Computers and the Future of Education

Barry W. Smith
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Occasional Papers in Continuing Education, No. 15

...G EDUCATION, AUSTRALIAN NATIONAL UNIVERSITY

COMPUTERS

AND

THE FUTURE OF EDUCATION

BARRY W. SMITH

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An edited version of Volumes 1 and 5 of the report of the Research Project, "Computer Education Needs and Resources at Tertiary Level", undertaken for the Commission on Advanced Education.

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GENERAL PREFACE

TO THE ORIGINAL REPORT

This report is the outcome of more than eighteen months work. It addresses questions of basic importance to all those concerned with computing in Australia, or with educational planning, or with broad questions about the likely shape of the future.

Our brief was primarily to examine the needs of the community over the next decade for staff of various kinds in the data processing field, the expected output of appropriately trained people from Australian universities and colleges, and hence the changes required in the level and use of resources that should be devoted to computing education in the colleges of advanced education.

However, before we could hope to answer these questions, we found it necessary to ask many other difficult questions. These concerned fundamental issues about the place of computing in the community, about the aims of higher education and likely changes in educational systems and practice, about the effects of dramatic social changes on attempts at forecasting, and about what in computing is most important to teach, and why.

We also had to gather data, both quantitative and qualitative, about subjects on which little was previously known: the nature and extent of the use of computing in Australia, organisations' plans for computer use, and the attitudes and expectations of employers with respect to education, training and recruitment in the data processing field.

Thus our results should be of interest to many, and of value to a much broader group than those who must recommend on immediate funding questions and related policy issues in computing education.

The rather eclectic nature of our work leads to problems in the preparation of a report, especially as it is likely to be read by many with diverse interests. It was essential to touch on many subjects relevant to our brief. These are broader than the key questions of immediate interest to the Commission on Advanced Education which sponsored the study. We therefore felt we should present as much as possible of the results of our work to all those interested. Hence we needed to report in a single document on a number of different, although linked, themes.

Though it has been physically impossible for us to include all the results of the project in detail, the outcome was a work of daunting size. While some readers will be interested in all of it, others clearly will wish to read only specific sections. We are very conscious that we have written many thousands of words, despite our efforts not to waste words.

We therefore decided that the most effective way in which to present the report was in a series of six complementary volumes. Each volume is designed to be coherent in itself and to be of interest to a particular group of readers.

Barry Smith
Canberra

Barry de Ferranti
Sydney

ACKNOWLEDGMENTS

The authors acknowledge the generous and enthusiastic involvement and significant contributions of some hundreds of people from many different organisations and sectors of the community.

It is impossible to enumerate all who helped, but some have made particularly substantial contributions:

Mr Keith Heydon, Deputy Chairman of the ACAE Computer Committee, was primarily responsible for the project's conception; as our liaison with the Commission he has been a sympathetic and constructive critic.

Mrs Meg Alexander (nee Baldwin) and Mr Daryl Douglas share credit for the success of the search conference in November 1973; their personal and intellectual contribution to the project was invaluable. (They also wrote earlier drafts of some of the material on which Volume 3 of the full report was based.)

Sir William Pettingell, who chaired the conference, and all the participants, gave time and effort in a strenuous but rewarding exercise; we also thank their organisations, including the Australian Computer Society and Australian Computer Users' Association.

Officers of the Australian Bureau of Statistics helped, especially in the survey of the private sector, which could not have been undertaken without their resources; we particularly thank Mr Ken Foreman, First Assistant Statistician, Mr T.R. Jones, Assistant Statistician, and Messrs Bill Pattinson and John Palmer.

The Department of Labour and Immigration [now the Department of Employment and Industrial Relations] prepared and supplied many tables from its Survey of Employment in EDP, and permitted us to publish their results.

Many organisations -- government bodies, universities, colleges, employers and vendors -- helped in interviews and as respondents to our own surveys.

IBM Australia Ltd: Dr Geoff Ford, Director of IBM's System Development Institute, has helped personally through involvement in the search conference, through the support of his staff, and through making available the Script facilities of CMS under the CP67 and VM/370 Monitors. These have been most valuable in the drafting, updating and printing of our report.

Some individuals made an outstanding personal contribution to the project through their intellectual involvement and continuing advice and comment; in particular we wish to thank Miss Lenore Cox, Mr Neville Holmes and Professor Alex Wearing.

Many major overseas contributions to the project, both by correspondence and by discussion with Barry Smith during July and August 1974, are acknowledged in Volume 6 of the full report. Others who have been most helpful to us at specific times or in specific aspects of the work, but too numerous to mention here, are also shown, or are referred to in the text.

Several people have helped by reading and commenting on earlier drafts of some or all of the report.

Our secretaries, research assistants, wives and families have been extremely supportive in many ways over a long period when the project has made heavy demands on us and them; we are grateful also for the many ideas they have contributed.

Finally, we thank Mr T.B. Swanson, formerly Chairman; Dr Ellice Swinbourne, formerly Deputy Chairman and now Chairman; and others of the staff of the Commission on Advanced Education, for the opportunity to undertake the project, and for much help and support.

