for not having had professionally prepared materials sooner'. (Zinn, 1981:234).

Informatics

It was noted above that the French approach to the place of computing in the curriculum is quite distinctive. In Britain, for example, according to Rushby (1981), teaching about computers (computer studies, computer awareness) is generally seen as quite distinct from teaching or learning with computers (where the computer is used essentially as a medium for learning). In France, by contrast, teaching about and teaching with computers are highly integrated, so much so that one term is used to encompass both aspects—informatique. The main features of this integrated approach are summarized by Maddison (1983):

> Informatics (i.e. computers and computer science) is characterised by a new mode of thought, modelling-based, algorithmic and organisational; computers should be introduced into the secondary curriculum as an element of general culture; the problems arising from the introduction of computers being pedagogical, the prior training of teachers is essential; one of the features of computers is that it creates in the pupils a mentality that is algorithmic, operational and well organised, qualities which are of value throughout the curriculum. (Maddison, 1983:53)

This dual emphasis in the French approach to schools computing is reflected in the importance attached to teacher training, as noted in the description of the 58 High Schools Project, as well as in the policy to regard computers as routine classroom aids, evident in the 10 000 Microcomputers Operation.

World Computer Centre

An indicator of the high priority that the French Government places on computers and information technology was the recent establishment of the World Computer Centre in Paris. More significant, perhaps, was the number of leading computer scientists who were attracted to top positions at the centre. The first Director General, for instance, was Professor Negroponte, formerly Director of Computers and Communications at Massachusetts Institute of Technology (MIT). Also from MIT, appointed as chief scientist, was Professor Papert, one of the leading names in educational computing, whose work is discussed in some detail in Chapter 4 in the section on LOGO. One ambitious program of the World Computer Centre is to place personal computers in some 500 villages in third world countries (Morgan, 1982), on the assumption that in the near future most people will be processors of information, production-line work being mainly done by robots.

Schools Computing in Continental Europe

A comparative study of the use of computers in schools in continental Europe would make a useful exercise because of the variety of models encountered. Along one dimension may be observed patterns in schools computing across countries, ranging from highly centralized to decentralized approaches. Along a second dimension, depending on whether teaching about computers and teaching with computers are considered as separate or integrated activities, patterns in schools

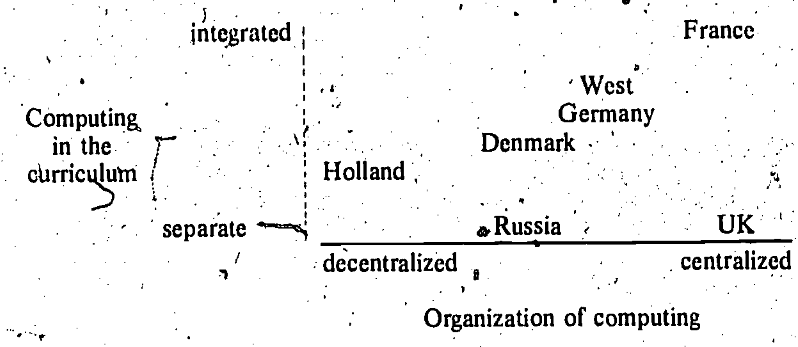

Figure 2.1 Patterns of School Computing in Continental Europe

computing extend from highly integrated to relatively distinct applications. The position of France along these continua is quite distinctive, as discussed above. Following, in part, the analysis in Rushby (1981), the approximate positions of other European countries along these same continua, in relation to France, has been shown in Figure 2.1.

Computer Literacy Programs in Silicon Valley

Silicon Valley, the name given to the area where computers on silicon chips are mass produced, is the very heart of the semiconductor industry in the United States of America. It is the home of such corporations as Intel, the developer of the first microchip, and of computer companies like Apple whose microcomputer is now a household name. Situated just a short distance south of San Francisco, Silicon Valley country includes the school districts of Santa Clara, San Jose, and Cupertino which, because of their promixity to institutions like Stanford University and their access to leaders in computing, have been to the forefront in applying information technologies in the classroom. Reviewed below are just three of many developments in Californian computer education, which could provide further models for schools computing in Australia.

Santa Clara Computer Education Consortium

About 25 school districts in the San Francisco area of California have joined together to form a computer education consortium. Led by the Co-ordinator for Computer Education in San Jose, Dr Wagner, the various school districts co-operate in sharing ideas and solving problems in the field of computer education.

Of many continuing projects of the consortium, the one discussed here is the production of the *Computer Education Handbook* (Dix, 1982). Designed to be an annual publication, the Handbook is a loose-leaf collection of the accumulated experience in the use of computers of the contributing school districts. Topics featured in the 1982 Handbook include uses of computers, case studies of actual projects, planning, selection and purchase of equipment, and staff development. This is a valuable resource, both to those already in computer education and to those who are new: the idea is one that could usefully be replicated here by States or regions.

Cupertino Union School District

The Cupertino Union School District in Silicon Valley was selected as one of about a dozen exemplars of state-of-the-art uses of computers in schools in the report on informational technology and its impact on American education (United States. Office of Technology Assessment, 1982). The information presented below is based in part on this report, and on case studies included in the *Computer Education Handbook* (Dix, 1982), as well as on interviews with personnel in Cupertino.

The experience of the Cupertino Union School District with microcomputers dates from 1977 and Education Superintendent, Sachmeier, and Computer Co-ordinator, Goodson, speak proudly of being shown the first Apple II microcomputer prototype. The first microcomputers in the school district were three Apples funded under an early Title IV program; the district's schools are now quite well equipped with microcomputers (Apple and Atari). Frequently cited as one of the district's special achievements is the development by teachers of the *Computer Literacy Curriculum K–8* (Cupertino Union School District, 1982). The underlying philosophy is that every student, from kindergarten upwards, should have the opportunity to become computer literate. The goals are that microcomputers should be a normal part of the school curriculum for all students in Grades K to 6 and should be widely available for individual use; by Grades 7 and 8, all students should have the opportunity to use microcomputers as tools for learning, and be introduced to programming so that they can 'make wise educational choices in high school and eventual career choices' (Introduction to *Computer Literacy Curriculum K–8*). Goodson emphasizes that the curriculum is very much a draft for no one really knows, she believes, what students' limits are with regard to computers.

Perhaps the most important point made by Goodson (1981) is that the implementation of any computer literacy curriculum is a gradual process which must rely for its success on the inservice structures that have been developed in a school district.

> The success of a program like this, introduced throughout a district, is dependent upon a well-developed inservice program with wide participation that gives teachers a good foundation to build upon. We have reached this point because we have taken time (over three years) and worked in stages. I think a district would have difficulty instituting such a program as a complete package. People need to be trained and ready with an explicit curriculum in hand if the program is to be truly successful. (Goodson, 1981:27)

The wide participation of teachers in inservice computer-based activities may be inferred from the comprehensive program of courses available to teachers in the 1983/84 school year and the suggested sequence that they might progress through these:

1 Computers for the Absolute Complete Beginner (4 hours)
to provide hands-on experience for computer novices who really do not like computers but feel they may be missing the crest of a wave

2 Computer Awareness Part I (4 hours)
to introduce teachers, administrators, and aides to the world of microcomputers

3 Computer Awareness Part II (4 hours)
to increase participants' awareness of the use of microcomputers in the classroom

4 Computer Awareness for Primary (Grades K–3) Instruction (6 hours)
to introduce administrators and primary teachers to the specific techniques for using computers in primary classrooms.

5 Computer Awareness for Intermediate (Grades 4–8) Instruction (4 hours)
to assist teachers and administrators to integrate computer literacy into their regular classes and to develop their skills in using the computer

6 LOGO (6 hours)
to teach the essentials of the LOGO language to participants

7 PILOT (13 hours)
to teach the essentials of PILOT, a beginning programming language

8 Programming in BASIC (15 hours)
to introduce participants to computer programming in BASIC

9 Computer-based Lessons using Apple PILOT (8 hours)
to enable participants to develop original lessons on the Apple using Apple PILOT as an authoring language

10 LOGO in the Primary Classroom (6 hours)
to extend participants' working knowledge of LOGO, as they develop

readiness, introductory, and basic activities for working with LOGO and the primary child

11 Computer Literacy Curriculum (Grades K–3)—Uses of Computer Software (10 hours)
to acquaint teachers with district computer curriculum and to develop self-contained units for classroom use for each of five samples of software appropriate for Grades K–3

12 Computer Literacy Curriculum (Grades 4–6)—Uses of Computer Software (10 hours)
as in 11 above but for Grades 4–6

13 Computer-based Classroom Materials (10 hours)
to introduce teachers to simple methods of producing classroom lessons on the computer using various authoring languages

14 Word Processing (6 hours)
to introduce participants to the principles of word processing on a microcomputer

Finally, mention might be made of the system devised in the school district for scoring tests and processing surveys. With standardized testing of students mandatory in California, claimed advantages for the Apple-based system are the rapid return to teachers of diagnostic information, more accurate and easier to interpret information, economy of teacher time, and a higher response rate of parent questionnaires.

Computer-Using Educators (CUE)

In 1978 a small group of teachers who had been meeting informally to talk about computer applications formed themselves into a support group for Grades K–12 teachers. So Computer-Using Educators (CUE) began with Dr Wagner as founding President. The first CUE Conference in January 1979 attracted 65 teachers; the Conference in May 1983 attracted more than 6 000.

> Its growth reflects the phenomenal growth of computer applications and mirrors the grassroots development of programs in schools up and down the San Francisco Bay Area. Groups modelled after CUE have also been formed throughout the country. (United States. Office of Technology Assessment, 1982:195)

The current President, Mrs Bobby Goodson, notes that CUE now has an international membership (including members from Australia), though its major focus is still on the computing needs of Californian Grades K–12 teachers.

CUE's most popular service is SOFTSWAP. Directed by Ann Lathrop from the San Mateo Education Resource Center (SMERC), SOFTSWAP allows teachers to exchange software. This is a free service and there are more than 300 teacher-contributed programs for the Apple, Atari, Compucolor, PET, and TRS-80 microcomputers from which to choose. LeRoy Finkel, Instructional Computing Co-ordinator, estimates that more than 8 000 disks have been distributed through SOFTSWAP.

Minnesota Educational Computing Consortium

Of all educational computing developments in the United States, the Minnesota Educational Computing Consortium (MECC) is arguably the oldest and the best known. It is also the one that has developed a centralized computing system for a whole State. This last feature, especially, makes MECC a potentially useful model for schools computing in Australia, a model that might already have partly influenced three Australian States to enter into an educational computing consortium. Personnel from MECC have visited Australia and MECC courseware (Note 4) is becoming known in schools. Evaluations of some of this courseware, for its applicability to Australian schools, have been conducted.

A Statewide Computing Agency

MECC began operation in 1973 with a brief to co-ordinate and provide computer services for all schools and tertiary institutions in the State of Minnesota. Several factors were particularly important in the establishment of MECC. One was the exchange of computer services already operating among schools in Minneapolis, a base for some major computer industries. The second factor was the firm belief that technology could assist education. And the third was the concern by legislators that access to computers should be freely available throughout the State.

Initially MECC operated a vast time-sharing network on the Control Data Cyber, Control Data being one of the giant computer corporations based in Minnesota. With the advent of microcomputers, standardization of equipment was decided upon so that one system could be fully supported with software and training. The contract was won by Apple and by 1982 the number of Apple microcomputers in Minnesota schools was reported to be approximately 3 000. In 1981 MECC issued specifications for a low-cost microcomputer and the contract this time was awarded to Atari.

A major service provided by MECC is the development and distribution of computer software. So widespread has this service become that MECC is now the largest distributor of educational software in the world. Several major microcomputer manufacturers have contracted with MECC for some of the original Apple software to be converted, with the result that MECC courseware is also available for the Atari, Commodore, IBM, and Radio Shack microcomputers, and is expected to be available for the BBC later in 1984. Other services provided by MECC include inservice training for educators and the development of training materials.

MECC Philosophy and Courseware

Since 1978 when MECC began producing courseware for microcomputers, a considerable library of programs has been built up in all subject areas and at all school levels. The underlying MECC philosophy, outlined in a useful document prepared by the Curriculum Branch of the Queensland Department of Education, is the firm 'belief that educational computer programs should not be regarded as stand-alone computer activities' (Gare, 1983:1). The computer programs are designed primarily to supplement teaching in the classroom. To help teachers incorporate the computer activities into their lessons, each program is accompanied by comprehensive supporting manuals describing the program and learning objectives, and containing suggestions for preparatory and follow-up activities, lesson plans, student exercises, and worksheets. Instructions are also included for using the microcomputer and all key terms are defined. So important are these supporting materials considered by MECC, that the programs may not be purchased separately and outside institutions distributing MECC courseware must abide by these same conditions.

Teachers are very much involved in developing ideas for software and sometimes also in the programming, with assistance from MECC staff. Teachers' opinions are constantly sought as the demand for new software continues. More recently, Minnesota teachers are reported as expressing a need for more problem solving, tutorial and simulation type programs, with less need for the drill and practice variety (United States. Office of Technology Assessment, 1982). The success of MECC courseware development is attributable, partly, to the practice of finding out what teachers need and working closely with them and, partly, to the decision to adopt just one microcomputer in the first instance:

> This decision provided an opportunity to refine authoring procedures, understand the capabilities of the machine, and develop more programs, e.g.

instead of three programs for three machines, nine programs for one machine. (United States, Office of Technology Assessment, 1982:218)

MECC Availability in Australia

Such has been the interest in MECC microcomputer courseware that, according to the Office of Technology Assessment Report (1982), two-thirds of the distribution goes out of the State to educational districts, departments, and centres throughout North America, to England and to Australia. There are three methods of ordering MECC products—by direct order, through a commercial distributor or through institutional membership. The last of these avenues allows non-profit educational organizations, under an annual licensing arrangement, to obtain and distribute MECC courseware and training products at substantially reduced prices.

Two state education departments entered into a one-year licensing arrangement with MECC: Queensland in 1982 and South Australia in 1983. Through these arrangements, government schools have been able to obtain courseware at very much reduced prices.

Evaluation of MECC Courseware

During August 1982, the Curriculum Branch of the Queensland Department of Education organized a MECC Software Evaluation Week when the staff of 17 primary, secondary, and special schools joined with Curriculum Branch staff to examine MECC courseware for cultural bias and general applicability to the Australian school curriculum. Some 38 disks and accompanying manuals, each disk containing up to 15 individual programs, were evaluated. The resulting series of in-depth reviews of materials considered appropriate for use in schools, together with an annotated list of all the MECC materials received, are contained in an annotated selection guide for teachers (Gare, 1983).

Some MECC material was judged clearly inappropriate: for instance, a mathematics volume focusing on imperial measurement, two social studies volumes dealing respectively with American presidential elections and the shape and location of American States, a disk on driver education featuring Minnesota highway rules, and a business volume deemed as overly simplistic. Some courseware was considered useful and parts of other programs as needing modification. This kind of evaluation (Gare, 1983) is valuable, provided findings are widely disseminated to potential users. It represents the kind of activity that could usefully be the business of a national or regional clearinghouse for educational software.

3 : SCHOOLS COMPUTING: THE AUSTRALIAN SCENE

One of the earliest reports on computers in education in Australia was that of Wearing et al. (1976). While this report was intended to promote discussions among computer users, it was several years before any further national study of computers in schools was undertaken. The impact of microcomputers was beginning to be felt in Australia by 1979 and the Australian Computer Society published a monograph (Caelli, 1979) which included examination of the social implications of the new technology for education.

However, not until 1982 did further reports specifically examine the question of computing in schools across States. One of the first such reports was that of the Committee of Enquiry into Education in South Australia (Keeves, 1982). This report strongly advocated new courses to provide an introduction to new technology—courses like technological studies, engineering science, modern industry, computing, and computer science. So that the courses might be accommodated into an already overcrowded secondary curriculum, it was proposed that such courses might be shorter than the common six periods per week and might be a semester or even a term in length.

Also in 1982, the Education Research and Development Committee commissioned a review 'to consider where computers are relevant to the education systems' (Brownell et al., 1982); an OECD sponsored review on education and the new technologies followed a few months later (Brownell, 1982); and a widely cited paper by Sandery (1982a) examined the future role of computers in education. Two major reports were published in 1983, one a report to the Minister of Education in Victoria (Shears and Dale, 1983) and the second the report of the National Advisory Committee on Computers in Schools to the Commonwealth Schools Commission (1983b).

Developments at the State Level

By the end of the 1983 school year, the majority of secondary schools in Australia had at least one microcomputer (Commonwealth Schools Commission, 1983b). The number of computers in primary schools also rapidly increased, with the percentage of schools estimated as having one machine reaching as high as 50 per cent in Tasmania (Scott, 1983a). There were; however, marked differences between States as Hoffman (1982:81) observed:

> Indeed it is quite obvious that there are already significant differences amongst the Australian States in the priority that each assigns to information technology education, the resources allocated and the policies being implemented.

The first obvious difference is that some States have supported computing in schools over a much longer period than others (Brownell, 1982). South Australia established a co-ordinating centre as early as 1968. This is the Angle Park Computing Centre, one feature of which is that it provides a service to all schools, government and non-government, as well as a service for some years to the Northern Territory. Tasmania established the Elizabeth Computer Centre in 1975 and a statewide timesharing network. Western Australia followed with the establishment of the Schools Computing Centre in 1977. In the Australian Capital Territory, the Schools Authority also adopted a co-ordinating role with the establishment of the Computer Services Section. During 1983, largely as a result of the federal initiatives in computer education, the remaining States either set up computer units or significantly increased the staffing levels of fledgling units. Thus a Computer Education Unit was established in Erskineville, New South Wales, with five full-time professional staff members; a Computer Education Task Force with a professional staff of seven was established at Ardoch Village in Victoria, where previously there had been a small computer centre; a Schools Computing Services Unit with the equivalent of 9.5 full-time staff was set up within the Curriculum Branch of the Queensland Department of Education, which Branch had previously been involved in computer education projects; and in the Northern Territory a Computer Education Centre with a professional staff of four is expected to be operational during 1984, where previously services were provided by advisory staff in computing (Commonwealth Schools Commission, 1983b).