PREFACE TO THIS EDITION

The full report of the research project was completed during 1975 and given to the Commission on Advanced Education in six volumes. These dealt respectively with:

1 Summary of Conclusions and Recommendations for Action
2 Computing Use in Australia and the Demand for Computing Education
3 The Search Conference
4 Computer Technology in Australia
5 Broad Perspectives to Planning for Computing Education
6 Background Material, including the background to the project, estimates of the supply of trained manpower, and various issues and policy questions related to the research project

It was originally thought that the Commission would be able to ensure publication of the report, in which widespread interest was shown by many people, both locally and overseas. Unfortunately, because of restrictions on government expenditure, this did not prove possible.

We are therefore particularly grateful that the Centre for Continuing Education of the Australian National University has offered to publish some of the material of particular interest to the educational community. Part 1 of this publication comprises the overall summary (Volume 1) of the original report, and Part 2 contains the material originally in Volume 5.

It is hoped that it may prove possible also to publish at least the extensive statistical material (in Volume 2) which reports the most detailed study yet undertaken of the present use of computers and the plans and expectations for future use of computing by Australian organisations. Those who wish to refer to the full report are advised that one copy has been placed in the National Library of Australia, and a few others are held by some Australian educational bodies.

In editing the material for publication in this form, I have avoided the temptation to revise it extensively or bring it up to date. It has been necessary to change or remove many cross-references within the original report to make this self-contained, and some brief notes have been added in the text of Part 2 where events in the last twelve months have clearly overtaken what was written. These are mostly included between square brackets. However, the wording of Part 1 has not been revised in any significant way, especially as this constitutes what was actually reported to the Commission, and our recommendations for action.

A brief postscript has been added, which discusses the implications of the report in the light of the events of the last twelve or eighteen months.

Barry Smith

Canberra

October 1976

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ABBREVIATIONS USED

ABS	Australian Bureau of Statistics
ACAE	(Australian) Commission on Advanced Education
ACM	Association for Computing Machinery (U.S.)
ACS	Australian Computer Society
A.C.T.	Australian Capital Territory
ADP	Automatic Data Processing (used synonymously with EDP)
APO	Australian Post Office (now the Australian Telecommunications Commission - Telecom Australia, following the creation of two distinct statutory bodies for postal and telecommunications services)
ASTEC	(Interim) Australian Science and Technology Council
AUC	Universities Commission (formerly, Australian Universities Commission)
AUS	Australian Union of Students
BCS	British Computer Society
CAE	College of Advanced Education
CAI	Computer-Assisted Instruction
CATV	Community Access Television
CCTV	Closed Circuit Television
CSIRO	Commonwealth Scientific and Industrial Research Organization
EDP	Electronic Data Processing (see also ADP)
ESCAP	Economic and Social Council for Asia and the Pacific (formerly ECAFE)
GNP	Gross National Product
HERDSA	Higher Education Research & Development Society of Australasia
IAC	Industries Assistance Commission
ICL	International Computers Limited
IFIP	International Federation for Information Processing
JIPDEC	Japanese Information Processing Development Center
M.I.T.	Massachusetts Institute of Technology
NCC	The National Computing Centre Ltd (U.K.)
N.S.W.I.T.	New South Wales Institute of Technology
O.E.C.D.	Organisation for Economic Co-operation and Development
R.M.I.T.	Royal Melbourne Institute of Technology
S.A.	South Australia
S.A.I.T.	South Australian Institute of Technology
STI	Scientific and Technical Information
TAB	Totalizator Agency Board
TAFE	Technical and Further Education

TPBS	Target-setting, Policy model Building and Scheduling system (Japan)
VIC	Victoria Institute of Colleges
W.A.	Western Australia

PART 1

SUMMARY OF

FINDINGS

CHAPTER 1

CONCLUSIONS

Overall Framework

THE NEED FOR A BROAD SETTING

In any educational planning, other than purely short term, and especially in planning for the needs of a rapidly changing technology such as computing, it is essential to consider the effects of many social, economic, educational and technological influences. (See Part 2.)

In particular:

Fundamental social changes have already taken place and are still taking place, probably at an increasing rate. These changes significantly affect the workplace and attitudes to work, and themselves largely result from the development of technology, particularly computing technology.

The aims of education, especially higher education, are increasingly being questioned, both here and overseas. Established priorities, policies and structures are also under attack.

The use of digital computers is not only increasing rapidly, but is becoming an essential component of many disciplines.

Computing as a discipline or a science, and as a profession, is still very young and brash. There is little agreement on what the study of computing is about, nor even whether there is a discipline, or a profession, of computing.

The technology of computing is evolving very rapidly, and there is no indication that its growth will slacken.

- Rapport and understanding between the relevant sectors of the community is far from perfect - in particular, employers, educators and suppliers of computing equipment and services are not agreed on what education in computing is needed.

- Australia, because of her distinctive geography, politics and economy, and her emerging regional role, may have differing needs for computing manpower from other advanced countries.

Further, these factors cannot be considered in isolation. We must adopt a systems view, and try to understand the interaction of these factors. Before attempting to forecast, plan or formulate policy, we should try to identify the interdependent processes that will change society and shape the future. Nowhere is this more important than in the field of education, in which policy issues are intrinsically long term.

THUS A BROAD VIEW IS ESSENTIAL. A NARROW INTERPRETATION OF OUR TERMS OF REFERENCE WOULD BE INAPPROPRIATE.