Other differences between States follow from the first. Thus a second difference is the perceived need by some States to adopt a co-ordinated, centralized approach to computing in schools, evident in early establishment of computer centres to provide services to schools. Beauchamp (1982), after noting computing activities in Tasmania, South Australia, Western Australia, and the ACT, and writing before the 1983 developments noted above, went on to observe:

In the remainder of the States (regrettably those having the largest population) there is as yet no co-ordinating authority for advising schools interested in computing. Microcomputers are appearing in a number of schools but, since no common bond is being established between the schools, a variety of different types is being purchased and little software sharing is possible between these incompatible systems and, of course, no co-ordinated approach to computer teaching methods. (Beauchamp, 1982:56)

Some computer educators would agree with Beauchamp that education systems have a responsibility to adopt a co-ordinating role (e.g. Hoffman, 1982). In contrast to this view, however, are most of the States in the United States (exceptions being Minnesota and Alaska). Similarly, in Australia some States (notably Victoria and Queensland) have more of a school-based approach. The argument has therefore been against establishing separate co-ordinating authorities in the past.

A third difference between the States relates to the adoption of policy on computing activities in schools. Again it is the States which have been actively involved longest and which have adopted centralized approaches (e.g. Tasmania, South Australia, Western Australia) that have formulated policy (Brownell, McShane and Read, 1983; South Australia. Education Department, 1982; Western Australia. Education Department, 1981, 1982). The States with larger populations (e.g. New South Wales, Victoria) have been slower to establish sets of guidelines, though the New South Wales Department of Education (1983) has recently released a comprehensive policy statement on computers in schools. Of course, the publication of a policy does not necessarily reflect practice, for any State.

Yet another difference, directly following from the adoption or otherwise of a developed policy, relates to the range of computer equipment in schools. Indeed, because of somewhat similar policies adopted by Tasmania, South Australia, and Western Australia, these three States formed a consortium in 1982 called TASAWA. The benefits of a consortium were seen to be sharing information and, more especially, making software available to schools in each State on the same cost basis, provided it is purchased through each State's schools computing centre. Some indication of the range of computer equipment recommended for schools in different States is evident from an examination of Table 3.1. Although the data presented are based on the latest information available (Commonwealth Schools Commission, 1983b), New South Wales and the Northern Territory have announced new contracts for the 1984 school year, which information is included in Table 3.1, and other States are similarly involved in calling for tenders.

Table 3.1 Microcomputers Recommended by State Education Departments in 1983

Recommended hardware	ACT	NSW	Vic.	QLD	SA	WA	Tas.	NT
Apple II/IIe	*	*	*	*	*		*	*
Atari		*						*
BBC		*		*	*	*	*	*
Commodore 64								*
Cromemco			*					
IBM PC		*						
Microbee 16K/32K		*		*				
Microbee 64K		*				*		
Micromation			*					
Tandy TRS 80				*				
Tandy Colour				*				

Source: Report of the National Advisory Committee on Computers in Schools (Commonwealth Schools Commission, 1983b)

A second point which needs to be made is that other microcomputers are widely used in schools (e.g. Commodore 64), some of which could be included in the near future in a listing of hardware recommended by States. Finally, the information relates only to state education departments. Because the non-government sector is much more varied, the kinds of computers in use in non-government schools proved more difficult to ascertain (Commonwealth Schools Commission, 1983b).

There are apparent differences, too, in the extent to which the purchase of equipment is subsidized or otherwise supported in different States. It is, however, difficult to make comparisons because the funding arrangements for schools differ from State to State.

An indication of the growth in acquisition of microcomputers by schools is seen in the following figures from Queensland (Commonwealth Schools Commission, 1983b):

February 1981 : 160 schools— 310 computers
February 1982 : 228 schools— 643 computers
February 1983 : 420 schools—1550 computers

Further quantitative information, obtained in a survey of all States and Territories, is reported in Brownell et al. (1982), though Queensland at that stage was not able to supply the information requested. Much of the information relating to numbers of students, schools, and type of computer delivery is now dated, because of rapid developments that followed, but the results for programming languages and sources of software are possibly less so. In courses where programming was taught, it is reported that the overwhelming majority used BASIC; in one State (Tasmania). Pascal was also widely used and there was some use of LOGO too. Three States (Tasmania, South Australia, Western Australia) are reported as developing the majority of software used by schools, while other States rely mostly on the equipment supplier, software companies, or teacher-developed software.

Developments at the National Level

Developments at the national level relating to computers in schools can be conveniently grouped into three. First, there is the role of subject and professional associations, together with Information Technology Week activities. Second, there are the meetings of the Australian Education Council and the Directors-General of Education, and meetings of schools computing personnel (leading to the TASAWA computing consortium). And third, there is the role of the Commonwealth Schools Commission.

National Conferences and Information Technology Week Activities

There have been a number of national conferences spanning more than a decade, which have provided some stimulus for educational computing. One of the earliest was in 1969 on the role of the computer in secondary schools,' sponsored by the Australian Computer Society and the Australian Association of Mathematics Teachers. More recently, computer-user groups have promoted the cause of computer education. To the forefront was the Computer Education Group of Victoria (CEGV) which was formed largely because of the lack of activity from the Victorian Education Department and also because of dissatisfaction with the Australian Computer Association. Other user groups to be modelled on CEGV were the Computer Education Group of Queensland (CEGQ) and of New South Wales (CEGNSW) and the West Australian Computer Educators (WACE). All these associations have organized seminars and conferences for teachers. The May 1983 conference of the CEGV, for instance, was especially successful in that large numbers of teachers and educators from around Australia attended. Schools symposia have also become a regular feature of the annual conference of the Australian Computer Society.

Another important development that has done much to raise the community's understanding of information technologies is Information Technology Week. Such has been the success of these over the past five years that the Commonwealth Government has decided to support an Information Technology Month in 1984.

TASAWA Computing Consortium

For the past several years, meetings of the Directors-General of Education, as well as those of the Australian Education Council, have considered the question of computers in schools (Shears and Dale, 1983). One meeting of particular importance was the Conference of Directors-General in Perth (October 1982) which considered possible areas of national co-operation. The most vigorously debated issue was the agreement already entered into by Tasmania, South Australia, and Western Australia to form a three-state computing consortium (TASAWA) to share all educational computing resources (Angle Park Computing Centre, 1982b). Several of the other participating States felt that the *fait accompli* presented problems on the grounds, first, that it pre-empted national co-operation; second, that there was a perceived unwillingness for other States to be allowed to join unless they could either provide software or make some financial contribution; and third, that TASAWA was seen as reluctant to agree to direction on the use of hardware, the development of software, or the provision of other services (Dale, 1982).

The Commonwealth Schools Commission

The Commonwealth Government has given some support in the past to computer education through several of its programs (for example, the Schools Commission Innovations Program, Projects of National Significance, Professional Development, and the Commonwealth Department of Education Transition Education Program), though none of these specifically related to computing. In its recommendations for 1984 (Commonwealth Schools Commission, 1983a), however, the Commonwealth Schools Commission concluded that large expenditure was urgent and necessary to overcome the serious deficiencies in current provisions. Among the Commission's recommended objectives were that schools should provide all students (Years 2–12) with at least 30 minutes hands-on experience per week, and that every school should have at least one teacher with sufficient competence to advise other teachers. To finance such a national program, the Commission recommended that the Government should provide $125m over a five-year period, that these funds should be directed to teacher professional development, development of computer courseware, and purchase of school and system level hardware. Such funding was to be in addition to that already provided by the States.

Both major political parties promised support for the program prior to the elections in early 1983. In March 1983 the National Advisory Committee on Computers in Schools (NACCS), with representation from all sectors, was established to advise the Schools Commission principally on 'the use of computers in schools as they relate to the educational needs of boys and girls enrolled in primary, secondary, and special schools' (first term of reference). In discussions leading to the August budget, the Government further advised the Commission that the amount to be available in 1984 was $6m (with a further $12m for 1984–86), of which $4.8m was marked for government and $1.2m for non-government schools, and further that the program should initially concentrate on secondary schools. Included in the guidelines were that, where appropriate, there should be standardization of equipment and materials and, if possible, services should be shared between schools and sectors and across States.

Six technical working parties were set up to consider issues of curriculum development, professional development, software/courseware, support services, hardware, and evaluation. The Advisory Committee also held meetings in all States with computer-user groups and with commercial and professional associations. The report was finally presented to the Minister for Education and Youth Affairs in November 1983. It contained 52 major recommendations relating to the six areas noted above.

Recommendations under curriculum development were that major priority be given, first, to computer awareness and computer literacy experiences for all students in the years of compulsory secondary schooling, second, to the integration of computing across the curriculum, and third, to the provision of optional computer studies courses at the senior secondary level. Professional development of teachers, particularly of women and of non-mathematics and non-science teachers, should be accorded high priority.

There was an emphasis in the recommendations on making available to teachers general purpose software—what is referred to in Chapter 5 as using the computer as a tool—word processing, spreadsheet, and database tools. Programming languages to be supported should include LOGO, BASIC, and Pascal. Teachers should also be helped to develop their own courseware by providing such software development aids as graphics tablets, light pens, and general utilities.

The preferred hardware, at least in the short term, was for the Apple II/IIe, BBC, and Microbee 64K microcomputers. Clearly this was a contentious recommendation, with two members of the Committee presenting dissenting opinions and arguing for a wider range of suppliers. States were encouraged to provide support centres to assist teachers from both government and non-government schools in the use of hardware and system software. There was seen to be an important role, too, for the Curriculum Development Centre in the schools computing area. Finally, it was recommended that a National Co-ordinating Committee should develop procedures for evaluating the program and for research and development activities.

As this review goes to press, the Schools Commission is yet to consider the report of its National Advisory Committee on Computers in Schools, after which it will advise the Minister for Education and Youth Affairs on the implementation of the Computer Education Program in 1984.

4 : THE LANGUAGES OF MICROCOMPUTERS

Fundamental to any consideration of microcomputers is how to communicate with them. The dramatic breakthrough that heralded the first modern computer was in fact the concept of a stored program. In the earliest computers, a program was stored in the machine by soldering wires together in given sequences. A later development was to use a series of switches which could be turned either on or off and it was from such a bank of on/off switches that the binary (zero/one) language of microcomputers (known as machine language) was developed.

Paralleling advancements in computer hardware have been advancements in communicating more easily with computers. These developments have resulted in what are called high-level languages because they resemble more closely the ordinary language of communication than do the low-level languages of machines. Many programming languages have now been developed and are available on microcomputers for particular applications. Some of these are general purpose languages like BASIC and Pascal; others are languages suitable for scientific calculations—for example, FORTRAN (an abbreviation of FORmula TRANslation); yet others are more suited for commercial applications—for instance, COBOL (short for COmmon Business Oriented Language). There have been advancements, too, in developing languages specifically for student use, and LOGO is one such language. Other languages have been designed specifically for education to make computer-assisted-instruction lessons easier to prepare. They are known as authoring languages or authoring systems, and one example is PILOT. As well, there are word processing programs now available, and these might be thought of as similar to programming languages in that to use them requires knowledge of a few commands.

There is some controversy among educators about the need for teachers to know how to program, though obviously there is a narrow line between using a programming language and, say, using a word processing program or a general statistical program. However, whether teachers learn to program or not, teachers and administrators should have the requisite skills to enable them to use computers in a manner appropriate to their daily activities, and this requires a general knowledge of the features of major programming languages since these have a bearing on how computers will be used in schools.

Currently BASIC is the most widely used programming language in Australian schools (Brownell, 1982), and this language is discussed first. The second language to be discussed briefly is Pascal since it seems likely, with the more widespread introduction of computer studies at the senior secondary level, that Pascal will become more evident (Lafferty, 1983; Halpin, 1983). Another language that is increasing in popularity in schools, especially at the primary level, is LOGO, and this language is discussed next. Finally, the chapter concludes with a brief consideration of an authoring language (one of the several versions of PILOT) and of two authoring language systems—ZES, which was developed in Australia, and the Shell Games.

BASIC—*Lingua franca* of Microcomputers

Every microcomputer in schools can be programmed in BASIC and, for most, the language comes with the computer. The exceptions, according to Williams and Shrage (1983), are the various Atari models and the IBM personal computer where it is an optional extra. An acronym for Beginner's All-purpose Symbolic Instruction Code, BASIC was developed 20 years ago at Dartmouth College in the United States by Professors Kemeny and Kurtz, primarily for use by college students on Dartmouth's time-sharing computer (Strong, 1983). It is important to recall this early development because more argument has raged over the advantages and disadvantages of BASIC than over any other higher-level programming language.

Advantages of BASIC

Among the advantages claimed for BASIC are that it is easy to learn and use, it is a general purpose language, and is interactive. Although developed for students at the college level, BASIC was conceived essentially as a language to introduce programming. To simplify it as much as possible, many of the complexities of the FORTRAN language, after which is was modelled, were omitted. The authors also wanted a language which, like FORTRAN, could be used for a variety of tasks and this, together with its ease of use, are reflected in its name. That it is easy to use is evident in the fact that many students, even in primary schools, learn to write in BASIC.

Perhaps most importantly, BASIC was developed as an interactive language for use on time-sharing computers (in contrast to the predominantly batch processing mode of the early sixties) and this feature made it popular for use on microcomputers. Its use of an interpreter, rather than a compiler, also makes it rather quick to get small sections of program running correctly. As well, the fact that it was designed as an interactive language means that it reads very like English, as the following short program segment written by a ten-year-old illustrates:

```
10  PRINT "WHAT IS YOUR NAME?"
20  INPUT NAME$
30  PRINT "HOW OLD ARE YOU"; NAME$
40  INPUT AGE
50  PRINT "YOU'RE ANCIENT"; NAME$
60  PRINT "WHAT CAR DO YOU DRIVE?"
70  INPUT CAR$
80  PRINT NAME$; "WHAT A BOMB!"
```

(The line numbers serve to indicate the sequence of instructions.)

Criticisms of BASIC

Unfortunately, BASIC has several disadvantages. Possibly the greatest of these is the multitude of different versions or dialects. Consequently, a program written in BASIC for one microcomputer will rarely run without some modification on another, and sometimes not even on another model of the same microcomputer. The reason stems, in part, from the very elementary nature of BASIC itself. Because the language is limited (deliberately so), different manufacturers have tried to outdo each other by offering additional features in their versions of the language. This situation applies also to other programming languages; and for schools, and publishers especially, it poses particular difficulties as far as software is concerned.

Other disadvantages asserted for BASIC are that it occupies more memory and is slower than other languages. The first of these disadvantages assumes less importance as the price of memory tumbles, but the speed factor is a real problem for longer or more complex programs. Programmers often resort to writing in machine code, which aggravates the transferability of programs across machines.

Some critics are quite vociferous in their condemnation of BASIC. Papert (1980), for example, author of LOGO, argues strongly that the programming language used by students influences the very way they think.

> . . . educators, too timid in technological matters or too ignorant to attempt to

> influence the languages offered by computer manufacturers, have accepted certain programming languages in much the same way as they accepted the QWERTY keyboard. An informative example is the way in which the programming language BASIC has established itself as the obvious language to use in teaching American children how to program computers. The relevant technical information is this: A very small computer can be made to understand BASIC, while other languages demand more from the computer. Thus, in the early days when computer power was extremely expensive, there was a genuine technical reason for the use of BASIC, particularly in schools where budgets were always tight. Today . . . the cost of computer memory has fallen to the point where any remaining economic advantages of using BASIC are insignificant. Yet in most high schools, the language remains almost synonymous with programming, despite the existence of other computer languages that are demonstrably easier to learn and are richer in the intellectual benefits that come from learning them. (Papert, 1980:34)

Papert is quoted at length since his is an influential voice. To be fair, it is not only teachers who have continued to accept the QWERTY keyboard, even though the reasons for the particular placing of the keys have long since passed. On Papert's major point about the richness or otherwise of BASIC, it may simply be an argument for students to learn more than one programming language, especially since they are claimed to be so easy. Indeed, in so far as most computer languages are more suited to some purposes than to others, a case could be mounted for students (and teachers) to be multilingual.

Structured Programming

Yet another criticism of BASIC is that it is not a highly structured language in contrast to, say, Pascal (available on some microcomputers). To appreciate this particular criticism, it is helpful to understand the GOTO statement in BASIC, an anathema to many advanced programmers. The purpose of the GOTO statement is to branch or jump to another part of the program. For example:

```
100  IF RESPONSE$ = "YES" THEN GOTO 130
110  TRIES = TRIES + 1
120  GOTO 50
130  SCORE = SCORE + 1
```

In this sequence, the first GOTO branches forward to statement 130 if the response is YES and the score is increased by one; if the response is anything other than YES, the number of tries is increased by one and there is a branch to an earlier part of the program (to statement 50). It is not hard to see how, quite soon, the program can become quite entangled with branches forward, backward, and into sequences of, instructions, disparagingly referred to as spaghetti code. Anderson and Camiller (1983:59) explain it in this way:

> Most complex programs can be broken down into a number of relatively independent steps, each of which can be represented by a flowchart. When program steps are written in this way and have one entry and one exit point, they are said to be structured. These programs are easy to correct or modify since the independent parts can be altered without referring to the whole program.

Some versions of BASIC make it easier to impose the kind of organization advocated by Anderson and Camiller with structures like IF ... THEN ... ELSE, and REPEAT ... UNTIL. One of the sternest critics of much of the BASIC on school microcomputers is Atherton who, in turn, advocates the use of COMAL (Common Algorithmic Language), which Maddison (1983) reports as having largely replaced BASIC in Danish schools. However, Atherton (1983) has written a book entitled *Structured Programming with BBC BASIC*, which suggests that the criticism 'unstructured' is not so much a criticism of the language as such, but the uses to which the language is often put. The point remains that it is rather easy to misuse BASIC and, in less structured versions of BASIC, the user has little alternative but to use GOTO rather frequently.

Will BASIC remain the most widely used language of microcomputers? Rushby (1981), from Imperial College, London, confidently predicted that Pascal would come into the ascendancy within two or three years. On the other hand, the choice of BASIC by the BBC Computer Literacy Project seems likely to introduce BASIC to an ever-increasing group of users. The BBC publication, *The Computer Book* (Bradbeer et al., 1982:105–6), summarizes the situation in this way:

> In some people's eyes, BASIC is not the world's best programming language but it is one of the most approachable—especially for beginners, as its full name implies—and that is one reason why it has been chosen as the main language for the BBC Computer Literacy Project. One of BASIC's virtues is that the various commands lead on very simply from ordinary written language.

Because of the influence of the BBC Computer Literacy Project and particularly of the BBC microcomputer in Australian schools, it seems likely that many students will be introduced to programming with languages like BASIC and LOGO, before branching to other languages such as perhaps Pascal or even PROLOG.

BASIC in Schools

Criticisms are often heard about teaching students to program, particularly from those in the tertiary sector, the arguments usually being that programming is too abstract, or that students will learn bad programming habits. A contrary view is that of the Professor and Dean of the Faculty of Mathematical and Computing Sciences at the NSW Institute of Technology (Gledhill, 1981:5):

> All students who can read can write programs. There is far too much mystique attached to programming—it is often seen as an art practised by the privileged few. It is important that this impression be set aside . . . any child can write small programs and appreciate what is involved in writing larger ones.

About programming in BASIC at the secondary level, Gledhill notes further: 'The BASIC programming language, used sensibly, can also give the students some actual programming experience' (Gledhill, 1981:5). A few teachers around the country are now introducing some programming in BASIC in primary schools. The Primary Mathematics Association in South Australia (1982), for instance, in a survey of the use of computers in primary schools, noted nine schools which involved students in some programming activities. Hancock (1983) also describes how students learn to program in BASIC. The teacher about whom she principally writes provides further details of how BASIC is used with her Year 6 and 7 students as part of their written language activities (A'Herran, 1984). The following is a sample of one student dialogue:

```
1 CLEAR 3000
10 CLS
20 PRINT "HELLO I'M EDDIE YOUR FAVOURITE TALKATIVE
COMPUTER. I BET YOU'LL GET A KICK OUT OF ANY
PROGRAM YOU CARE TO RUN THROUGH ME!";
30 PRINT "I BET YOU DIDN'T KNOW THAT I CAN TALK TO
YOU, DID YOU! BUT NOBODY'S PERFECT—NOT EVEN
COMPUTERS. SO YOU CAN TALK TO ME IF—AND ONLY IF—
YOU KEEP IT PRETTY SIMPLE. OH I TALKED TOO MUCH
AGAIN. TO START WITH, WHAT'S YOUR NAME!": INPUT
NAME$
40 FOR A=1 TO 1000:CLS:PRINT "AH, UMMMM...DID YOU
KNOW THAT I ONCE HAD A FRIEND CALLED"; NAME$;"........I
SUPPOSE YOU WANT TO KNOW WHAT HAPPENED TO
HIM.....": INPUT A$ :IF LEFT $(A$,1) = "Y" OR LEFT (A$,1) = "y"
THEN 60
PRINT "
WOWEE, I'LL TELL YOU ANYWAY." GOTO 60 ELSE
```

```
50 PRINT "YOU DON'T WANT TO KNOW ABOUT"; NAME$; "?!?!
I TELL YOU !!!!!!!!!";
60 PRINT "WELL MY FRIEND HAD THIS ROBOT CALLED
MARVIN........HE HAD A NERVOUS BREAKDOWN!!!!SOB
SOB!!"
```

According to A'Herran, students are learning much more than programming in these activities, for they are involved in predicting their fellow students' responses, providing options, sequencing ideas, and being consistent with their use of variables. In editing their programs, students learn about the writing process. The topics about which they write cross subject boundaries as the following program excerpt shows. The students are clearly highly motivated, and their writing takes on a purpose as other students eagerly try them out and suggest improvements.

```
120 PRINT "HOW OLD ARE YOU, "; A$
130 INPUT D
140 PRINT "WOW IF YOU ARE "D" YEARS OLD THEN YOU
ARE
"D*365" DAYS OLD, WOW WEE MAN!!!!!!";
150 PRINT "GUESS HOW MANY HOURS THAT IS MAN—JUST
A NUMBER";
160 INPUT E
170 IF E <D*365*24 PRINT "NO, TRY A HIGHER NUMBER"
180 IF E >D*365*24 PRINT "TRY A LOWER NUMBER—YOU'RE
TOOOOOO HIGH !!!"
190 GOTO 150
200 IF E=D*365*24 PRINT "******** COOOOLNESS! ********"
210 PRINT "WELL THAT WAS PRETTY GOOD THAT
QUESTION NOW I DON'T KNOW WHAT TO ASK YOU SO I
SPOSE THIS IS THE END OF MY PROGRAM SO BYE SNIFF
SNIFF BOO HOO SNIFF SNIFF WAA WAA"
```

Reference was made in Chapter 2 to the BBC Computer Literacy Project, which had as its aim to increase community computer awareness and to introduce programming in BASIC. In addition, there are many books on the market about BASIC programming on microcomputers. Choice may depend on the particular dialect of BASIC available on the school microcomputer. Among recent Australian titles that might be used for teaching/learning BASIC in schools are the following: Anderson and Camiller (1983), Kelly-Hartley and McKneil (1983), McShane (1983b), and Wolfe (1982).

One of the best ways of learning a computer language is, of course, by computer. An Australian software package comprising disk (lessons and test) and manual which exemplifies some of the better ways computers can be used in learning is Legg (n.d.).

Pascal—A Language for Teaching Programming

Pascal was developed towards the end of the sixties by Professor Wirth at the Federal Institute of Technology in Zurich, Switzerland, to overcome perceived deficiencies in languages such as FORTRAN and BASIC. Wirth's major aim was to introduce a language 'to teach programming as a systematic discipline' since he was convinced 'that the language in which the student is taught to express his ideas profoundly influences his habits of thought and invention' (Wirth, 1974:133). These sentiments are very similar to those of Papert cited above. Wirth named his new language after the French mathematician, Pascal. Because the name is not an acronym as in several other programming languages, full capitals are not used. There are many implementations of Pascal, a major one of which is UCSD Pascal, so named after the University of California at San Diego where it was developed. Of importance to this review is that Pascal is now available for a number of microcomputers.

A trend towards Pascal in formal computing courses in schools was reported by Brownell et al. (1982), though this was marked only for one State (Tasmania). With the wider availability of Pascal on microcomputers, the language is increasingly being used at the senior secondary level elsewhere. One teacher to write enthusiastically about students' reaction to the language is Lafferty (1983). The major advantage claimed for Pascal is its modular structure. This is especially advantageous in writing longer programs, for a large task becomes more manageable if subdivided into modules. Thus it is generally quicker to get a long program running if written in Pascal, and it is easier to maintain. Furthermore, the modular structure makes programs more elegant and certainly easier to read. The language is thus said to encourage sound programming habits.

Other claimed advantages for Pascal are that it allows recursion whereby a procedure can call itself, and that it allows the use of local variables thus contributing to the ease of combining modules. Both these features, however, are available in some versions of BASIC, such as BBC BASIC. Yet other advantages noted by Halpin (1983), particularly in comparison with BASIC, are the wider range of data types permitted, that lines are not numbered, that Pascal is largely standardized, and that the language promotes understanding of computing concepts. There are disadvantages too. Lafferty (1983), while advocating its wider use, nevertheless comments that shorter programs entail more coding in Pascal, the use of a compiler rather than an interpreter requires some knowledge of the operating system, compilation is often time-consuming, and the language demands more from both students and teachers.

Factors likely to influence the wider adoption of Pascal in schools, at least at the senior secondary level, are its cost and its use in universities and colleges. Whether the language comes on disk as for the Apple or as an additional plug-in ROM with the BBC microcomputer, Pascal needs to be purchased separately and budgeted for, and this could be a constraining influence. On the other hand, Pascal is favoured by most departments of computing science at the tertiary level, and this might promote its use in so far as tertiary personnel are involved in the framing of matriculation examination syllabuses.

LOGO—A Language for Learning

LOGO is a programming language developed at the Artificial Intelligence Laboratory at Massachusetts Institute of Technology (MIT) in the late sixties/early seventies (Papert, 1971; Papert and Solomon, 1971). Originally available only on mainframe computers, versions are now becoming available for most microcomputers. Unlike BASIC, LOGO must usually be purchased as an optional extra; it requires more computer memory to run and generally requires a disk drive. Despite the extra costs involved, LOGO is beginning to be more widely used in Australian schools, especially in primary schools.

Papert, who developed LOGO when he was Professor of Mathematics and Education at MIT, originally conceived the language as a problem-solving tool and a means of researching how children solve problems. Prior to his appointment at MIT, he had worked with Piaget in Geneva for five years and this influenced much of his thinking. Taking issue with many mathematicians and psychologists, Papert argued strongly that most computer-aided instruction was being wrongly implemented. In his best-known work, a book that is becoming one of the most quoted in the field of education, *Mindstorms: Children, Computers and Powerful Ideas*, he writes:

> In many schools today, the phrase 'computer-aided instruction' means making the computer teach the child. One might say the computer is being used to program the child. In my vision, the child programs the computer and, in doing so, both acquires a sense of mastery over a piece of the most modern and powerful technology and establishes an intimate contact with some of the deepest ideas from science, from mathematics, and from the art of intellectual model building. (Papert, 1980:5)

Papert's vision has already influenced many computer educators in Australian schools.

Turtle Graphics

What distinguishes LOGO from most other languages is the use of a turtle. The physical turtle looks rather like a large beetle about 23 cm in diameter. Inside its plastic shell can be seen its motor, touch and light sensors, and pen which can be lowered to leave a trail as it is manoeuvred across large sheets of paper (its microworld), controlled by signals through a cable connected to the microcomputer. In its slightly more abstract form, the turtle consists of a triangular pointer which, similarly, can be manoeuvred in any direction around the screen (yet another microworld).

Students are usually introduced to turtle graphics using English-like commands such as FORWARD, BACK, RIGHT, and LEFT. Each of these commands is followed by a number indicating the number of turtle steps FORWARD or BACK, or the number of degrees RIGHT or LEFT turn.

The aim in turtle graphics is not just to draw pictures with a turtle instead of a pen but to use this microworld to solve problems. Interesting problems that might follow the drawing of simple shapes like squares and rectangles are for students to show the turtle how to trace letters of the alphabet—for example, the letter E or H.

The real power of LOGO is that the turtle can be 'taught' new commands from a few primitives. To add RECTANGLE to the turtle's vocabulary, for instance, the user defines what is known as a procedure. Now in deferred mode, the starting and end points of the procedure are signalled by TO and END respectively.

```
TO RECTANGLE
FORWARD 50
LEFT 90
FORWARD 80
LEFT 90
FORWARD 50
LEFT 90
FORWARD 80
LEFT 90
END
```

The final LEFT 90 is inserted so that the turtle faces the direction where it originally started. Through many examples such as this, students 'discover' the turtle total trip theorem, where the turns sum to 360 degrees. Most LOGO commands may be abbreviated using initial and final letters (e.g. FD BK LT RT); by use of the REPEAT command, the procedure for, say, TRIANGLE can then be shortened to:

```
TO TRIANGLE
REPEAT 3 [FD 50 LT 120]
END
```

The LT 120 in the above procedure may come as a surprise to many brought up in the knowledge that an equilateral triangle has three angles of 60 degrees. However, children readily discover that, for the turtle to return to its starting point, it is the 'outside' angle (not the 'inside' angle) that is important, another instance of the turtle total trip theorem (incidentally, the only LOGO theorem).

A useful beginner's guide to turtle graphics may be found in Abelson (1982), in an article appearing in the August 1982 issue of *Byte*, the whole focus of which is on the LOGO language. From a simple procedure such as the one above, Abelson goes on to discuss further student projects involving simple recursive procedures, games for exploring mathematical worlds, random numbers, list, and text manipulation. Solomon (1982) in the same issue describes how a six-year-old and an eleven-year-old used procedures to draw balloons, flowers, and bears. As one Australian newspaper headline expressed it, 'Turtle brings kids out of their shells'.

The notion of recursion (which may be likened to the person who, when granted three wishes by the genie of the lamp, always on the last wish selects three more wishes, and thus goes on wishing for ever) is an important one in programming. Students may be introduced to this concept quite easily in LOGO by making a very small addition to the TRIANGLE procedure:

```
TO TRIANGLE
REPEAT 3 [FD 50 LT 120]
LT 10
TRIANGLE
END
```

As with the three wishes, the TRIANGLE procedure calls itself, resulting in the generation of quite complex patterns and, more importantly, the potential discovery of further mathematical relationships.

LOGO in Schools

Pioneering work with LOGO in schools has been one of the achievements of the Elizabeth Centre in Hobart (Wills, 1979). The

LOGO Project (described further in Wills, 1980) used a minicomputer (PDP-11) with a turtle and graphics screen. The students did not regard their assignments with the turtle as mathematical but more as artistic activities, according to Wills. Work at the Elizabeth Computer Centre and the University of Tasmania played a major part in the manufacture by Flexible Systems, a Tasmanian firm, of what is called the Tasman Turtle, now exported to many countries including Britain and the United States. Meanwhile other pioneering work was taking place at the University of Wollongong (McKerrow, 1980) where an interface for the Apple was developed, and also at the University of Western Australia (Allison and Edmiston, 1981).

Up until the end of 1981, trials of LOGO with students were largely confined to a handful of centres around the world, notably Edinburgh, Boston, Dallas, New York and, in Australia, principally in Hobart. The explosion of turtles into schools everywhere came with the development of versions of LOGO for microcomputers. Four versions were reviewed by Williams (1982)—TI Logo for Texas Instruments microcomputers; Apple, Krell, and Terrapin Logos, all for the Apple; and Color Logo for the TRS-80—but since then versions of LOGO have appeared for the Commodore, BBC, and IBM microcomputers. With the widespread introduction of microcomputers in schools, LOGO has become quite popular throughout Australia. As one instance of this, a regular column, Turtle Talk by Sandra Wills, now appears in the journal of the Computer Education Group of Victoria (*COM-3*).

From a school in Queensland comes a report of the Gabbinbar Project, which has among its objectives to develop programming and thinking skills using LOGO. One of the several interesting aspects of this report is what the students themselves (Year 7) thought of LOGO:

> 'It is an efficient, simple, easy-to-use language that facilitates graphics programs, geometry and logic.'
> 'Logo is a good way to get started in programming.'
> 'It is fun to use and you can see your results.'
> 'I follow the path of the turtle in my head and this improves my logical thinking.'
> 'It (turtle graphics) helps me to understand geometry.'
> 'It helps in problem solving because you have to think.'
> 'When you have got a bug, you have to use logic to get it right.'
> 'Your skills increase by working out how to do programs and then trying to simplify.'
> 'It has helped me work out problems that usually I couldn't do.'
> 'The ability to form one's own commands: it is easier in Logo than Applesoft or Integer.'(Crameri, 1983:9)

Two publications likely to increase the popularity of LOGO in schools are *Learning LOGO on the Apple II* (McDougall, Adams and Adams, 1982) and the MECC (1983) handbook on LOGO. The first of these may be useful for schools with Terrapin, Krell, or Apple versions of LOGO. It is a very gentle introduction to computing with LOGO for students and teachers alike. The second publication, reviewed by Wills (1983), like most publications from the Minnesota Educational Computing Consortium (MECC), contains many useful student activities and worksheets.

Other versions of LOGO are available—for instance, Wollongong LOGO developed by Miller at the University of Wollongong and TAS LOGO adapted by Hayhurst of Reece High School in Tasmania. From being one of the least known programming languages, LOGO has fired the imagination of many teachers now that it is more widely available on microcomputers. One primary school principal noted that children can become either computer programmers or computer puppets and, if teachers want the former, then LOGO is the language to choose (Beaumont, 1983).

Advantages of LOGO

Many of those who write enthusiastically about LOGO describe its advantages in terms of the shortcomings of BASIC (see, for example, Papert's comments in the previous section). As one instance of this, the BASIC programmer who enters, say, RECTANGLE receives the following unhelpful comment:

?SYNTAX ERROR

With LOGO, on the other hand, the message is:

I DON'T KNOW HOW TO RECTANGLE

At one level, there is little difference between these two messages. At another, there is a whole philosophy, for the implication of the first message is '*You* have made a mistake' whereas the implication of the second is '*I* (the computer) lack the knowledge. Please teach me'. In other words, LOGO has the child or learner in control of the computer; with many other languages, or at least with teaching programs using them, the computer is in control of the learner. To quote Papert again, 'The best learning takes place when the learner takes charge' (Papert, 1980:214).

For Papert, too, LOGO encourages syntonic learning—that is, when children interpret the movements which they want the turtle to make in terms of their own bodies. Thus, learners wanting to teach the turtle how to RECTANGLE must first be able to do it themselves. Children who walk, for instance, tracing a rectangular route (walk so many paces, turn left, walk . . .) or who see in their mind's eye themselves walking to trace out a rectangle are likely to be able to program the turtle to do likewise. From teaching the turtle how to RECTANGLE, how to SQUARE or POLYGON, it is a small step (though a giant learning leap) to teach how to CIRCLE: forward a small step, turn a little, forward a little, turn a little . . . until you arrive back at the starting point (a further instance of the total turtle trip theorem). The power of LOGO is that learners are in control of their learning.

Another claimed advantage for LOGO is that it encourages structured programming or, more specifically, procedure oriented programming. A commonly quoted example is teaching the turtle how to draw a house. This task can be broken down into two steps or procedures—drawing a rectangle and drawing a triangle—and the whole becomes more manageable. Any complex task can similarly be subdivided into a number of procedures. Getting each procedure to work separately encourages good programming habits.

LOGO also encourages debugging, the computing term for locating and fixing errors in a program. The learner who has developed procedures for RECTANGLE and TRIANGLE may, when putting them together in a procedure for HOUSE, write:

```
TO HOUSE
RECTANGLE
TRIANGLE
END
```

In response to entering HOUSE, the turtle may trace the triangle inside the rectangle, or under the rectangle, or even to the side. A positive feature of LOGO is that the learner can actually see the turtle producing each procedure in turn, and it becomes a relatively simple task to find the logical bug in the program. To remove the bug (i.e. debug the program) the turtle must be in a particular position and direction before commencing a procedure.