IN THE NEXT CHAPTER, CONTAINING OUR RECOMMENDATIONS, WE CANNOT PROPERLY ADVISE ON COMPUTING EDUCATION WITHOUT ADVISING ON EDUCATION AT LARGE, NOR CAN WE PROPERLY MAKE RECOMMENDATIONS ABOUT EDUCATION AT LARGE WITHOUT EXAMINING, AT LEAST BRIEFLY, EDUCATION IN ITS SOCIAL CONTEXT.

SOCIAL CHANGE - IMPLICATIONS FOR COMPUTING EDUCATION

There is much evidence that we are experiencing fundamental social change, and that it is accelerating and in some ways irreversible. The most immediate direct consequence of this, already evident, is extreme value conflict: we cannot ignore this is in any long term view of education.

Integral to the process of social change is a shift in attitudes to work, education and leisure. The distinction between these is breaking down, and fewer and fewer people can now (or wish to) follow a single career path.

At the same time, changes in organisations, towards more participative, less hierarchical and more fluid forms, are influencing the way in which work is being carried out, and in particular are emphasising generalist rather than specialist skills.

The growing complexity of organisational life is leading to an increasingly important role for the information manager, in many guises, who manipulates data (increasingly held on computers), often with sophisticated quantitative techniques (usually requiring use of computers), to produce the information needed to cope with the demands of the highly interdependent modern world.

The effect on computing of managerial attitudes is also an important, but largely unknown, factor.

These considerations, together, imply:

* increasing job mobility
* general, and growing, future uncertainty
* dynamically changing occupational roles
* more and more questioning of accepted values, including those relating to work and education
* the naivety of any simple manpower forecasting
* a need for more adaptive, responsive and anticipatory planning
* the crucial importance of recurrent education.

Whilst all of these conclusions apply to the whole field of educational planning, they are especially critical in the particular area of planning for computing education. This, more than almost any other, is an area of very rapid change, with a strong likelihood of major shifts of overall societal impact, and hence with a future which cannot be confidently predicted in other than broadly qualitative terms.

INTERNATIONAL FACTORS

Australia's geographic and political location is likely to lead to a distinctive pattern of computing requirements. Despite notable early contributions to computer development, we now import most of our computing equipment, and of our computer technology.

There are, however, stirrings towards greater self-sufficiency and a local computer industry. As we lack the market and capital for development of competitive, complete large scale computer systems, any substantial local industry is likely to be based on peripheral equipment, small systems, software (especially applications software) or support. The rate and form of any such development will depend vitally on government policies to promote it (should this be desired), and the educational requirements would be considerable.

A greater regional role for Australia in the development of computing in the Pacific seems probable in the relatively near future. But this role will again be influenced powerfully by policy measures to establish it. The most obvious focus for a leadership role with our near neighbours is in computing education and software - especially in developing applications software that effectively fulfils the needs of smaller users on systems of modest power.

Within the next decade or so, much closer links between Australia and Japan in computing appear likely. Japan has a large and dynamic computer industry, is now marketing to the Western world, and naturally regards the Asian region as offering growth potential. Scope exists for joint projects and co-operative ventures, but only if Australia seizes the initiative early enough.

All these factors will influence both the pattern of computer use and the profile of educational needs in Australia.

COMPUTER TECHNOLOGY

Electronic computing is barely thirty years old, and the use of computers in administrative and commercial data processing in Australia is only twenty years old. Those who graduate now will be using computers for another 40 years. In this time the computer industry and the "information industry" will undoubtedly become the largest single industry group in the Western world. Computing will pervade almost all aspects of life and work in Australia.

Whilst the overall direction and nature of technological development can be foreseen, the likelihood of major shifts in the technology that may transform the whole pattern of computer use (as well as the effect of many other factors) make detailed or long term quantifiable prediction impossible.

There is no immediate end in sight to well established trends that computers are rapidly increasing in power while decreasing in hardware cost. The minicomputer of today has the power of earlier "large" machines at less than a tenth of the cost, and microprocessors are now available of comparable power that cost only a few hundred dollars to make and sell.

At the same time, but more slowly, software in support of computers (both systems software and applications software) is improving in power, generality and versatility, is becoming less intrusive on, and more transparent to, the user, and thus is putting computing resources more directly into the hands of the end user, progressively reducing the need for applications programmers and others as intermediaries between users and computer equipment.

These trends have several important consequences:

* More and more applications of computing are becoming economically feasible; the use of computers is quickly becoming very widespread.

* The cost of computing equipment itself is reducing, and will soon form an insignificant part of the total cost of putting computers to work.

* Software and, more generally, human resources already represent the major cost element in computing.

* The functions of applications programmers (the largest occupational group in data processing today) are changing; well before the end of the century the applications programmer as now known could have disappeared.

Two apparently contrary but complementary trends are discernible. The growing power and decreasing hardware cost of minicomputers and now microprocessors are making possible the use of computing in ways hitherto uneconomic, often with a computer processor dedicated to one or two specialised functions. On the other hand, the vast power now available with very large systems, together with the progressive merging of computing and communications technologies, are leading to the establishment of more, more powerful, and cheaper computer networks, public and private, general purpose and special purpose. The rate and form of development of computer access through telecommunications in Australia will largely depend on government policies both on the kind of facilities offered and on the tariff structures applied.