Limitations of LOGO

The most often voiced criticisms of LOGO are that it is slow, that it is a language for children only, and that it is primarily a language for mathematics learning. It is worth considering briefly each of these limitations in turn.

LOGO is relatively slow and requires considerably more memory than, say, BASIC. Thus it will not run on small microcomputer systems.

The developers at MIT were less concerned about speed and memory than with developing a powerful language for learning. For many applications in schools, the limitations of speed are not noticeable and, with further advances in technology, considerations of speed and memory will become less important.

LOGO certainly is a language that young children can use to explore powerful ideas. In Australian schools it is being used mainly at the primary level (see, for example, Carter, 1983) and often with five-, six-, and seven-year-old students (Beaumont, 1983; Rebbeck, 1983). LOGO is also being used in special schools to develop logical thinking skills (Williams, 1982). In the early development of LOGO, it was more often used at the secondary and college levels, possibly because there were few computers in primary schools. Abelson (1982:90) notes:

> In our research at MIT, working with preschool, elementary, junior high, high school, college students, and with their teachers, we've used LOGO to introduce programming and the computational perspective at all levels.

It seems likely that, with greater familiarity, teachers will use the language here 'to introduce programming and the computational perspective' at higher levels too.

That LOGO is primarily a language for learning mathematics or teaching children to be mathematicians, as Papert (1971) expressed it, is not altogether surprising in view of its development at MIT. A dynamic turtle, or dynaturtle for short, has also been developed, which is used for learning physics, particularly Newton's laws of motion. Less well known is that a version of LOGO music has been developed (Bamberger, 1982). Other writers (e.g. McDougall and Adams, 1983) have highlighted that LOGO can be used also for generating patterns with words—as in writing poetry, for example. LOGO is frequently thought of as being just turtle graphics (which low-level versions on smaller microcomputers often are) when it is in fact a language that has arithmetic and list processing facilities. That LOGO is less used for non-mathematical applications may simply be because of its early origins. It is, however, a language that is still evolving and it seems likely that it will be used in more varied ways in the future. The use of sprites in some versions of LOGO is yet another example of extensions to the language. These are shapes such as planes, rockets, and trucks (or even shapes defined by the user) which may be variously coloured and moved around the screen at different speeds. As was noted in the discussion of BASIC, most computer languages were developed for particular purposes and it is limiting horizons to think of users being familiar with just one language.

Authoring Systems and Languages

Authoring systems and authoring languages are specialized programming languages that are designed specifically to assist teachers write educational programs or computer-assisted-instruction (CAI) modules. They are usually designed as conversational languages and read very like normal English text. It is sometimes said that they are programming languages for those who do not wish to learn to program.

Three such authoring systems and languages in use in schools are described here. The first is COPILOT, a version of PILOT of which there are many other versions (COMMON PILOT, MICROPILOT, SUPER PILOT). The second is the ZES authoring system which is an Australian software development. The third is the Shell Games.

COPILOT

PILOT, an acronym for Programmed Inquiry Learning or Teaching, was first developed in 1969 at the University of California. In the years following, Palo Alto School District near San Francisco explored the use of this language with teacher-written computer programs for hearing-impaired primary and secondary school students. However, differences in computer systems meant that the language needed to be largely re-written and the new version was called COPILOT. One of the researchers involved in the Palo Alto research program, now resident in Australia, developed a microcomputer version of COPILOT (Keepes, 1982) and it is this version which is described briefly below.

An example from Keepes (1982) best illustrates the nature of a CAI segment written with COPILOT. The sample sequence is for teaching the difference between 'doesn't' and 'don't' in simple sentences. One student's interaction with the computer might look like this:

```
A MONKEY —— HAVE A SHORT TAIL.
?DOESN'T
VERY GOOD
```

and for another item:

```
ZEBRAS —— HAVE SPOTS.
?DOESN'T
TRY AGAIN
?DON'T
VERY GOOD
```

This simple dialogue, which is illustrative only, requires the student to enter a response ('doesn't' or 'don't' in this instance) following a question and prompt.

The teacher wishing to construct such a lesson sequence must obviously enter, for each item, the question to be asked and some appropriate response for correct and incorrect entries by students. This is what the teacher's written program might look like:

```
 90 Q.A MONKEY —— HAVE A SHORT TAIL.
100 L.1
110 A.DOESN'T
120 R.VERY GOOD
130 W.TRY AGAIN
140 WX1
150 W.THE ANSWER IS: DOESN'T
160 Q.
170 Q.ZEBRAS —— HAVE SPOTS.
180 L.2
190 A.DON'T
200 R.VERY GOOD
210 W.TRY AGAIN
220 WX2
230 W. THE ANSWER IS: DON'T
```

This kind of programming is relatively easy to learn. There are just 11 commands (e.g. Q. L. A. R. W. WX). When the computer encounters Q., the line is printed (e.g. line 160 prints a blank line while 170 prints a question). Answers are indicated by A. and responses to right and wrong tries by R. and W. respectively. WX1 is a branch to an alternative response for a second wrong try and L is a label.

Lesson sequences may be considerably more elaborate with the addition of just a few additional commands. Speed of printing can be varied and parts of text may be highlighted by printing in inverse or flashing mode. Graphics can be incorporated, as can simple animation. Even sound can be added–musical notes together with clicks, zips, whoops, and buzzes. Use of COPILOT forms a component of the South Australian College of Advanced Education postgraduate diploma in instructional uses of computers and increasing numbers of teachers are now becoming acquainted with this language.

The advantages of COPILOT, and other versions of PILOT, are that teachers who wish to construct programmed inquiry learning or teaching sequences may do so much more easily and quickly than in either BASIC or LOGO, or any other language like FORTRAN or Pascal. Disadvantages are that the current version of COPILOT is rather slow and it does not make use of the full power of the microcomputer.

Another problem applying to PILOT more generally is that, like BASIC, there are many versions and little standardization across versions. Nevertheless, Willis, Johnson, and Dixon (1983:135) conclude their account of authoring languages with the statement: 'We believe that PILOT will become a widely used language among educators'. Whether PILOT becomes widely used in Australian classrooms will depend primarily on how teachers choose to use computers, whether essentially for drill and practice or more as a tool as in, say, word processing, simulation, or data processing.

The Zenith Education System (ZES)

Like COPILOT, ZES is a teacher's tool for creating CAI lesson modules. The total system comprises a number of subsystems, each of which is designed to help the teacher who has had little or no programming experience. Written for the Apple II with at least 48K or memory and one disk drive, ZES is produced by a Sydney company. The version described briefly here was released in 1981 (Zenith Education Systems, 1981).

The main program within the ZES authoring system is used to create the lesson sequence. This consists essentially of multiple-choice type questions with up to four different responses from which to select. Questions may be accompanied by textual information, as well as by pictures and illustrations, these latter produced with a separate graphics facility. The teacher can incorporate hints and other branching as desired. Yet another program allows questions, answers, or lesson flow to be altered or modified. The whole system is menu driven, by which is meant that the lesson writer is presented with lists of options at different choice points in creating the lesson. What ZES does, like the PILOT authoring languages, is to simplify computer programming, while at the same time allowing teachers to create individually tailored lesson sequences.

Yet another feature of ZES is a reporting program which monitors student performance. This can take a variety of forms. For example, the teacher may request a question analysis, or the results of individual students or for the whole class, or even an analysis of student response times.

The Shell Games

The Shell Games (Tognazzini, 1979) is yet another authoring system that allows teachers to create their own quizzes. The name 'Shell

Games' comes from the fact that each game consists of a shell into which teachers can insert content for learning and testing. There are three different games: The Match Machine, Professor True, and Mr Multiple. As the names of the games imply, the Match Machine requires students to match up items (words, foreign phrases, mathematical expressions . . .) in one column with items in a second column; Professor True is a true/false quiz; and Mr Multiple, the familiar multiple-choice format.

What distinguishes the Shell Games from most other authoring systems is that the teacher's only task is to specify the items for matching or the questions and answers from which to choose. The program has built into it the instructions for administering each quiz, the scheduling of items, the giving of praise for right answers or encouragement for incorrect responses. In this sense, the games are literally shells which may be used to test/teach a wide variety of subject matter.

The concept is quite a clever one. With the aid of this program, the teacher can quickly construct a quiz to test almost any content and the result is software tailor-made for some chosen instructional sequence and, at the same time, with a professional touch matching most commercial programs of the same kind. There are two negative aspects. Teachers do need to know some programming (perhaps all teachers should) for it is necessary to delete and insert lines in the shell of the program (written in BASIC). Secondly, the praise and encouragement built into the program have been selected for some anticipated typical group of students; the language may not suit young students, for instance.

5 : USES OF COMPUTERS IN SCHOOLS

Microcomputers are being used in Australian schools in a multitude of ways. School administrators are realizing that here is a powerful management tool and that many administrative tasks are similar to those in small businesses where the computer has proved an aid in inventory control, access to records, budgeting, and accounting. Teacher-librarians are appreciating that the computer can be used to good effect in many aspects of library work. In the classroom, computers are being used to teach programming, to teach about computers, to solve problems, to simulate processes, to draw and design, to assist writing, to compose and play music, to access information bases, to drill facts, to test learning, to stimulate thinking, and to play games.

One confusing aspect about much of the literature in this field is the range of terminology encountered and the lack of consensus about meanings of key terms. Some writers, for instance, describe learning with computers in terms of drill and practice, tutorials, simulations and demonstrations (Lathrop and Goodson, 1983). Others use a range of overlapping terms—computer assisted instruction (CAI), computer aided or assisted learning (CAL), computer based learning (CBL), computer managed instruction (CMI), electronic blackboard. Yet others sum up the use of microcomputers in schools in terms of six or seven major areas: teaching about computers, teaching/learning with computers, curriculum support applications, administration, use of the computer as a tool, communication/information access, and recreational computing (Sandery, 1982b; Elizabeth Computer Centre, 1983).

The approach preferred here is, first, to separate learning about computers from learning with or from computers. Then Taylor's (1980) framework is used to distinguish between the various categories of learning with or from computers, which clearly embraces the major uses of computers in schools. Taylor suggested that all computing in education can be accommodated in one of three modes—'tutor/tool/tutee'.

> In the first, the computer functions as a *tutor*. In the second, the computer functions as a *tool*. In the third, the computer functions as a *tutee* or student. (Taylor, 1980:2)

Any classification of computer use in schools must be arbitrary to some extent with categories inevitably overlapping. It is convenient here to review the myriad uses of this very general purpose machine—the computer—in terms of how they are commonly used in schools, that is augmenting Taylor's framework to include:

Learning about computers
The computer as tutor
The computer as tool
The computer as tutee.

While it would be the exceptional school that could currently claim to use the computer in all these modes, nevertheless the descriptions that follow are based in the main on practices in Australian schools using computer software developed for the most part in Australia. This chapter shows the wide variety of ways computers are being used in the nation's classrooms; in the next chapter more complete programs or projects are presented in the form of case studies.

Learning about Computers

The school with access to microcomputers can essentially use them, as just noted, to learn about computers or to learn with or from computers. Although there is not yet agreement among teacher educators about the meaning of key terms, learning about computers (that is, as a subject to be taught) commonly encompasses computer awareness, computer literacy, and computer electronics.

Computer Awareness

Given the impact that computers are now having on every aspect of daily life, it is hardly surprising that computers themselves should be considered an object of study. School councils and parent groups are being vocal in urging schools to purchase computers, and computer awareness courses are beginning to be included in the curriculum offerings of many schools. Considered by Sandery (1982b) as 'a national asset', computer awareness is described by him as follows:

> I like to think of computer awareness as the knowledge required by an intelligent citizen to enable that person to make informed decisions about computer related issues that impinge upon their daily lives. It is essentially a knowledge of the power and the limitations of computers. (Sandery, 1982b:75)

While much is being made at present of the need for computer awareness courses, Barrett (1983) notes that this need may diminish as the level of computer awareness in society rises.

Most computer awareness courses usually include some treatment of such topics as the history of computers, the components of computer systems, how they work, how they are used in industry and commerce, social consequences arising from the introduction of computers in society, issues like privacy of information, automation, and a cashless society. A computer awareness course that has received some recognition beyond the State in which it was developed forms one of the case studies in the next chapter.

Computer Studies

Overlapping computer awareness is the question of how to use computers—that is, how to program and how to run applications packages, and this is often termed 'computer literacy' or 'computer studies'. Many would argue that learning how to use a computer is the best way to become aware of computers.

Which programming language is taught in computer literacy courses depends partly on whether such courses are offered at the primary or secondary level and partly on those advising teachers in computing. Overall, BASIC is the most widely used microcomputer language in schools at present. At the primary level, LOGO is gaining in popularity. At senior secondary levels, structured BASIC or Pascal is increasingly advised, and sometimes there is an introduction to assembly language.

Computer Electronics

Computer electronics is often included as part of an introduction to electronics or digital electronics. Sometimes offered as electives at the senior secondary level or as part of the physics syllabus, such topics usually provide an introduction to integrated circuits and how these can be combined to form more complex chips. Circuits studied may include flip flops, counters, clocks, and logic gates, leading in some schools to the building of simple computers.

The Computer as Tutor

The use of the computer as tutor has a relatively long history. Both Taylor (1980) and Lathrop and Goodson (1983) note that this mode of use goes back to the days of programmed instruction; it also rests on a foundation of research conducted on mainframe computers in the sixties and seventies, mainly at the tertiary level but extending down to schools (e.g., project PLATO at the Universities of Illinois and Delaware;

program TICCIT at Brigham Young University, and the work of Atkinson and Suppes at Stanford, of Bork at California, and of Dwyer at Pittsburgh). Extensive reviews, particularly of applications in reading, may be found in Mason, Blanchard and Daniel (1983) and in Marsh (1983). Shears and Dale (1983) cite an evaluation study by ETS at Princeton, which largely confirmed earlier evaluations of computer assisted instruction: for subjects like mathematics, CAI generally produces greatest gains, whereas CAI gains for reading and language skills, though still significant, are usually smaller. General support for these findings is seen in the Australian replication of Atkinson's program at Stanford by Cumming and Willox (1982).

However, there is a paucity of Australian research regarding the use of microcomputers in schools, not only as tutor but also as tool and tutee. This is a field in urgent need of concerted action by research bodies, by individual researchers and, indeed, by the whole educational community.

The computer as tutor may be used to provide drill and practice (e.g. the learning of tables), to teach and test factual information (e.g. memorizing capitals of the world), to develop mastery in spelling or number facts, to develop reading speed, and improve comprehension. Good examples of the computer used in this mode are that it can be tailored to the individual needs of students, can provide diagnostic information as well as keep records of all student learning, always provides positive reinforcement, and, of course, is infinitely patient. Some brief descriptions of computer programs available in classrooms follow. These are a small sample only of the wide variety of software that is available. Their inclusion here is not an endorsement but, rather, an indication of the different ways in which microcomputers may be used as tutor in schools.

Practice in Science

Funded under the Microelectronics Education Programme (MEP) in the United Kingdom is a set of microcomputer software called Five Ways Software (Council for Educational Technology, 1982; Note 5), named after the school in Birmingham which field tested the resource materials.

Consideration of one of the Five Ways programs indicates the general underlying philosophy of this set of software. *Symbols to Moles*, for example, is designed for chemistry students to practise symbols, valencies, formulae, equations, and mole concept calculations. The accompanying manual contains suggestions for using the program following teaching of the concepts involved. The program is designed for use individually or in small groups, and there is the facility for the teacher to check students' progress.

Teaching notes supplied with each program in the Five Ways software series provide full instructions about running the programs, selecting topics for practice from the menu, viewing students' scores, and using the management section to govern different aspects of program use. All programs were designed for the Apple, with versions for the BBC in preparation. There are other programs in the series for geography, French, business studies, maths, physics, and biology.

Teaching and Drilling in Language

One example of courseware available through the Minnesota Educational Computing Consortium (MECC), designed both to teach (termed 'tutorial') and to drill (termed 'drill and practice') commonly used prefixes in English, is a Language Arts package, *Elementary Volume 5* (MECC, 1980). When the program is run, seven lesson choices are displayed in menu form, five tutorials and two review lessons. As with most MECC software, the computerized modules make use of the computer's graphics capabilities, and its random number generator to randomize question order. A comprehensive manual (50+ pages) accompanies the disk with instructions on each of the programs, suggestions how the lessons might be used, worksheets, scoresheets, and background information about using a microcomputer.

Other MECC courseware is available in all subject areas, primary and secondary. Training materials, too, have been produced on different aspects of programming in BASIC and assembly language.

Practising Basic Number Skills

One of many programs designed to give students practice in basic number skills is *Mathvader* produced by the Angle Park Computing Centre (1983; Note 6). It is in game form and modelled on popular video games, and students must enter the correct answers to basic number facts (addition, subtraction, multiplication and division) to shoot the mathvaders descending from the top of the screen.

Level of difficulty and skill to be practised can be selected using the teacher option. For example, level of difficulty can be varied by extending or curtailing the range of numbers. Thus if the 6-times table is to be practised, the teacher may select 1 to 12 (or 1 to 10) as the range of the first number and 6 to 6 as the range for the second. The available documentation is on the disk itself, which is accessed by typing HELP.

The Computer as Tool

The major function of computers in schools is as a tool, as in business and in commerce, and in home computing if games are included in this mode. Like any other tool, the computer may be used to perform particular tasks but, because it is such a general purpose tool, the range of tasks it can perform is wide. Computers may be used as calculators, as accounting machines, as rather special typewriters, as well as for storing vast quantities of information for subsequent access and retrieval; but computers may also be used as learning tools, as tools to draw, to play music, to play games, and much more besides. Some of these uses of the computer as a tool in schools are considered below.

A Tool for Calculation and Statistical Analysis

Computers can be used as simple calculators using, say, BASIC or LOGO. Thus with BASIC, one could enter:

```
PRINT 243.27 * 12.7        to multiply numbers
PRINT 49.82/0.296          to divide numbers
PRINT SQR(1024)            to take square roots
```

and, similarly, for common trig or log functions. Calculations in LOGO are very similar, for example:

```
PRINT 2*2/(6+4)
PRINT SQRT 129
```

Random numbers can also be generated. The instruction in LOGO, for instance, for a random number less than 100, is:

```
PRINT RANDOM 100
```

In these rather simple examples, the computer is used as a tool, instead of a calculator, or instead of mathematical tables and tables of random numbers.

From small-step calculations in immediate mode, microcomputers can be programmed to perform various statistical analyses. Program *T-Test* (Queensland. Department of Education, Curriculum Branch, 1981a), for instance, allows inferences to be drawn about single samples. The main aim of the program, however, is to give students insights into use of the t-distribution rather than to undertake significance tests on data. In this sense, it is essentially a simulation package. The use of the graphics facility of microcomputers permits students to see the effect of changing conditions (e.g. confidence levels) when they ask questions of the sort 'What happens if . . . ?'.

Another series of programs that would find ready application in schools, this time more as a tool by teachers in analysing students' tests, is that produced at Macquarie University (Note 7) as part of the Student Assessment Project (Baumgart, Low and Riley, 1982). The whole package, comprising sets of slides, computer programs for the Apple microcomputer, and comprehensive manuals, was designed as a kit of materials for preservice and inservice education of teachers.

One of the program modules, TESTAN, produces test analysis statistics for classroom tests. The program may be used for both norm-referenced and criterion-referenced tests. Tests are scored, and percentages and a histogram of the distribution of marks displayed. Statistics which can be computed include mean test score, standard deviation, reliability coefficient, and standard error of measurement. Then for each item is displayed the distribution of responses for each alternative, facility and discrimination indices, reliability if the item is omitted, and point-biserial correlation coefficient. Two other program modules allow the teacher, in interactive mode, to enter student data into a file or add data to an existing file.

Another program module, GRADER, combines marks (tests, projects, and so on) within a subject or across subjects. Yet another program module, MODERATION, is used to adjust marks so that the mean and standard deviation are aligned to those of another test. The final program module RASCH is for item analysis using the Rasch model.

This set of programs could be useful as a tool, not only for analysing classroom tests but also for providing insights into topics like moderation and scaling.

A Tool for Writing

As more teachers appreciate that microcomputers can be used as tools for writing (or word processing), so the use of computers is capturing the imagination of increasing numbers of educators. When computers are used as word processors, they are tools in very much the same way that pencils and rubbers, biros and liquid paper, and typewriters are tools. The enormous advantage of computers over these other tools is that what is written is stored in the computer's memory, rather than on paper, for easy retrieval and editing or printing as desired. What enables the computer to do these tasks is a program called a word processor. There are scores of word processors available for practically every microcomputer—Atari Writer, Bank Street Writer, Easy Script, Easy Writer, Gutenberg, Perfect Writer, Scripsit, Vic Writer, View, Visiword, WordStar, Zardax—to name just a few of the best known ones. Man (1983) notes that there are more than 35 word processing software packages for the Apple alone, ranging from under $100 to more than $500.

A key criterion for recommending a microcomputer for educational use might well be the availability of a reasonably versatile, easy-to-use word processor. The advantages of word processing programs are that they enable text to be entered into the computer, edited and formatted on the screen, and subsequently printed. Paragraphs can be inserted and moved around at will. Different formats can be experimented with and displayed. Limiting factors which schools may need to take into account are that word processing applications make heavy demands on computer time, depend for effectiveness on standard, often more expensive type of keyboards, desirably should have 80-column display, usually require considerable memory or auxiliary storage, and necessitate the purchase of a printer, a relatively expensive item if good quality output is wanted.

The biggest impact of word processors in the classroom is on the process of writing itself. From around Australia are coming reports of how teachers are using this new educational tool on a variety of microcomputers. Earle (1983) and Inkster (1983), for example, describe the work in one primary school using the Tandy word processing program, Scripsit; Smith and Gray (1982, 1983) working also at the primary level use Zardax, a word processor for the Apple; and Kaiser (1983a) reports the use of Hi Writer using the Peach microcomputer with remedial reading groups.

In a detailed case study, Kaiser (1983b) reports on his investigation of the use of a word processor in conjunction with a process or conference approach to children's written language. How the word processing program was introduced, the difficulties experienced with teaching keyboard skills, the progress made by a sample of children, and the views of other teachers in the school about the project as a whole are fully described in a way that makes this a most useful case study for other teachers. Three trends noted by Kaiser were a tendency for students to write at greater length when using the computer, for the increase in length to be accompanied by an increase in the complexity of

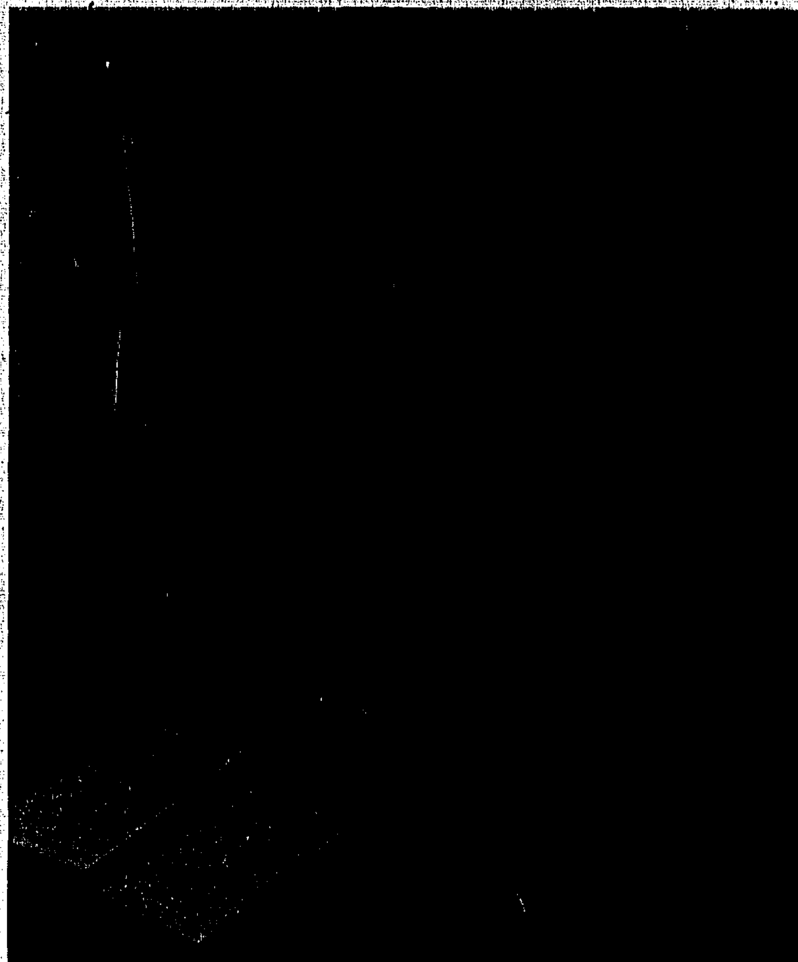

Figure 5.1 Using a Computer for Writing an Essay (Photograph by courtesy of Apple Computer Australia Pty Ltd)

written work, and for no lessening of enthusiasm on the part of students as a result of using the computer as a writing tool.

In an address to English teachers about the use of microcomputers in writing, Woods (1983a:35) notes:

> The possibilities should be explored with a sense of optimism and not a Luddite-inspired gloom. English teachers dwell in a world of words, of literature, and of the imagination. We should be in the vanguard for discovering the potential for computer technology in learning and in shaping language and thinking.

Other tools available to writers, in conjunction with word processors, are programs to check spelling (e.g. Easy Spell, SpellStar, Visispell). These are not yet widely used in classrooms, probably because a second disk drive is usually needed. In regard to spelling, Earle (1983) makes the interesting observation that students note spelling errors more easily when their writing is printed by computer than in its handwritten form.

So far, word processors have been used in schools to do what has been done before, but in different ways that lead to an extension of the writing process. Exciting as these might be, new and creative uses of word processors are being explored. At the Edinburgh University Department of Artificial Intelligence, for instance, Sharples (1983:54) describes what he calls 'a construction kit for language'. Programs are being developed which, in conjunction with a type of word processor, are being used to generate sentences, to plan stories, to transform text, and as a thesaurus. The use of the computer as 'writer's assistant' seems certain to challenge the imagination of teachers.

A Tool for Music

Not too dissimilar to word processing programs are programs for processing musical notes. One such program, developed for teachers and students to create their own tunes, is *Sing* (Queensland Department of Education, Curriculum Branch, 1981b). As with word processing, users interact with the computer and create their own musical compositions. Notes are entered singly, the user specifies time signature and type of note, and the score is progressively displayed on the screen. At any point users can press a key; and the tune they have created is played back on the microcomputer's speaker. Tunes may also be saved. Program *Sing* was written for the Apple II with 48K of memory.

A Tool for Drawing

In the discussion of LOGO in Chapter 4, we have already seen how the microcomputer can be used to draw pictures, though the computer here might more appropriately be considered as functioning in tutee mode rather than as tool. A graphics tablet, available for some microcomputers, illustrates how the computer may be used as a tool for drawing. Thus, instead of programming the turtle to trace, say, a circle, students can use a light pen. Any selected shape drawn on the graphics tablet immediately appears on the computer screen. These shapes can be shaded in and the created picture stored on disk for retrieval at a later date, in very much the same way that text or musical tunes can be retrieved. From drawing simple shapes and pictures, it is a relatively small step to using the graphics tablet for handwriting.

A Tool for Displaying Information

The computer's graphics facility coupled with its speed of computation make it a useful tool for displaying information or for demonstrations. This function of the microcomputer is often termed 'electronic blackboard'.

An example of the microcomputer being used to good effect as an electronic blackboard is the MECC program, *Aestheometry Volume I* (MECC, 1981), which demonstrates the drawing of curves from a series of straight lines. One of the six programs on the disk, CURVE DEMO, displays a succession of quite elaborate curve sketches, all produced from straight lines. A second program, 'CURVES', demonstrates how to draw an ellipse, a parabola, and a hyperbola using the approach called aestheometry. Like all MECC software, these programs are accompanied by an extensive manual which suggests ways the programs may be used in teaching. These particular programs illustrate how some software can be used across subjects (e.g. Years 3 to 12) depending on the depth or treatment given.

A Tool for Simulation

Among the powerful functions of microcomputers is the capability of simulating the operation of a system—perhaps the ecosystem of a lake, the operation of a nuclear power plant, breeding experiments, the search for energy, or growth in world population. Simulations usually permit users to examine some aspect of the real world under controlled conditions, they often enable the study of variables which might otherwise be inaccessible, and they can promote a range of educational goals.

Illustrative of the many simulations in classroom use, available in all subject areas, are *Archeological Search* (Snyder, 1982) which simulates an archeological dig, and *Gold Dust Island* (Gare, 1984), a simulation game. Project RIME (Victoria. Education Department, Curriculum Branch, 1984), by contrast, is not a software package but it is worth noting for the way in which simulations (and other types of computer activity) are integrated into regular classroom teaching.

In *Archeological Search* (Note 8) students have the task of organizing the excavation of a newly discovered historical site. They are faced with problems of competing commercial interests and shortage of time and money. The microcomputer simulates the stages of the search—the surface examination, probes beneath the surface, laboratory examinations and expert assessments of specimen findings. Decisions must be made on funds to be spent at each stage of the dig in the search for data that might give some clue about those who formerly occupied the site.

The accompanying Teachers Manual and Students Workbooks suggest ways that library and other activities may be integrated with sessions at the computer. Particularly effective in this courseware are the suggestions for class management, enabling a microcomputer to be used with a class of students, for students need to do much reading and discussion before they take their turn at the keyboard. Logs are kept, tentative hypotheses made, to be confirmed or rejected in the light of evidence uncovered. Through this simulation, reading, writing, and reasoning are all promoted, and students are introduced in an exciting way to scientific method, all in a real and believable context.

Gold Dust Island (Note 9) is a rather unusual computer simulation game, unusual because the underlying educational objectives are not cognitive but affective. It is a simulation in which co-operation among players is encouraged. There is no individual winning or losing as such. Rather the game simulates a slice of life and allows players to experiment with different behaviours in their personal dealings with other players. It is true that players can die in the game, though this results in a loss to the group as a whole, and players quickly learn that individual survival depends on group cohesiveness and harmony. Part of the objectives of this simulation game are for students to establish even what the problem is, and then to determine what their goals should be. As in real life, students learn that one person's actions have a ripple effect on others.

Gold Dust Island is one of a new series of Australian produced software which demonstrates the versatility and potential of microcomputers to enhance learning. This simulation is produced for the Apple and BBC microcomputers.

The Reality in Maths Education Project, known better as RIME (Victoria. Education Department, Curriculum Branch, 1984; Note 10), is a newly available set of mathematics materials. What the RIME materials endeavour to do is support teachers by illustrating, among other things, how computers may be used in mathematics classes for simulation and modelling. Particularly noteworthy is the way computer activities are integrated into regular mathematics lessons, how account is taken of the fact that most classrooms will have at best but one microcomputer, and how lesson sequences are designed so that all students will have a turn at the computer.

A Tool for Data Processing

The most common use of computers by government, business, the military, and nearly all major institutions, according to Coburn et al. (1982), is in data processing. The information society depends on vast files of information organized in databases; and only through computers is it feasible to access, manipulate, and retrieve selected information. These authors go on to comment:

> Until recently, the sole instructional application of data processing has been to teach it, as a skill, in business education courses. In some schools, advanced business education students even carried out most of the data processing tasks for the school on computers. However . . . imaginative educators are beginning to devise ways of adapting the data processing capabilities of computers to enhance student learning. (Coburn et al., 1982: 43–4)

Two imaginative database program packages are discussed here, both produced by the Elizabeth Computer Centre in Tasmania (Note 11). The first, produced in 1982 and given wide publicity during Information Technology Week, is *The First Fleet Database: Convicts and Computers* (Tasmania. Education Department, 1982). The second, scheduled for publication early in 1984, is provisionally entitled *Birds of Antarctica* (Tasmania. Education Department, 1984).

The First Fleet Database package comprises one disk containing the database (versions available for Apple and BBC), computer printout of the data, Teachers Guide and student worksheets. The database itself contains the personal details of the 777 convicts who arrived with the First Fleet in 1788—given name, surname, alias, sex, ship, date of trial, place of trial, crime, value of crime, sentence, term, trade, and age.

One educational application of a package like *The First Fleet Database* is the example it provides of the structure of a database—the organization of the data into files, each file comprising records (one for each subject), and each record made up of fields (one for each datum recorded). How to treat missing values can also be observed.

The major purpose of this database, however, is 'to give secondary students a greater understanding of information technology by giving a practical demonstration of computer application to historical research' (Tasmania. Education Department, 1982:Preface). A simple query language is provided which allows students to interrogate the database, to test hypotheses, and to engage in historical research. From simple requests like, How many convicts were named, say, Smith? (e.g. SURNAME = SMITH) or, How many convicts were boys under 15? (e.g. SEX = M and AGE > 0 and AGE < 15), students may go on to test such hypotheses as whether, say, the Essex Assizes were harsher or more lenient than others.

The database provides a rich source of classroom activities, not all necessarily computer based (e.g. reconstructing a map of England or finding out about such occupations as caulker, currier, and furrier). The 32 worksheets and guide for teachers contain many suggestions for use in the classroom, and could provide a good model of the kind of documentation that ought desirably to form part of any courseware package.

Birds of Antarctica represents something of a departure for the Elizabeth Computer Centre, as this particular database is an example of scientific research and the data are very recent. In November and December 1982, as part of the Australian National Antarctic Research Expedition, one scientist's task was to record all sightings of bird life. This survey, in turn, formed part of an international program called BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks), the aim of which is to try to understand the interrelating components of the Antarctic marine ecosystem. It is an ongoing program of scientific enquiry.

The database itself comprises all the observations of seabirds made by the scientist during the voyage, together with meteorological information, time, date, and ship's position and activity. Interrogation of the database follows the style of *The First Fleet*, allowing the user to answer questions such as, In what latitude ranges, or in what conditions of ice density, are cape petrels observed? The student can become the scientist through the use of this database, building up a picture of the habitat and behaviour of seabirds, in what is an area of scientific and economic importance for Australia. Several additional features of this database permit information to be displayed in histogram, barchart, or scattergraph form, with the option of several descriptive statistics.

A feature of the *Birds of Antarctica* database is the comprehensive manual that accompanies it. There is an introductory section on climate, marine ecosystem, and seabirds of the region, together with a brief history of exploration. Full background information is provided on how the data for the seabirds were collected. These sections lead in to details of how the database was structured and how information may be retrieved from it. And, as in the *First Fleet* database, there is a range of student activities, not all necessarily involving the computer, suggesting ways for imaginative teachers to enter into continued exploration and discussion.

Versions of the database are to be available for the Apple, BBC, and Microbee 64, with the possibility of extensions to the IBM and Tandy microcomputers.

A Tool for Accessing Remote Databases

In the previous section, the use of the computer to access information in databases near at hand and of a static kind was described. Neither of these conditions is necessarily restrictive. Most people today take for granted the facility offered by the major airlines and some travel agents to access information about flight schedules and reservations, or the similar facility that allows theatre seats to be reserved and issued from remote outlets. Microcomputers in schools can similarly tap vast storehouses of knowledge wherever these might be located, in one of the capital cities or in another country. The implications for education, while potentially far-reaching, are still largely unexplored. It is, however, a development available now.

To connect a microcomputer to an information database, usually stored on a much larger computer, what is required first is access to a telephone. While a dedicated line may be used, the ordinary telephone provides a ready means of connection to virtually anywhere on the globe for the price of a telephone call. Required next is a relatively inexpensive device called a modem to connect microcomputer and telephone. The modem (so called because of its modulating/demodulating functions) converts or modulates outgoing digital signals from the microcomputer to audio signals necessary for the telephone line, and then reconverts or demodulates incoming audio signals to digital signals for the microcomputer.