The middle ground previously held by medium scale general purpose batch processing computers is already falling away, leaving a relatively few large systems (mainly operating as hosts to networks and utilities) and a proliferation of small and relatively inexpensive computers.

The recent application of microprogramming techniques and advanced components to the development of the hand-held calculator illustrates the vast potential for computing in both work and domestic settings, as well as the growing difficulty of categorising computers in any fixed and meaningful way. It is not hard to envisage the effect of the much greater versatility and power of the general purpose computer once it is readily available at a cost comparable to that of today's pocket calculator.

The implications for computing education are clear:

* Adaptability, and emphasis on basic skills and concepts, are vital in all computing education if we are to cope with rapid change, technological obsolescence, and innovation.

* Thus very heavy emphasis must be placed on continuing education of many forms.

* Computing education is not required solely, or even primarily, for a small elite of computing specialists, but for the mass of professional, managerial, clerical (and ultimately trade and sales) workers. The needs of each group demand consideration.

* Basic motor skills (in keyboard operation) and basic intellectual skills (in problem solving) should receive early and fundamental attention.

* The spread of computing applications will demand, and ensure, a comparable diffusion of understanding of computing. In the short term lack of sufficient people of many kinds with a sound grasp of computing principles may impede and limit the growth of computer use, but ultimately the need for, and use of, computing must result in widespread appreciation.

* Inevitably, the distribution of computing skills and occupations will change. New specialities will emerge, and are already emerging, as in communications software, data management, and particular application fields. Computing skills cannot remain the exclusive preserve of a high priesthood: they will become the essential, expected and everyday tools of more and more occupations, which will gain more direct access to computing facilities and become less dependent on the help of intermediaries. Although the relative importance of today's applications programmer may diminish, the needs for highly skilled EDP systems designers will grow, and the skills expected of those who develop ever more general applications software for the end user must rise.

PATTERNS OF USE

While general growth in the use of computing may be expected, because of increasing accessibility and reducing hardware cost, it will be greatest in the following areas:

(1) applications not previously justifiable because of cost;

(2) applications in those sectors experiencing relative growth within the economy; and

(3) applications supported by improvements in technology.

The most marked change in the pattern of EDP use in Australia will be widespread acceptance by the small organisation. Large public and private organisations now, almost without exception, use computers, and in many cases could not function without them. Whilst their computer use will grow in size and sophistication, this will not result in a corresponding increase in the number of computing specialists employed by existing users. The real change in the next decade will be the entry into EDP for the first time of thousands of small users. Most will not at first obtain their own computers; they will use utilities, networks and bureaus. Those that do buy computers will get minicomputers. Before long, microprocessors will be commonplace, and will confound current notions of computing and calculating equipment.

More generally, computer applications that have been attractive in the past (to both large and small organisations) but that were of marginal profitability may now become feasible through the declining cost of computing power, provided that the costs of software and of human resources can be kept down. Those who succeed in developing general, user-oriented software that is simple to use should find a lucrative market, and encourage others to emulate them.

As the economy shifts concentration from the primary and secondary to the tertiary and "quaternary" sectors, we may expect rapid growth in the use of EDP in the service, but even more in the "knowledge-based", industries, especially since the latter depend crucially upon the storage, retrieval, processing and dissemination of data, in many ways, to which the computer is well suited. Microprocessors, however, will also result in much wider penetration of computing into primary and manufacturing industry.

Of the many trends in recent computing practice in Australia, two that portray the shape of things to come are the development of more, and diverse, computer networks, and the concentration on data management (currently shown by the almost obsessional interest in data base management software). Improved telecommunications facilities, better software, and above all growing awareness and understanding of communications requirements, should lead to widespread network use of all kinds, including complex, and adaptable distributed, resource-sharing systems; but at the same time others may opt for multiple minicomputers, each with mass storage and capable of interconnection. (They may do so for many reasons, including social concern.) Improved software, declining costs, communications developments and (again) better knowledge will lead to development of large scale data bases, often linked.

These developments will have considerable social consequences, and concern with ethical questions will increase. These will deal not only with privacy, but also with data security and the rising incidence of computer based crime, as well as more deep-rooted doubts about dependence on computer technology and on data. One likely common result of social concern with computer use is a call for greater regulation of computer use, and for more strict control over entry into computing employment. Such questions will inevitably be intertwined with those of professionalism (and unionism) in computing, on which confusion may well abound for many years.

EDUCATIONAL QUESTIONS
(See Part 2)

When one considers broad questions about the aims and nature of education, and particularly of post-secondary education, within the wide framework we have urged, a number of different paths inevitably lead in the same direction.

Thus, with particular reference to computing education:

* The growing uncertainty we all face in times of rapid and turbulent change implies a need for adaptable people able to cope more readily with an environment that is no longer stable and fixed.
* The strong and continuing change in computer technology and application, together with the long time-span during which people expect to work, suggest strong emphasis on basic concepts and principles, rather than on techniques that may prove ephemeral.
* The technical problems of achieving reliable manpower requirement or educational enrolments forecasts, even in the short term, suggest that any attempt to balance sectoral demand and supply through simple manpower planning approaches is unlikely to succeed. When future unpredictability and the needs of a peculiarly volatile industry are taken into account, long term manpower planning must be seen to be fraught with particular dangers: one-time long-term planning denies the problems of forecasting the future behaviour of a complex dynamic system. What is needed is adaptive planning

based on continuous feedback.