The Source is one of two major general purpose databases operating in the United States (the other being CompuServe). Willis and Miller (1983) describe some of the facilities available to registered users. These include such consumer services as making travel, car, and accommodation reservations, buying and selling real estate, placing classified advertisements, and discount buying. Sending messages to other subscribers is possible through the associated electronic mail service. Users may also access a variety of computer programs (e.g. for statistical analysis). Yet other services available provide current news bulletins from the major wire services (e.g. United Press International) or the latest share prices, say, on the New York stock exchange.

To become a subscriber to The Source, there is an initial connection charge (approximately $100) and a minimum monthly charge (about $10). Thereafter the user pays for the time connected and the rate varies according to the time of day. Similar networks are beginning to operate in Australia.

A somewhat different mode of access to database information is referred to as videotex, a generic term applied to the display of text, print, and still pictures on a video screen. Several different videotex systems have developed (principally in France, West Germany, the United Kingdom, and Canada), of which the best known is the United Kingdom public system, now called Prestel. Of significance to Australia is that, in October 1983, the Commonwealth Government, reversing a decision of the previous government, gave its approval to Telecom to establish a national videotex data service. Since this system is likely to be closely modelled on Prestel, a brief description of Prestel follows.

Originally known as Viewdata, Prestel was developed by the British Post Office and introduced as a public system in 1976. Information is transmitted from a central database over the telephone network, to be received on a user's television set equipped with a modem-type device. The modem is equipped with a keypad which permits the user to relay information back to the data base. Dunnett (1983:1) describes its operation more precisely:

> To receive information you telephone a data bank, identify yourself as a subscriber, and use your remote control unit to call up the pages you want on your television screen. The data, stored in digital form, is converted first to audio signals for transmission by telephone, then back to digital form by the decoder attached to the television set, before finally being displayed on the screen. Being a two-way system it is possible to use the keypad to answer back.

As with The Source, Prestel enables subscribers to call up a wide variety of information, to place orders, make travel reservations, read financial newsletters or the news, see weather forecasts, through a modified television set or microcomputer linked to the telephone network. Prestel can be accessed from Australia, though telephoning ISD is obviously expensive. The user with access 'dials' the Prestel computer centre by pressing the appropriate keys on the numeric keypad. Following the display of the contents pages, the user may, for example, choose to branch to travel information from where the next choice may be to a particular airline and then a particular route. The database may then be interrogated about the availability of seats for particular dates and, finally, a message may be relayed to the airline requesting a booking to be made. The use of colour and graphics makes for readable presentations.

The Telecom service, expected to be operating by the end of 1984, is likely to offer similar services together with some of its own, such as the information contained in the Yellow Pages of a telephone directory. It has also been announced that the service will provide what is called a gateway facility to give access to external databases. The Minister for Communications in announcing the new service said, 'In effect, the national videotex service will serve as a decentralized national library, with an extensive range of information being made available via the telephone line' (Press release). With the domestic satellite system, Aussat, extending Telecom's communications network to the remote areas of Australia, a library of information will be available to anyone with a telephone and a suitably equipped visual display terminal, for an annual charge plus, in all likelihood, the cost of a local call.

Modelled on The Source, and providing some similar services to Prestel, is The Australian Beginning. Like these overseas networks, The Australian Beginning comprises a number of separate databases which the user may interrogate to find, for example, information about weather, airline schedules, sporting results, or news. An electronic mail service is available and computer programs may also be run on the host mainframe computer. To subscribe, users pay an annual membership and then according to time used on the system. Currently users in Melbourne and Sydney can access The Australian Beginning for the price of a local call. Other users need to pay STD rates, though developments by Telecom are expected soon to extend the local call rate.

A Tool for Organizing and Handling Numerical Information

Another very common business application that is beginning to flow through to business studies courses in schools is the use of 'electronic spreadsheet' programs. In fact the availability of these programs on most microcomputers, perhaps more than any other single program, has contributed to the popularity of personal computers. The earliest and best known spreadsheet program is VisiCalc. Released in 1979 for the Apple II, it has become the most popular software product yet produced

(McMullen and McMullen, 1983). Other spreadsheet programs now on the market are Supercalc, Multiplan, and an Advanced Version of VisiCalc. Versions of these programs are available for most major microcomputers.

In the business world a program like VisiCalc (short for visible calculations) allows the user to process many columns and rows of numerical data simultaneously by asking questions of the kind 'What if . . .?'. For example, what will happen to projected weekly, monthly and half-yearly profits if an additional tax of half of one per cent is levied on all financial transactions? At the press of a few keys all rows and columns affected by the imposition of such a tax visibly change. Formerly such calculations were done on large sheets of paper (hence the name spreadsheets) with pencil and rubber. The microcomputer provides a window view of an enormous spreadsheet which extends, depending on the computer's memory, for several hundred columns and rows; the window may be moved horizontally or vertically by pressing the arrow keys and, of course, all changes to row and column entries are made electronically. Its ease of use and its applicability to a wide range of problems makes a program like VisiCalc a powerful tool.

The potential of educational applications of spreadsheet programs would appear to be considerable, though to date such programs are not widely used in schools. There is an obvious use in accounting for balance sheets and profit and loss statements, and some teachers are using spreadsheet programs in business education. Some teachers of agriculture, too, use VisiCalc for farm management. Spreadsheet programs might be used also, for instance, in health and nutrition courses to analyse calorie intake and energy consumption, in geography to analyse demographic and population trends, or by administrators to analyse patterns of retentivity—indeed, in any subject area where it is appropriate to look for patterns and test hypotheses from numerical data. It seems probable that the use of the computer as a tool in areas such as these will increase as general subject teachers realize the potential of spreadsheet programs.

A new software release (reviewed by L'Allier, 1983) is a courseware package that provides instruction in the use of VisiCalc—an instance of the computer as tutor for the computer as tool.

A Tool for School Administration

It is recognized that computers have an important role to play in the running of any modern business, and certainly the projection of sales of microcomputers to this section of the market far exceeds that of sales to schools. Less widely appreciated is that the average-sized primary or secondary school is comparable in terms of administrative tasks to be performed to a medium-sized business. As Sandery (1982b) noted, in many country towns the school is the largest business. Some of the functions of a computer in school administration include staff and student records, inventory control, timetabling and scheduling, financial transactions (accounts payable and receivable, general ledger, payroll), attendance records, enrolment information, students' academic results, age-grade statistics.

It is important to recognize certain problems which confront individual schools wishing to use the computer as a tool for administrative tasks. A trial report on the use of a general database management system (Angle Park Computing Centre, 1982a) highlighted such difficulties as the amount and variety of information to be stored, the diversity of school organizational structures, the lack of suitable hardware and software at the school level, the shortage of computing expertise within schools, maintaining systems when staff leave and, not least, questions of security of information.

The Computer as Tutee

In the computer as tutee mode, users teach the computer, in contrast to being tutored or using the computer as a tool. The major difference between this mode and those discussed above is that now the user must communicate with the computer in a language it understands—in other words, program the computer. As programmer, the student assumes responsibility for his or her own learning rather than being a mere computer puppet (Beaumont, 1983) and this, according to Leuhrmann (reprinted in Taylor, 1980) and Papert (1980), makes learning qualitatively different.

Taylor (1980) who coined the terms, 'tutor', 'tool', 'tutee' notes several benefits arising from knowledge of programming:

> First, because you can't teach what you don't understand, the human tutor will learn what he or she is trying to teach the computer. Second, by trying to realize broad teaching goals through software constructed from the narrow capabilities of computer logic, the human tutor of the computer will learn something both about how computers work and how his or her own thinking works. Third, because no expensive predesigned tutor software is necessary, no time is lost searching for such software and no money spent acquiring it. (Taylor, 1980:4)

Some support for Taylor's views about the benefits of programming is forthcoming from other sections of this review. The evidence from cross-age tutoring studies (see, for example, Craker and Richardson, 1981) generally shows benefits accruing from the practice of older students tutoring those in lower grades. Although no studies were located in the field of schools computing in this regard, it would seem potentially useful for, say, secondary school students with programming projects to locate these in nearby primary schools. Taylor's second observation, that the human tutor of the computer learns simultaneously about human thinking and about computers, comes close to the approach to educational computing in France called 'informatique'. Taylor's third observation is only partly right. While BASIC is usually supplied with most microcomputers, other programming languages need to be purchased and require a certain minimum memory to run. Languages like LOGO and Pascal are not available for all microcomputers currently in schools.

It is interesting to note that the major pioneers in educational computing—for example, Papert and Luerhmann—have been more interested in the computer as tutee than in the computer as either tutor or tool.

6 : CASE STUDIES

This chapter presents descriptions of developments in schools computing from different parts of Australia. No claim is made that this is a comprehensive listing of key developments. The studies are a sample of the innovative work being done which came to the author's attention during the course of this review.

There is the possibility, in presenting a series of case studies such as those which follow, that the impression could mistakingly be given that these are fairly typical of current developments in schools computing. This is not so. It is worth reiterating that the examples were selected because they were pioneering or appeared highly innovative.

Computer Awareness Teacher Support Material

The Angle Park Computing Centre (APCC) within the South Australian Education Department (1982; Note 12) has developed a package of computer awareness teacher support materials which is becoming known throughout Australia. The package is designed for use at the secondary level (Years 9 and 10), though in some schools it is used at lower levels, and at others in Year 11 as part of an elective topic. According to Sandery (1982b), it was used in 1982 by approximately 16 000 students in South Australia and by about 600 classroom teachers. Since the vast majority of these teachers had no special qualifications in computing, the materials served an important inservice function. Enquiries for the materials interstate suggest that they are also serving a useful function elsewhere.

The materials come in loose-leaf format and consist of overhead projector masters, background information sheets, suggestions for student worksheets and assessment exercises. The loose-leaf format allows the ready insertion of more up-to-date materials, cuttings, reviews, and so on. The materials are, for the most part, machine independent, though some were originally developed for use with an optical reader batch system, and other parts of the materials apply specifically to the Apple microcomputer. However, parts of the materials are becoming dated because of the rapidly changing field, and are currently being revised.

The course outline comprises five main topics:

1 The components of a computing system
2 The history of computers
3 Using a computer—student classroom activity
4 Everyday use of computers in society
5 The social implications of the widespread use of computers.

Each of these major topics is supported by materials designed for teacher use. The history of computers section, for instance, comprises OHP masters showing, with approximate dates, the development of the abacus, Napier's bones, Pascal's adding maching, Leibniz's calculator, Babbage's engines, right up to the present large-scale integrated circuits, together with accompanying documentation about each of these milestones. A recent article by McShane (1983a) could probably complement this history of calculating devices, for McShane argues that the history of computing should be considered within the wider context of the history of information processing, which dates back to early cave paintings of 20 000 years ago. The loose-leaf format of the APCC teacher support materials allows for this and other materials to be inserted easily.

Computer Studies at the Upper Secondary Level

Tasmania has a long lead in offering computer studies at matriculation level, for this subject was first introduced at the Higher School Certificate level (Years 11 and 12) in 1972 (Wills, 1980). Computer studies is now also offered as an option in the School Certificate course (Years 9 and 10) and is one of the most popular student choices after English and mathematics.

The aims of the computer studies course are described in the *Higher School Certificate Manual for 1983* as follows:

1 To introduce appropriate aspects of computer education which will satisfy the needs of students preparing to live in a modern technological society
2 To produce an awareness of the social, cultural and economic impacts of computers on a modern society
3 To develop skills for the analysis and solution of problems, some of which may be solved using a computer
4 To provide experiences which will form a basis for further study
5 To develop an appreciation of some of the many and varied applications of a computer
6 To provide an intellectual challenge in an area of learning which demands precision in thought processes and the use of language
7 To provide skills which may be useful in the study of other Higher School Certificate subjects and which may make the study of these other subjects more meaningful. (Tasmania. Schools Board, 1982:77)

Examination of these aims suggests, and this is confirmed by a more detailed analysis of the syllabus, that the computer studies course is non-mathematically oriented. The course is offered at two levels, Level III (Advanced) and Level II, and within each of these levels three broad areas are encompassed—computer concepts, computers in society, and programming. Practical work accounts for 50 per cent of the assessment. Bock (1983:10–11) describes this practical work as follows:

> This practical work varies in its nature. It may consist of learning programming and problem-solving techniques using a high-level language such as structured BASIC (Years 9, 10) or Pascal (Years 11, 12).
>
> It may consist of the completion of exercises and projects using software packages such as data bases, simulations, logic games, word processing, editors, financial systems, and so on.
>
> . . . areas such as the history and development of information processing, computer systems and computer applications are dealt with to some depth. During this part of the course many projects, assignments and exercises are set. At Years 11 and 12 other topics such as data representation and data communications are covered.

Two signficant factors emerge from the above. The first is the non-mathematical orientation of the Tasmanian course. There is a ready appreciation, it would seem, on the part of those who framed the syllabus that computers have as much (perhaps even more) to contribute to subjects like business studies, English, social sciences, and languages, as to subjects like mathematics and the sciences. The second factor, which may be inferred from the large numbers of students electing computer studies at these advanced levels, is that teachers in Tasmania must be qualified to teach these computing courses. Bock (1983) reports that a tertiary subject, 'Computers in Education', is regarded as minimum qualification on top of other teaching qualifications and that more than 200 secondary teachers have completed this subject. This subject is the most popular of inservice courses offered (Sale, 1982).

Microcomputers in the Primary School

There have been several instances of highly innovative work in primary schools highlighted in the national press. In an outer suburb of Brisbane, for example, there is the Centre 2000 which, with its mobile computer centre van, takes information technology to students in schools that have no computing equipment. From Melbourne comes the description of St Catherine's School, where students in the preparatory grade work with and learn about microcomputers. Spreyton Primary School in Tasmania is said to be the first primary school in the country to install a computer network (Scott, 1983a). The focus here is on a primary school in Adelaide which, quite unexpectedly, was asked if the staff would like to give a computer network a trial in the school to gauge the effect on children's development.

During 1982, Tandy's education division donated a network of 16 microcomputers, work station, and printer to the South Australian Education Department. It was a bold move by Sandery to ask Mitcham Primary School if it would like to use the network as a general school resource, and in particular to test the hypothesis that access to a word processor improves the quantity and quality of children's writing, for none of the staff had any prior computer expertise. According to Earle (1983:40), the successful implementation:

> . . . has been possible because of a school-based staff/curriculum development focus. We were deskilled but technology has been treated in context with staff, students and community learning together—and with system support.

That it has been successful so far is attested to by others (e.g. Hancock, 1983; Woods, 1983b).

Woods (1983b) has implemented the project, helping teachers observe students' writing behaviour when using microcomputers in a language arts program. Using video recorders, the team has been noting what happens as students make and revise their written drafts, observing particularly students' talk, how writing dovetails with reading and other skills, and what students feel about computers and about themselves as writers.

The early experiences of five of the teachers working in the project have been recorded (Woods, 1983b). Here teachers touch on such issues as the introduction of keyboard skills, the use of word processing with young children, the motivation effects of interacting with the computer, and the relationship of programming to editing and writing.

The use of the computer network has not been restricted to the primary school level only. Watts (1983) provides a comprehensive account of the experiences at Mitcham Junior Primary School with five- to seven-year-olds. This report details the support received from the Angle Park Computing Centre staff as well as from the staff of the primary school, the gains and changes noted in children, and the considerable gains also made by teachers. What makes this account particularly useful is the highlighting of issues emerging from the program: issues like availability of software, demands on equipment and time, problems of class management, the role of ancillary staff, and equality of access by girls and boys.

The two-year project is still ongoing and further results and conclusions must await further reports. Hancock (1983) notes how the computer experiences at Mitcham provide for a range of student abilities and learning needs, how students view written language as something real and worthwhile, and how using the computer has increased interaction in the classroom. Part of the success at Mitcham is that the staff of the school, and all those engaged in the project, have gone to the trouble of recording their experiences for others. It is a model that might usefully be extended.

Computer Based Learning in Clinic and Classroom

Can microcomputers provide a means of increasing learning in schools? Do microcomputers extend the ability of children to learn, as Papert asserts? These are among the pressing questions about microcomputers in schools. The whole schools computing movement, both in Australia and overseas, is predicated on the assumption that computers in the classroom are in some way beneficial to learning. Yet evidence with regard to microcomputers is sparse. This view is supported by Roblyer and King (1983:22):

> Until now, commonly held but largely unsubstantiated beliefs have been the driving force behind the educational movement. Unless we conduct some fundamental research now, we may soon be heading in unwanted directions.

Basic as well as classroom-based research into all aspects of the use of computers in schools, desirably of a sustained and systematic kind, is clearly needed.

Possibly the best counter-example anywhere, to the statements immediately above, is the ongoing research being conducted in a small laboratory at the Australian National University. The somewhat unlikely sounding department to be investigating children's learning with computers and the development of basic skills is the Department of Engineering Physics. Led by chief investigators, Lally and Macleod, the Information Sciences Laboratory in the ANU's Department of Engineering Physics has been researching computer-aided skill development for nearly a decade. More than 60 research publications have been produced by the small team of computer specialists, engineers, educators, and psychologists since 1975. The most recent work of the unit has been to extend the earlier findings of laboratory and clinic to the classroom, in a systematic exploration of microcomputers for developing handwriting, reading, and number skills (Lally and Macleod, 1983a).

Computers and Handwriting

The early work of the research unit focused on teaching handwriting skills. Working with mildly intellectually handicapped students at the Woden School in Canberra who could not sign their names, Macleod and Procter (1979) investigated the use of a DIGIVUE graphic display screen connected to a PDP-11/20 minicomputer. Students used a 'pen' to which were attached two fine strings. The movement of these strings tracked the horizontal and vertical positions of the pen as it pressed down on the display screen, leaving its trace in the form of movements (similar to the turtle's movements in LOGO). The study was essentially one of shaping students' fine motor control while teaching them to perceive differences between the shapes traced and their attempted reproductions. Conducted in a clinical situation, using small groups of students and determining in advance required levels of accuracy for acceptance, these computer-based handwriting studies broke new ground, both in the development of teaching equipment and of new instructional strategies.

Continued studies by the ANU researchers have had as their aim to extend the benefits of what was learnt in the clinic to the regular classroom. With the wider availability of microcomputers in schools, the focus of current research has been to transfer programs from mini to microcomputer and to continue handwriting trials with further groups of students. Lally and Macleod (1983b) report the successful implementation of computer programs on an Apple II Plus with 48K memory, single-disk drive, and graphics tablet. Figure 6.1 shows the kind of work being done with the equipment.

What are the advantages of computer-based handwriting exercises over traditional teaching methods? According to Lally and Macleod (1983b:8–9):

> Computer-based handwriting exercises enable students to be both accurate and active learners: accuracy of response is maintained even though students have to think about what they are doing and predict the sequence of strokes needed to complete letter shapes. This is achieved by using exercises with varying degrees of computer guidance (e.g. partial cues), and by informing students quickly of any incorrect movements (thus localizing the consequences of wrong choices and interrupting development of erroneous patterns). The procedure adopted emphasizes the *process* used in handwriting as well as the appearance of the *product*. Physical separation of

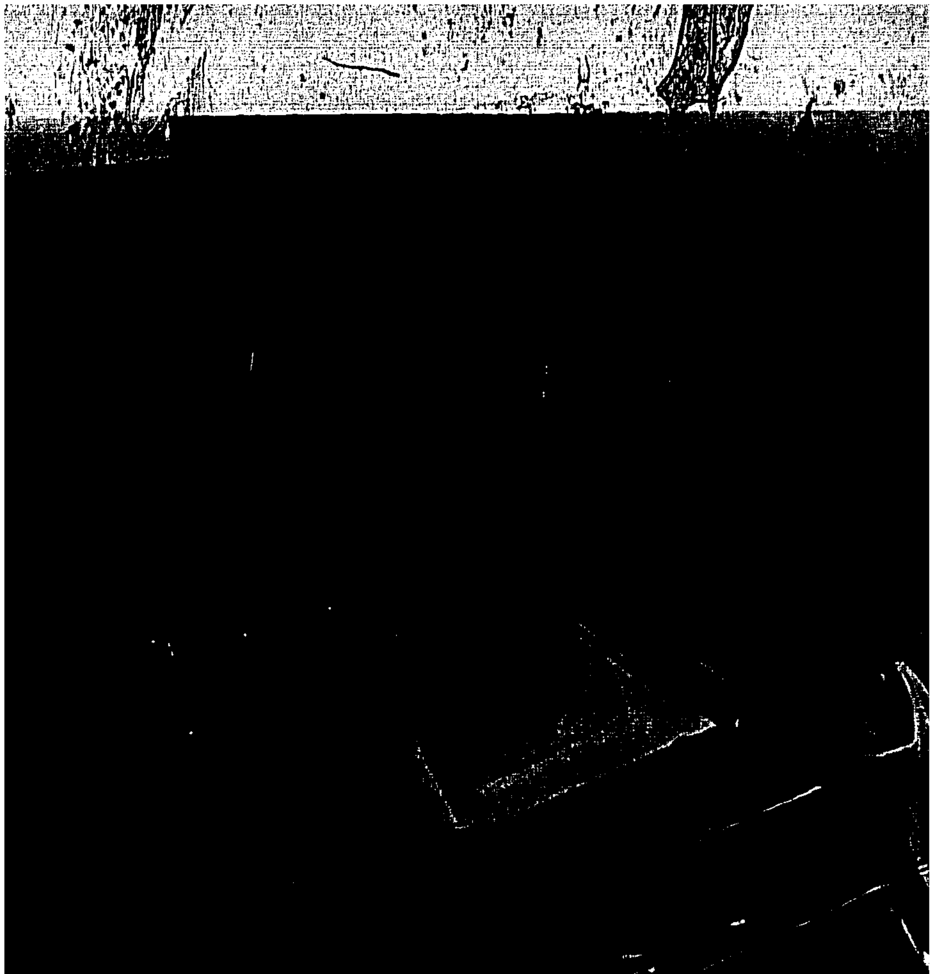

Figure 6.1 Microcomputer Handwriting Exercises Using Graphics Tablet

the pen and display helps to explicate relationships between visual and muscular feedback in a way that is not possible with traditional media.

Computers and Reading

In parallel to the handwriting trials, the ANU research team has been investigating the use of computers for teaching reading. Trials were conducted, again with mildly intellectually handicapped students at the Woden School, and also with students with specific learning difficulties at the City Educational Clinic in Canberra. Grocke (1983a) describes two experimental trials, one a sight word program designed to teach recognition of words on the Dolch Sight Word List, and the second to improve reading comprehension using a modified form of cloze procedure.

What makes these reading programs exciting is the use of a touch sensitive screen in conjunction with a speech synthesizer. Students, for instance, who are attempting to complete blanks in passages of text (cloze procedure program) may receive help by pointing to any word which is not known, and a moderately successful version of its pronunciation is immediately rendered (see Figure 6.2). The computer also provides feedback. A correct choice receives the spoken response 'Good work' and the word is typed in the gap; for an incorrect choice, the student is told to read the sentence again.

Evaluation studies (Grocke, 1983a, 1983b) showed that students referred to the Educational Clinic and receiving computer instruction made significantly greater gains on sight vocabulary and comprehension tests than did control groups. Where follow-up tests were administered, the training groups maintained the gains previously made.

The reading programs have gone through a similar transformation to the handwriting programs. Developed first on PDP 11 minicomputers, versions of the programs are now available on Apple microcomputers and are being field tested in several Canberra primary schools. Although the Apple versions are not as powerful as the programs first developed, the microcomputer has enabled the ANU research to be extended from the clinic into the classroom.

A School Computerized Administration System

A computer system to handle much of the routine administration necessary for the smooth running of a school has evolved at Brisbane Grammar School (BGS). Like most computer systems, the one at BGS developed gradually and will no doubt continue to change as needs arise. Described below are the chief features of the system, as it currently operates on a VAX 11/730 minicomputer installed at the school during 1983. A second minicomputer (PDP 11/04), which previously handled the administrative tasks of the school, is now used exclusively for student programming, to process mark-sense cards, and to serve a network of microcomputers. The school also has nine stand-alone Apple microcomputers.

The computer philosophy of the school is described by Solomon (1983) in a comprehensive account of the administration and accounting programs in use at BGS. Routine accounting within the school is catered for by a standard accounting package (Digital Integrated Business Systems) and is not described further here. It is the

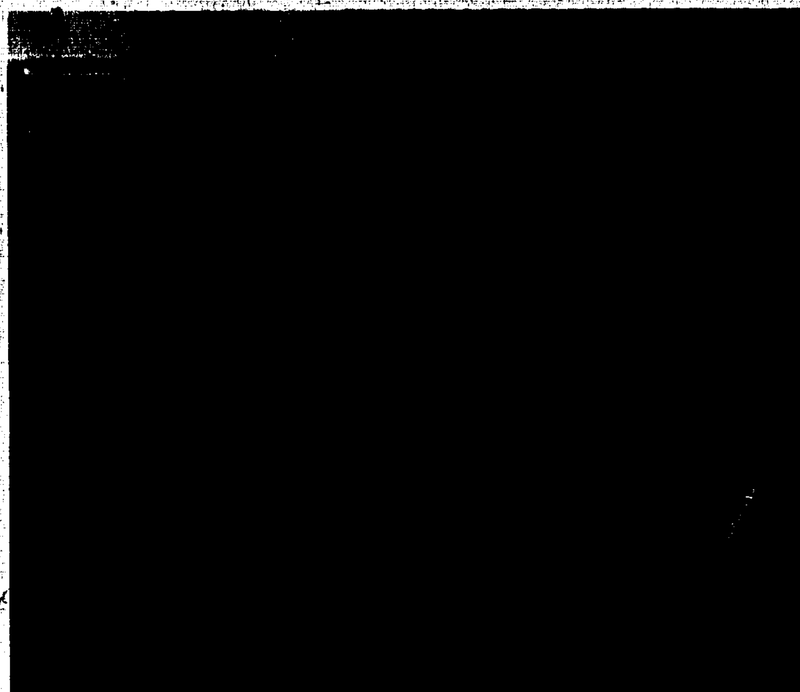

Figure 6.2 Microcomputer Reading Exercises Using Touch Sensitive Screen for Prompting (Photograph by courtesy of the Department of Engineering Physics, Australian National University)

administrative suite of programs, all developed at BGS, that may provide pointers to other ways that computers can be used as tools to lighten the administrative burden of teachers.

There are five main computer programs in the BGS system. The first is ADMIN which controls the student and teacher master files. This program generates name, address and phone lists, class lists, and sets of adhesive labels at any of several locations around the school (main office, computer centre, headmaster's office and subject masters' offices).

A second program, ENROL, maintains and accesses a database of all those who have put their names down to enter the school (up to the year 1996). Yet another program TIMTAB is used as an aid in constructing the school timetable and printing a variety of individual and teacher timetables.

A fourth program CUMAS is used to generate cumulative assessments for students. Allowing up to 40 test results per student, options are provided for weighting and standardization of student scores before aggregating them for different purposes. Teachers may select result lists to be printed, rank-ordered if desired, and with gradings included.

The program REPORT, described here in slightly more detail, helps in the preparation of school reports. Figure 6.3 shows the computer-produced comments made on one sixth former's report card (just the student's name has been changed). The second page of the student report is produced manually but the first page, as shown here, is generated by REPORT from a minimum of teacher input.

To use REPORT, subject masters have constructed, for each subject taken at the school, four banks of comments, each bank containing 25 comments (labelled A through to Y). The following is a selection of comments from the first bank for the subject, English (the ? standing in place of the student's name):

A. ? has a sound understanding of the language. He is able to understand, interpret and write satisfactorily.

J. ? has a good understanding of the set novels, but has found the drama and poetry difficult.

R. ?'s reading comprehension is poor because his vocabulary is limited.

The remaining three banks contain further comments about different aspects of the subject. Thus the fourth bank for English includes the following:

G. His oral work is well prepared and the presentation is entertaining, clear and sincere.

N. His shyness prevents the development of oral skills. He must become more involved in classroom discussion.

Y. His oral skills are limited; he does not speak clearly, tends to be too brief, and has insufficient prepared material.

The way REPORT works is, first, to print the subjects studied by each student together with teachers' names, these being drawn from the student and teacher files respectively. Teachers then select comments from the four banks—for example, BGHJ. If no comment in a bank fits the letter Z is used—for example, BGZJ and, if none of the standard comments are thought appropriate, a paragraph may be written for subsequent typing.

It is interesting to note that most of the administrative programs described above were written in BASIC, since staff found the VAX

BRISBANE GRAMMAR SCHOOL
First Assessment 1983

Name: NULL Alexander Graham (Alex) Form: 6L
Age: 16 years 8 months Date: 19 May 83

ENGLISH – MR R. BOYD

Alex has a very good understanding of the set texts. He shows original ideas in class discussion and in writing. An ability to understand ideas from varied sources and to draw sound conclusions has been demonstrated. His approach is enthusiastic at times but he does not maintain his efforts consistently.

EARTH SCIENCE – MR D.L. MORRISON

Alex shows considerable talent for the memory and recall of the definitions, laws and concepts in Earth Science. His enthusiasm for practical work is reflected in a very good result. He is an enthusiastic participant in class activities and works without close supervision.

MATHEMATICS I – MR D.J. O'NEILL

High achievement has been attained by Alex in Mathematics I. He is an industrious student who works with commendable care. His interest in his own advancement has assisted in gaining this good result.

MATHEMATICS II – MR D.J. O'NEILL

Alex has shown considerable ability in Mathematics II and has produced work of a high-standard. His attitude and his standard of work are commendable and he is making satisfactory progress at this stage.

CHEMISTRY – MR J.K. WATT

Alex is an attentive student, with good self-discipline. He attacks problems with confidence and determination. He has a reasonable knowledge of facts and laws but there is need to improve in this regard. He fully comprehends and is able to apply them to both familiar and new situations.

PHYSICS – MR F.J. MEEKING

Alex has learnt definitions, laws and formulae well. He has shown considerable ability in problem solving. He is an attentive student making sound progress.

In terms of meeting the achievement objectives of the programme of work for each subject, the student appears in the position indicated e.g. High Low

Figure 6.3 Computer Generated Report Form

version of BASIC 'such an amenable language'. Solomon (1983) concludes his description of the BGS computerized administration system with these comments:

The lesson to be learned is that the installation of a machine with an advanced operating system and versatile file handling may appear to be initially expensive, but in the medium-to-long term, lends to untold benefits in time saving and the degree of acceptance of the system and its user programs. (Solomon, 1983:9)

An indication that the system has been widely accepted by all staff is that further expansions and developments are being suggested.

A Statewide Computer Network

The Director of Computer Services from the University of Lancaster, who visited Australia towards the end of 1980, said of the three state departments most involved in schools computing (Tasmania, South Australia, and Western Australia) that 'Tasmania is easily the most technically advanced' (Beauchamp, 1982). The case study presented here is based on observations of the Tasmanian computer network (TASNET), referred to by Beauchamp, and the quite comprehensive account in Brownell, McShane, and Read (1983).

The geography of Tasmania has no doubt contributed in part to the development of TASNET though, as noted in another case study in this chapter, the interest in schools computing by education department personnel in Tasmania is a long one, dating back to the early seventies. Beauchamp (1982) noted that another contributing factor is the strong commitment to the belief that every child should have some exposure to computing in school and, further, that the most valuable exposure is in interactive computing.

The basis of TASNET is the location of PDP processors in the four major centres of population (Hobart, Launceston, Devonport, and Burnie), each of which is connected by a dedicated line to a central processor in Hobart, as illustrated in Figure 6.4. Each centre services the schools, colleges, and administrative offices in its region while at the same time having access to common shared databases at the central facility. Every high school in Tasmania and every further education college is equipped with terminals which provide an on-line facility to the central processor and thus ready connection to all other users on the network. Operating in tandem to TASNET is a large number of microcomputers, largely purchased by schools to complement the TASNET terminals.

Three examples of administrative support that TASNET offers to schools are described by Brownell, McShane, and Read (1983). The first is a centralized library cataloguing facility:

> TASCIS was developed as part of the Schools Commission project to improve the role of centralized library cataloguing by using a computer based

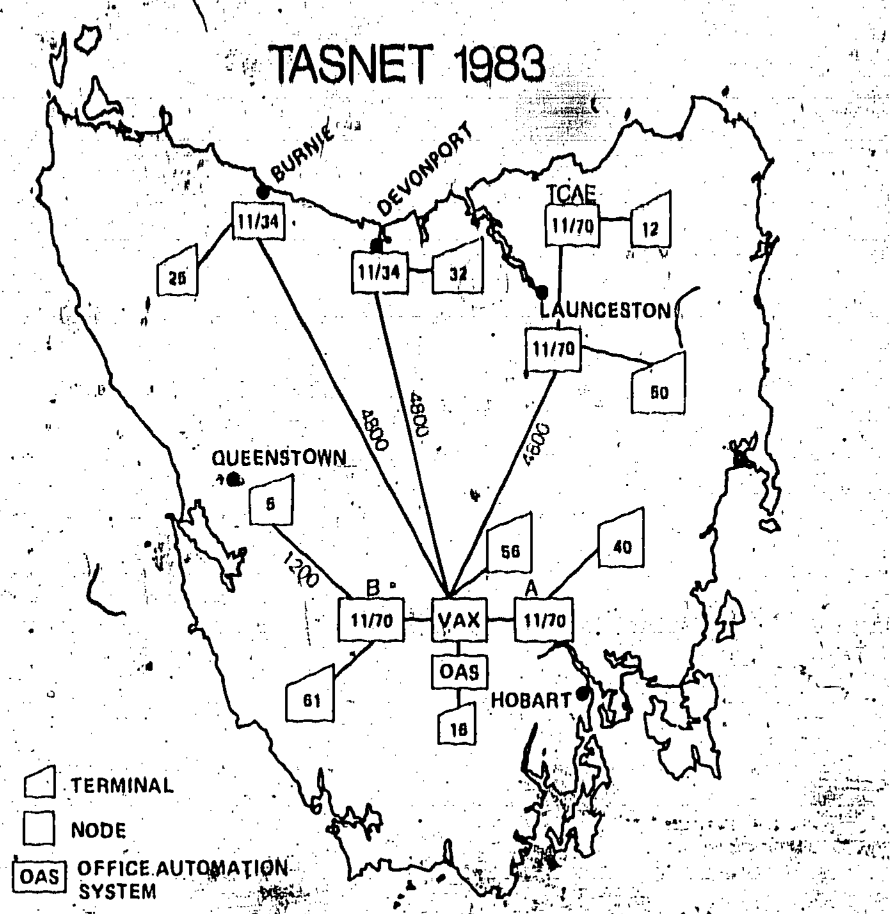

Figure 6.4 TASNET—A Statewide Educational Network

> system in Adelaide, Tasmania decided to take the South Australian data and to set up an on-line cataloguing data base. This system now has more than 100 000 items available for on-line searching by any school or college with a terminal. Schools can request catalogue cards to be printed at the School Library Branch on a high quality printer or can copy catalogue from the computer terminal. Currently 15 000 cards per week are being printed on the central printer. (Brownell, McShane and Read, 1983:5)

The second example is a support system called MEDIA which controls the movement of all audiovisual materials (films, tapes, slides) loaned to teachers by the Education Department's Media Centre:

> The system was expanded in 1977 to allow any schools with a terminal to interrogate the system in a variety of ways. For example, a school may wish to run a course on computer awareness for Years 9 and 10 students. The

teacher can ask the MEDIA system for a list of films suitable for this level and on the subject of computing. After identifying useful films, the system will print out details of their availability. The effect of this system is to provide all schools with the same access to information no matter how remote they may be. (Brownell, McShane, and Read, 1983:6)

Yet another example of support for teachers through TASNET is a system called ISIS which allows teachers to gauge the performance of their students relative to students elsewhere in the State. This system is cleverly updated each time it is used, providing always the most current norms available. This is how the operation of ISIS is described:

> ISIS system is a computer-based aid to moderation. Teachers are able to select a test from a large item bank in their subject area and give this to their students. The computer then marks and analyses the test and compares the students' results with the state average for these questions. The teacher is then given a report showing the raw and normalized results for each student. This means that the school is informed about the way its students are performing relative to the rest of the State.
>
> The question profile is also updated as a result of each test so that the state averages always reflect the current student population. (Brownell, McShane, and Read, 1983:6)

Educational Application of Videotex

Only limited trials of the educational applications of videotex have been conducted, and leading in this field has been the work of the Technology Centre of the Education Department of South Australia. Dunnett (1983) describes how Prestel in the United Kingdom was accessed first in 1981 as part of a trial in distance education methodologies. Further trials followed to test the feasibility of a videotex-type system for use in government departments. More recently, a larger-scale experimental trial of videotex in schools was completed which pointed to the potential of videotex in education, a potential that could soon become a reality now that the Federal Government has made a commitment to develop a nation-wide videotex service.