* The attitudes of the students themselves, as well as of employers, and the wide range of views of educators, cast doubts on the idea that neat distinctions can be made between general and specialist, or between vocational and non-vocational education. In respect of computing education at least, the task of Australia's CAEs cannot simply be described as to provide more specialised, and explicitly vocational, education.

* The continued rise in the proportion of Australians pursuing post-compulsory education, and the consequent growth in the proportion of new entrants to the labour force who have higher qualifications, are disturbing hallowed notions about the personal, vocational and societal purposes of higher education.

* Already the differences between individual CAEs and the differences between the universities are more striking than the supposed differences between the two systems; the press of the CAEs for academic recognition and status is making them look more and more like universities.

* The needs for adaptability generally in times of change and turbulence, the special needs of computing education, and the values increasingly espoused by individuals and by policy-makers, all point to the necessity of much greater emphasis on continuing and recurrent education of several kinds.

* Part of most philosophies of recurrent education is greater unity between work, education and leisure. Yet in computing as in other fields there are clear indications of a major communications gap between educational bodies, industry and government. Most tertiary educational bodies are relatively isolated from the world of practical computing, often for reasons that are not their fault, and despite their best efforts to overcome this. Greater co-operation, interchange and joint ventures are called for, but these require dedicated and stubborn encouragement and support to be fully effective.

* Again, considerations of social change, of educational need, and of likely developments in computing all suggest the need for much less rigidity and more varied and versatile approaches in educational planning, in opportunities for education, and in course structures. Whilst these needs are doubtless general, they are nowhere more pronounced than in computing education.

Empirical Findings

FUTURE DEMAND

<u>The use of computing will continue to grow rapidly</u> for many years to come. At present about 2.4% of all enterprises in the private sector make some use of computing, and our most conservative estimate is that the number of enterprises using computers will at least double in the next decade. (The application of EDP is very firmly established already in the Australian public sector.) Most of the new organisations using computers for the first time in the next few years will be small, because most large organisations, and virtually all very large organisations, already use computing extensively.

We are chary of making firm quantitative forecasts for several reasons: First, there are, as we have argued, many interrelated factors to be considered, including external changes and disturbances, which could affect the results substantially (in either direction). Second, the coverage, accuracy and detail of the data are limited; even though the project has been able to improve the situation, the quality of the data is (almost necessarily) inadequate. Finally, an appropriate analytical basis for reliable forecasts does not yet exist.

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Despite these reservations, which we urge should be taken most seriously, there remains no possible doubt that computing use and its associated employment needs will rise dramatically, under any set of plausible short term assumptions one may choose.

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Overall, the <u>growth in organisations using computing</u> to some extent (by their own present plans, which most probably fail to take into account fully the potential benefits of computing beyond the next one or two years), is expected to be 16 to 18% p.a. over the next few years. If this rate of growth were maintained (as it well could be for many years), if there is growing managerial awareness of the range of useful computer applications, if expected improvements in cost/performance eventuate, and if the technology continues to improve (especially in placing tools more immediately in the hands of the end user), this would represent a five-fold increase in computer users in the next decade.

At the same time existing EDP users may be expected generally to widen and deepen their use of computing. There is a growing dependence upon computing. Of over 15,000 organisations in Australia using computers already or planning to do so, more than 4,000 regard computing as essential to their functions and another 3,000 or more consider computing to be very significant.

Most organisations using, or expecting to use, computing do so for essentially commercial or administrative tasks. While it is increasingly difficult to make clear and simple distinctions between "commercial" and "scientific" computer use, there is no indication that this mix is likely to change in the short term. Already only a minority of users have their own computers, a trend likely to increase with growing use and effectiveness of utilities and computer networks of diverse kinds. Most organisations still predominantly use computers in "batch" mode (that is, essentially "across the counter"), but there is a discernible trend to greater use of interactive and other forms of on-line access.

The growth in personnel in the EDP field is remarkable, especially when it is realised that the use of computing in Australia is hardly more than 20 years old. Our best estimates are that there are now about 11,000 full time systems and programming staff employed in Australia, and that over the next three years a further 8,200 or so will be needed. [These, and other quantitative estimates, relate to survey data mostly obtained in 1974.] This represents a compound growth rate of over 20% p.a. Clearly such rates cannot continue indefinitely (they would imply more than a million systems and programming staff in Australia by 2000 A.D., at least 10% of the total work force!), and one can postulate many specific reasons for a slackening of growth in the medium term. In the short term (say the next six to ten years), however, there is no compellingly obvious reason why the demand should slacken greatly.

In particular it should be noted that more than half of the additional staff expected to be needed in the next three years are for small organisations - in fact, nearly half are for organisations not now using EDP at all or employing any EDP staff. Whether the needs of these organisations are met by recruitment of newly trained people from post-secondary courses or, as is more likely in most cases, by recruitment of experienced staff from other organisations, there are clear implications for vocational educational programmes.

The growth in demand for capable computer users who are not full time systems and programming staff, but practitioners in other fields, is likely to be even more marked. It could exceed these figures in the short term by an order of magnitude.

As indicated in more detail in the statistical sections of the full report, there are wide variations between States in the use of computing, employment needs and expectations, and attitudes towards formal education.