As part of the South Australian experimental trial of videotex, a number of schools and regional offices were supplied with Prestel-type decoders which, when connected to television sets, enabled selected information to be received and transmitted over the telephone network. The major trial involved the ordering of equipment by schools from state supply. Teachers and bursars in the selected centres were able to dial up the database in which was stored the state supply equipment catalogue and order supplies. The dialling was done by pressing keys on the numeric keypad; once connected, users could branch to desired sections of the catalogue and place orders for equipment directly. If such a system were to become fully operational, schools would be able to know

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V A C A N C I E S

APPOINTMENT TO NEWLY ESTABLISHED/DEVELOPING HIGH SCHOOLS 1984

In accordance with established procedures, applications are invited for transfer to Reynella East and Aberfoyle Park High Schools. Applicants should note that the filling of these positions is by transfer but outside the normal process. Applications for these positions should be on separate ED112 forms (using 1982 forms) marked either REYNELLA EAST HIGH SCHOOL ONLY or ABERFOYLE PARK HIGH SCHOOL ONLY in box 18 on the form. An attached "curriculum vitae" would be appreciated. These forms must be forwarded

Key *50001# for index # to continue

Figure 6.5 Page of *Education Gazette* Received on TV Screens in Videotex Trial

immediately how much the ordered goods would cost, their availability and delivery schedule. Further, as orders were placed, so the inventory would be immediately updated.

As part of the trial, teachers could also access the *Education Gazette*, a regular bulletin distributed by the Education Department to all schools: that is, teachers in the trial schools were able to read the *Education Gazette* on their TV screens, rather than in the usual published form. One of the sample pages is reproduced in Figure 6.5.

A number of problems were experienced in the trial of videotex (see, for example, Anderson and Ehvart, 1983). Some teachers were less confident about using the system than others; there were some difficulties in making connection, because of busy lines; and when the telephone was connected to the school's television, it precluded the use of either for other purposes. Despite these problems, the system demonstrated how information could be transferred to schools as it became available. In the case of the *Education Gazette*, for example, the production—typesetting, printing, distribution—is time-consuming and costly. The trial showed that it is now technically feasible with the linking of TV, telephone, and computer to replace the current fortnightly publication of this journal. The implications of a national videotex service are enormous but most educational applications are yet to be explored.

7 : EMERGING ISSUES

This concluding chapter looks briefly at some of the emerging issues in computer education for Australian schools. In a field that is changing rapidly, it is not possible to see much further ahead than two or three years, the period of time currently considered a generation in microprocessor technology. A second caveat is that, with the uneven development in schools computing across Australia, what is thought of as an issue in some parts of the country may not yet be an issue elsewhere, or may have ceased to be an issue.

Objectives

The release of the Report of the National Advisory Committee on Computers in Schools to the Commonwealth Schools Commission (1983b), together with the establishment of a national structure to oversee the allocation of federal funds, will result in increased debate about national and state objectives for computer education. This debate will form part of the wider discussion of the role and impact of technology on Australian society.

Contributing to the debate at the national level are continuing discussions about objectives for schools computing at the system and state levels such as, for instance, the priority of computer awareness within computer education. Co-operation between States in making software available on advantageous terms to contributing members and in framing of policies for computers in schools may extend further to include regions within States, and to embrace non-government and government schools.

As schools acquire computer systems, as stand-alones or networks, there is increasing debate within school communities about the deployment of these sytems. For secondary schools, what is emerging as an issue is that part of the regular intake of students has participated in computer awareness courses at primary school while other students, except for experience acquired informally, are entering secondary school with little or no knowledge of computers. An urgent issue at all levels is the lack of any planned or co-ordinated activities at present, with the result that transferring students, or even students progressing within the same school, are not receiving a coherent introduction to computers and computer concepts. This, of course, is a problem of school-based curriculum generally and is not specific to computer education.

Needs and Priorities

A continuing issue is the adequate preparation of teachers already in schools to use computers with confidence in their regular teaching. This need is unlikely to diminish in the near future since many teachers, after an initial introduction to the new technology, wish to further their knowledge about computers and their use.

An associated issue is the preservice education of teachers. The United Kingdom experience is that while nationally funded schemes make some impact as far as increasing awareness of teachers in schools is concerned, preservice education is harder to change and lags behind. The importance of this factor depends on whether teacher employment is in an expanding or declining phase.

Administrators, as well as secretarial staff and aides in schools, need consideration in the planning of computer development training courses. At the Cupertino Union School District in the United States and in certain Australian States, different courses have been provided for those groups since experience suggests that school principals, for instance, are noticeably less reticent and tentative about the new technology in a group with other principals than in a wider group.

The special needs of girls is yet another issue with regard to computers in schools. Do boys tend to monopolize computers? Are there more opportunities for boys to use computers because of frequency of use in certain subjects? And, what is the role and participation of women in computer-related positions, both within the education system and outside? These are important questions with implications for policy and for curriculum. The non-involvement of women in computing is one of the major problems identified in the report of the South Australia Tertiary Education Authority (1983).

Another aspect of the equity issue is the extent to which the provision of computing facilities depends on type of school, affluence of school community, or regional location. Problems of distance and isolation in most States mean, as Hoffman (1982) points out, that to take equality of access seriously is a major consideration.

What is likely to continue as an issue is an attempt to specify minimum standards for computer equipment, and perhaps even to aim for a common operating system to allow more ready interchange of software. Developments in this area could become even more complex than at present, since some of the computer manufacturers that may in the future dominate the personal computer market are yet to enter the field; as well, the current market place is witnessing a severe shake-out with the result that some currently popular microcomputers may cease manufacture. The appearance of more 16-bit microcomputers and the move towards more portable (battery-powered) systems, coupled with further advances in technology, seem likely, at least in the short term, to complicate the attempt to produce a common set of specifications for computer systems across States or regions.

Rapid changes in technology also pose problems for software developers. Improved disk operating systems, for instance, limit the life of software developed for earlier versions of such systems. Choppin (1984) predicts that other developments, such as software with audio input or access to videodiscs, will severely reduce the demand for current software.

Ergonomic considerations will loom as issues too. Questions of furniture design (e.g. height of desks, type of chairs) and eye strain resulting from prolonged use or caused by monitors with flickering images, are beginning to be raised. Lighting, too, will assume greater importance, giving rise to questions about source of light, screen reflections, and glare.

Schools are coming under increasing pressure from vendors of computer equipment, from the media, from parents, and from enthusiastic staff. Sometimes schools commit themselves to heavy expenditure on microcomputers without determining how these are to be used. Parents are also selecting and rejecting schools because of schools' computer offerings or non-offerings. An issue that has not been widely recognized with respect to computer hardware is the extent to which schools might ascertain the kinds of computer experiences available in students' homes with a view to complementing these.

Other pressures faced by schools result from competition for funds. The purchase of computer equipment is a major expenditure and one for which a continuing budget is necessary. In the typical business situation, for instance, an approximate rule of thumb is that the cost of software is 80 per cent to 20 per cent for hardware. Yet some schools, in striving to purchase hardware, are failing to budget for software at all. In this sense, computers are competing for funds at the expense of other equipment, at the expense of software which limits the use of computers, and often at the expense of library purchases.

With limited resources and funds, a contentious issue is to determine priorities in placing microcomputers in schools. This issue has already surfaced at the national level. The Commonwealth Schools Commission in its recommendations for 1984 urged the Commonwealth Government to develop a national computer education program for all schools. However, in issuing its guidelines to the Commission, the Government allocated funds initially for secondary schools only. Some would argue that, if resources are limited, the initial emphasis should focus on those about to enter the workforce. Others counter that it is sensible to include primary schools at the outset in the development of a total, coherent program for all schools. And others argue for an intermediate position of supporting senior school activities and, at the same time, progressively advancing a program from the earliest school years upwards. The same kind of debate occurring at the national level is being heard at the system and state levels and in many school councils across the country.

Within schools, an emerging issue is the degree of support for administrative applications as compared with instructional uses of computers. Much school administration—accounting, record-keeping, scheduling—is similar to any business, and like any business is aided by computerization (Sale, 1982).

One of the major needs of teachers, along with inservice and preservice education, [illegible] information about computer hardware and, more especially, [illegible] computer software. This issue was voiced by Shears and Dale [illegible] in their call for a national clearinghouse for information about computers 'to facilitate the interchange of hardware and software information between States and the co-operative development of appropriate high quality software' (Shears and Dale, 1983:78). Unfortunately, centralized agencies, particularly if located in Canberra, are often looked at with suspicion by the States. An alternative model might be a series of regional clearinghouses. Following the British Microelectronics Education Programme lead, these might even cut across state boundaries, and have just a small centralized co-ordinating function.

An important role of any clearinghouse for information about computers and their use is a disseminating one and there are many forms this might take. Information or Fact Sheets, such as are made available by the Council for Educational Technology in the United Kingdom, would be useful. So, too, would a publication like *The Digest for Software Reviews: Education*, a new kind of journal which made its first appearance in 1983. In loose-leaf format, such a publication, containing reviews of software readily available in Australia, could help meet a need felt by teachers in all subject areas and levels.

Usage and Approach

The use of computers in schools and classrooms is an area bristling with issues, most of which to date have received scant attention. For example, what are the educational implications of using computers in the regular classroom, perhaps drawn from a central resource, as against a centralized school facility for which class groups are scheduled? Does the type of organization adopted determine how computers are used, say, as tutor, tool, or tutee? This kind of question may be one of the major issues to emerge in the use of computers in schools.

Not unrelated to this issue is the whole question of networking. Current practice in many schools is to group a number of networked machines in a single room. This is not the only arrangement but it is the most common. The advantages advanced are that it facilitates management, it aids security, and it results in economies from the shared use of peripherals like disk drives and printers. Whether there are educational benefits besides these administrative and economic advantages is a question to be debated.

There are other problems associated with networks relating to licensing fees, royalties for programmers, and the participation of publishers in educational software production (Anderson, 1983b). It is reported that a major problem for many network users is 'getting software to run at all' (Watt, 1983:74). Much software—for example, that produced for the BBC microcomputer in England where the predominant usage is as a stand-alone—is found not to work on networks in Australia.

While some of these problems may be short-term in that advances in technology will produce solutions, the location of microcomputers within a school and the decision to purchase, say, a network system in preference to a series of stand-alones are important issues impinging upon the way teachers use computers and their approach to them.

The whole question of copyright of computer programs is a highly contentious issue. The Federal Court decision (December 1983) that computer programs cannot be protected by copyright and the appeal against this decision (February 1984) seem certain to lead to demands for change in the copyright law.

Yet another issue in the immediate future is the high student-to-computer ratio. Even in the best equipped schools, computers are a scarce resource and a difficult task for teachers is the management of this resource. Different organizational arrangements discussed by Vogler (1983) include the teacher using the computer for demonstration, students working at the computer in groups, and individual use. For the administrator, there are major organizational problems faced with scheduling a limited number of microcomputers, often just one, throughout a school (Scott, 1983b). What are the pedagogical implications of these various administrative constraints?

Further issues relate to the way computers are used at different school levels. Is there a difference, for instance, in usage between primary and secondary schools, or between lower secondary and pre-tertiary levels? Are computers used differently in the different content areas? And does the type of organization, noted above, affect usage at different levels or in different subjects? Associated issues are how to implement the use of computers in schools and classrooms.

A major need also is to re-examine teaching strategies to take account of the impact that microcomputers are having in schools. Publishers sometimes promote the use of computers to do the same kinds of things as were done before, frequently in thinly disguised versions of the same way as previously, and often with no clear advantages.

Some schools are experimenting, not in any controlled way, with the use of different kinds of software, such as word processing, database packages, and programming languages. Whether some of these applications are more useful at certain levels or in some subject fields and whether certain applications are more appropriate as an introduction to computers are questions likely to emerge as schools acquire more software and as different kinds of software are produced for educational use.

Outcomes

Of all the important questions and issues about computers in schools, perhaps the most important would be expected to relate to outcomes. As Roblyer and King (1983:2) remark:

> It would be a shame if [computer] use were predicated on the basis of 'The kids love it and we can tell just by watching them that they are really learning'.

The overriding impression, however, of schools computing in Australia, and elsewhere, is that much current practice rests more upon faith than upon a firm research foundation. This observation would, of course, apply not only to computer education.

It seems reasonable to surmise that, in the immediate future, an emerging issue must relate to the effectiveness of computers in schools. As for some of the issues noted above, such a broad question is most usefully subdivided into a number of more manageable questions.

Effectiveness might first be approximately equated with cognitive outcomes—that is, with growth in students' knowledge and learning. Then a framework, like that put forward by Taylor (1980) and discussed in Chapter 5, could be used to examine the effectiveness of the computer in the various modes of tutor, tool, or tutee. There are other related issues. For instance, as Ballard (1983:13) highlighted recently:

> Computers in schools are already unintentionally being used in a way that reinforces social divisions. In middle-class areas, computers tend to be used to develop problem-solving skills (the child programming the machine); while in lower-class areas, they are being used for drill and practice activities (the machine programming the child).

Although reference was being made primarily to observations in the United States, the fact that it was raised within a local context suggests the question as an emerging issue here.

Other issues relate to affective outcomes resulting from the use of computers in schools. For some, an important question is students' attitudes to learning with computers. Again, such a question becomes more defined by considering the various modes of computer use—for example, as tutor, tool, or tutee. Indeed, it is more than likely that students' attitudes will vary according to the ways in which computers are employed in schools. Mention has been made of the use of computers by boys and girls, and so another issue concerns the attitudes of boys and girls to learning about, with, or from computers in schools. Already suggestions are being made that some computer activities, especially games, are more designed to appeal to boys' interests, and this is likely to remain a continuing issue.

The attitude of teachers to the computer as tutor/tool/tutee is yet another issue. It was noted in Chapter 5 that many English and language teachers are becomming attracted to the use of the computer as a tool, especially for word processing, and that computers are being used in conjunction with a process approach to students' written language. As is obvious, none of the emerging issues discussed in this chapter rests in isolation from other issues. Thus the attitude of teachers to computers is enmeshed with how they are used, which in turn relates to cognitive and affective outcomes of students, and so on. Many interrelated issues are often entangled within any single issue.

Evaluation

To conclude this brief overview of what appear to be some of the emerging issues in schools computing, this review closes on what is a recurring theme—computer software.

While evaluation encompasses many of the issues already noted, an important question concerns the very nature of evaluation criteria. What criteria, for instance, are to be used to evaluate software or courseware? There is a tendency for some to place major emphasis on the technical aspects of software; others regard computer software as not essentially different from any other instructional product; and, of course, there are many intermediate positions. Whatever users' positions, the criteria to adopt when evaluating software are likely to remain continuing questions, and ones which are not independent of issues relating to approach and usage of computers.

Related to evaluation criteria is the issue of field testing of software. While field testing is usually conducted during software development, it is essential also in the full evaluation of newly developed software. Teachers are well placed to participate in this cycle of developing learning materials. Indeed they must be involved, for teachers are the crucial agents of change in schools computing.

NOTES

The Australian suppliers of software, courseware, and other computer-related materials described in the review are listed in order of appearance in the text.

1 British Broadcasting Corporation. 'The Computer Programme' (10-part television series); 'Making the Most of the Micro': Available on VHS and Beta formats through BBC Enterprises, Westfield Towers, 100 William Street, Sydney, New South Wales 2000.
2 British Broadcasting Corporation. Microcomputer: Distributed by Barson Computers, 335 Johnston Street, Abbotsford, Victoria 3067.
3 British Broadcasting Corporation. Books and software: Available through Pitman House, 150 Bouverie Street, Carlton, Victoria 3053.
4 Minnesota Educational Computing Consortium. Courseware: Available through Computer Edge, PO Box 44, Albert Park, Victoria 3206.
5 Five Ways. Software: Available from Heinemann Publishers, PO Box 133, Richmond, Victoria 3121.
6 Angle Park Computing Centre (APCC). Software for both the Apple and BBC microcomputers: Enquiries to be directed to the Angle Park Computing Centre, Trafford Street, Angle Park, South Australia 5010.
7 Macquarie University. Student Assessment Project: Further information from Professor N. Baumgart, School of Education, Macquarie University, North Ryde, New South Wales 2113.
8 *Archeological Search*: Available for Apple and TRS-80 microcomputers from McGraw Hill, PO Box 239, East Roseville, New South Wales 2069.
9 *Gold Dust Island*: Available from Jacaranda Wiley, 65 Park Road, Milton, Queensland 4064.
10 Victoria. Education Department. Reality in Maths Education Project: Materials available through Victorian Government Bookshop, 41 St Andrews Place, East Melbourne 3002; enquiries about the Project to be directed to Mr I. Lowe, Education Department of Victoria, 234 Queensberry Street, Carlton, Victoria 3053.
11 Elizabeth Computer Centre. *The First Fleet Database: Convicts and Computers; Birds of Antarctica*: Enquiries to be directed to Elizabeth Computer Centre, Cnr Warwick and Murray Streets, Hobart, Tasmania 7000.
12 South Australia. Education Department. Computer awareness teacher support material produced by Angle Park Computing Centre: Enquiries about availability to be directed to Education Department of South Australia, 31 Flinders Street, Adelaide, South Australia 5000.

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