EXPECTED SUPPLY

The accuracy of estimates and forecasts of the likely "output" of qualified people must be regarded with even more reservations than estimates of demand. Apart from the same kinds of fundamental problems as just discussed - the influence of external factors, inadequate data and the lack of any appropriate basis for sectoral forecasting - there is an additional problem. This is that quite clearly most universities and colleges that have not already approached their planned ceiling for enrolments have assumed very high rates of growth. The result is that total enrolments in all courses for all institutions, as indicated by their stated forecasts [in 1974], would represent a totally unrealistic and abrupt rise in the proportion of the population undertaking higher education. [The estimates of total enrolments given to the research project by the institutions considerably exceeded those subsequently published in 1975 and 1976 by the Universities Commission and the ACAE.] If the overall figures so obtained are in doubt, we must assume that figures relating specifically to computing courses are likewise based on improbably optimistic assumptions.

However, it is possible to build up a rough picture of the likely number of people completing "specialist" computing courses at universities and colleges. Taking a very broad view as to what such a course comprises, we can say that in the next one or two years there are likely to be 300 to 400 graduates per annum completing university courses which contain a computer science or information science major, about 250 per annum completing CAE degree or diploma courses in information processing, computing studies, business studies (E.D.P.) and the like, and about 200 to 250 who complete graduate diploma courses in computing at CAEs. Taking a generous view, then, about 800 or at most 900 will complete courses each year in the next few years who could be regarded as having a training at post-secondary level relevant to specialist or professional employment in computing.

This is a very raw figure. Some growth in enrolments and completions may be expected, especially in the CAEs if their plans are realised, but it is hard to see that a growth of more than 50% per triennium - to say 1,200 in three years' time - is likely.

If one makes admittedly qualitative and subjective judgments about the appropriateness of these courses to a professional career in computer systems work, where most jobs are likely to be found in the next few years, this number must be reduced substantially. One dispassionate and reputable study by a major employer organisation would regard about half the students emerging from these courses as insufficiently trained for full time systems and programming, on the grounds that the courses are inadequate in depth, or breadth or both. Without wishing to dispute the efforts of the institutions concerned, or to maintain that all these courses are in fact intended to produce potential professional programmers, systems designers or analysts, we would not quarrel with the substance of this conclusion.

Apart from the fact that many of the 300 to 400 university graduates just referred to have a major in computing and a major in something else, and may very aptly not wish to enter EDP as a career, the overall situation with respect to the teaching of computing to those in other disciplines is even less heartening. As indicated in Chapter 5, the need is much greater for people with a deep understanding of computing, as part of an education embracing other disciplines, than it is for those who are to be primarily computing specialists. Although it is very hard to quantify the likely supply, it seems unlikely that there will be more than a few hundred leaving the universities and CAEs each year who are in this category and do not intend to make EDP their career.

Other sources (migration, private computing schools and institutes, and "in house" courses) will make some, but quite modest, contribution to the supply of appropriately trained people.

CONCLUSION: THE GAP

Although the project was originally specified primarily as a manpower forecasting exercise, we believe that the interpretation we have placed on our terms of reference, after consultation with the Commission, is essential to a proper understanding of the dynamics of the situation under study. This involves placing the quantitative aspects of forecasting within a broad framework that attempts to understand the nature and interactions of the influences at work.

Further, it would be irresponsible not to point out the inherent limitations of supply-and-demand manpower planning approaches, as well as the specific difficulties in quantitative estimation of computing education needs. Such limitations could lead to an illusory confidence in quantification. This would be an especial danger if one were to adopt a narrow approach, to ignore the system complexity and dynamics of both sides of the manpower equation, to use one-time long term manpower forecasts without provision for adaptive planning based on feedback, and to assume that accurate quantification was possible in terms of detailed educational categories. We say this for reasons similar to those given by the study into manpower forecasting and educational planning undertaken for the Ontario Commission on Post-Secondary Education [Holland et al. 1971, Editorial Foreword]:

> "...as the Commission noted in its Statement of Issues, education is often regarded as an instrument of manpower planning. At the same time we also noted that the experience to date with manpower planning suggests that it is a notoriously unreliable instrument of public policy, perhaps in part because of technical difficulties inherent in such exercises, but also possibly because of the difficulty of establishing, as we said there, 'any but the most tenuous links between educational requirements and future manpower needs.'"

Both "supply" and "demand" data are too limited; forecasting into an uncertain future is precarious to the point of impossibility, especially in a rapidly changing field such as computing; the connection between education and employment is loose and unclear, and the substitution possibilities are numerous; and the desirability of a manpower planning approach can be questioned, even if it could be achieved.

Some of the specific difficulties in matching employment demands against educational output in the field of computing include:

* the indifference (and in cases even opposition) of many employers to formal educational qualifications in those they employ as systems and programming staff, together with the absence (at least at present) of any generally recognised certification standards or requirements;

* the lack of a clear vocational motivation on the part of many students in choosing courses with substantial computing content;

* the fact that many of those who undertake courses in

computing for vocational reasons are already employed in EDP, and hence do not represent net additions to the work force;

* the difficulty and imprecision in defining knowledge standards for EDP or computing employment, and substantial scope for substitution between people with different kinds of training (for example, most of those in computing who are aged 35 or more, including most of those in senior positions, have no formal qualifications in computing, apparently without this proving to be a serious obstacle); and

* very great difficulty in foreseeing (more than a few years ahead) what the qualitative or quantitative effects will be of changes in technology on patterns of computer use and on the types and distribution of occupational skills requirements.

<u>Nevertheless the situation indicates a gap between "supply" and "demand" in the short to medium term of such a size that it is safe to draw some clear conclusions.</u>

Even if one takes into account the fact that of the expected 2,700 net increase in the number of full time systems and programming staff needed each year, some will not be required by their employers to have any post-secondary qualifications, certainly not at degree or diploma level, it would seem that it would be highly desirable for <u>most</u> to have formal qualifications and training. Also, if the participation of those aged from 18 to 25 in full time education continues to rise: if it is virtually accepted as a right of any person qualified to enter a university or college to have a post-secondary education, and if a large proportion of those who matriculate expect to enrol, then we may anticipate a growing proportion of those who enter data processing to be graduates or diplomates.

There is already a clear tendency, here as in the U.S., for employers to seek graduates in occupations which 10 or 20 years ago would have been filled by those who had completed only a full high school education, and for qualifications to be used as a screening method in selection. We do not advocate that <u>all</u> who wish to be programmers or computer systems workers should undergo a concentrated and specialised course in EDP; nevertheless a large proportion are likely to be graduates or diplomates, and it would clearly be wise for them to have completed <u>some</u> substantial study of computing in their courses.

<u>The potential demand for full time systems and programming staff in the next few years is likely to be three times as great as the number who complete university or college courses</u> that could by any stretch of the imagination be

considered a suitable professional preparation, and five or six times as great as the number who complete courses that are really well-suited for those who seek a broad and deep vocational education for a career as computing systems specialists. Further, in the next few years at least, the rate of growth in demand is likely to be higher than the rate of increase in supply from tertiary courses and other sources.

Thus a very substantial increase in the number of places in post-secondary courses in computing is called for, and consequently a substantial increase, both absolutely and relatively, in the resources devoted to computing education.

It is not possible to place a precise quantitative limit on the resources that would be appropriate. However, even in relation just to courses aimed at producing full time systems and programming computing specialists, an increase in places of between 10 and 20 times, over the next six years, would not be excessive: a factor of between three and six to try to bridge the gap, and a further factor of three for anticipated growth. However, the biggest unfilled needs are not in this area. There is an even greater need for, and a much bigger shortage of, those who take a sound mastery of computing principles with them to employment outside specialist computing applications.

It therefore seems of little account that the needs cannot be measured accurately. We would urge educational policy-makers to increase the provision of resources for computing in the short term to the maximum level that can be effectively attained. Limits are likely to be placed, not by demand levels, but by the resources that can be found for the purpose. There will be very substantial costs in terms of computing equipment and ancillary facilities to support computing education, and these need to be met. This could cost a mint, but presumably if the need is established money can be found.

The real limiting factor inevitably will be human resources. How many additional academic staff with appropriate backgrounds and teaching skills can be found to provide the computing education needed, and how quickly can academic institutions respond to the needs, once approvals for courses, staff, and facilities have been given? If these questions can be answered, they should determine the levels of educational provision that should be made.

We would then urge that appropriate arrangements should be made to monitor changing needs continuously, to provide a basis for future policy decisions relating to later triennia.

If the limits to the provision of computing education are placed, not by expected demand, but by resources, it is vital that those resources which are provided are used to best effect.

The really important questions are those of balance and emphasis, and these are addressed in the next chapter.

The use and management of resources must be subject to continuous and critical appraisal, based on the feedback of appropriate information.

CHAPTER 2

RECOMMENDATIONS FOR ACTION

OUR FINDINGS GIVE RISE TO THE FOLLOWING RECOMMENDATIONS:

Immediate Consequences

LAUNCH A MAJOR EXPANSION

1. A very substantial increase should be made in the provision of computing education of all forms and at all levels of post-secondary education in Australia.

   For at least the next six years the expansion of effort devoted to computing education should be limited only by the quantity and quality of the resources (especially staff) that can be found and used effectively.

2. Consequently many more staff and much more recurrent and capital expenditure will be needed in support of computing education. These should include substantial computing facilities, which in addition to their primary use in teaching about computing should be a general educational resource available particularly for appropriate instructional, administrative and library functions, as well as for research, experimentation, data acquisition and digital control.

3. While every post-secondary educational institution in the country should have some computing facility of its own (at least a minicomputer), there is considerable scope for co-operative arrangements, including the use of computer networks, to improve the efficiency, economy and effectiveness of computer use and application. Networks should be adequate in power and properly supported by software and professional staff, to serve all users. The very substantial practical problems of

ensuring effective networking should not be allowed to divert attention from the primary objectives, which are to increase and improve computing education.

4. While innovation in the teaching of computing should be encouraged in individual institutions and in staff members (and their autonomy respected), much benefit could derive from greater sharing of ideas, teaching materials and educational resources between educational bodies than at present. The establishment of resource centres for the development and interchange of material of general value in computing education should be considered. (Specific recommendations on the establishment of centres of excellence and of advisory centres appear in paragraphs 39-41.)

5. In educational technology and in the use of computers in support of instructional, administrative and library functions, the potential waste and duplication of resources is so great that all major development projects should be co-ordinated for the benefit of all users. This might, but need not necessarily, require establishment of central units for these functions.

ENSURE PROPER BALANCE

6. Since growth in computing education will be limited only by the resources available, very careful attention should be given to the balance of educational needs to which resources are allocated. Not all needs are of equal importance or urgency and some of the more vital needs are at present neglected.

PROVIDE CONTINUING EDUCATION

7. A major shift in emphasis is needed to meet the needs for continuing, continuous and recurrent education. Despite the commendable introduction of many graduate diploma courses, the needs of continuing education in computing are not yet well met. Continuing education is the greatest and most urgent single area of need examined by the project.

8. Those already working in computing will present heavy demands on educational resources, particularly for continuing education, until all have both a sound foundation of computing principles and current knowledge of immediate relevance. Changes in technology will impose many needs for continuous education; and the diffusion of computing through many kinds of work will broaden these needs. Continuing education should be

broader, more varied and less rigid, and requires the undivided attention of many experienced staff.

GIVE PRIORITY TO TEACHER EDUCATION

9. It is essential that primary and secondary students should be taught about computing. The social consequences of computer use, and the application of computing in more and more aspects of life require that all in compulsory education should gain a basic exposure to, and awareness of, computing.

   Further, the central importance of problem solving, and the intellectual and educational value afforded by its study, strongly indicate that many, if not all, secondary students should have the opportunity to undertake significant computing studies.

10. These viewpoints have been repeatedly urged on us, and we fully share them. In the last ten years a growing number of schools has offered some computer exposure, but we are a very long way yet from realising "computer awareness for all" as a national objective. A major study of the computing education needs of Australian schools is required. This should involve all educational systems and all interested sections of the community.

11. The implications in teacher education are overwhelmingly profound. Of all areas of post-secondary education, the teachers' colleges and schools of teacher education show the least concern with, and progress in, computing education. Because of the long lead time before a substantial number of primary and secondary teachers can acquire the necessary understanding of computing to impart to their students, every effort to introduce computing studies in teacher education, and all possible forms of continuing education in computing for practising teachers should be encouraged.

12. Our recommendations regarding continuing education and teacher education are more urgent and crucial than any others.

EMPHASISE THE "OTHER DISCIPLINES"

13. All levels and sectors of the community are involved in education in computing. Computing will become a familiar part of most human activities, and there are few who would not benefit from the ability to use a computer as a tool. Most students, in all disciplines, at universities and colleges will need substantial

grounding in computing. (This is also true of many studying in the "TAFE" sector.)

14. Therefore greater emphasis should be placed on the educational needs for understanding of, familiarity with and competence in, the use of computers by professionals, sub-professionals and others outside computing than on the specific needs to produce specialists of various kinds for employment in computing and EDP.

15. Our aim should be that eventually computing principles and applications become, where possible, an integral part of the teaching of all relevant disciplines, rather than being taught as a separate and distinct subject. To this end, it is vital that academic staff in fields outside computing should be encouraged to explore the teaching of computing in their own areas.

In addition, the general approach to problem solving that we advocate should have much value and application in many fields.

COMPUTING SPECIALISTS - IMPLEMENT CHANGES

16. A careful balance is needed between the supply of "high technology" computing specialists and the supply of "medium technology" practitioners of computing. Only a few of those engaged full time in computing will work on research and development, and require advanced training in computer science. The bulk will be mainly concerned with computer applications, and in their professional training should study other disciplines, covering especially their computational and systems aspects, rather than more esoteric and advanced topics in computing.

17. The few who do enter "high technology" employment will require increasingly advanced training and experience, but if they are to stay in Australia should concentrate on those fields likely to be of greatest relevance to the emerging needs of the local community. Prediction of what these are likely to be would be assisted by a more coherent national policy on the development of an indigenous industry and on our regional role in computing.

18. Computing practitioners working on applications should receive a multidisciplinary education, combining subject areas with computing. For many a double major or double degree may prove appropriate; others may benefit from a master's degree or graduate diploma after work experience.

19. Systematic thought and attention should be given to the needs of technicians and sub-professionals, who may increasingly undertake operational, maintenance and routine tasks in computing. Premature professionalisation and institutionalisation of computing is unlikely to succeed, and should be resisted. Occupational roles are not well defined and are likely to change. The whole spectrum of education should be considered.

CHANGE CURRICULUM EMPHASES

20. In all computing education sound foundations must be laid. Concepts and principles, a critical awareness and an understanding of the logical approach needed to delineate and apply problem solutions must be emphasised from the outset. Effective use of computing as a tool depends on this.

21. The primary emphasis should be on problem solving: the recognition and description of, and a "systems approach" to, the solution of problems, independent of the technology. Problem solving techniques, and a study of the use of data, should be included in all curriculum areas, at an appropriate level.

In Part 2 we have outlined what we regard as the "informatics approach", which should apply to the teaching of computing at all levels.

22. Implied by this are: early emphasis on basic concepts, on structure, and on effectiveness, to provide problem solutions relevant to the user's need, rather than undue concern with specific techniques, languages or hardware; an effort to adopt educational approaches that depend as little as possible on the particular technology in use; and avoidance of undue emphasis on programming in a narrow sense. Although at present an essential skill for the computing specialist (and for some others), programming is likely to be of declining importance, and may progressively reduce to a routine clerical operation.

Educational Policy Issues

PLACE EMPHASIS ON THE INDIVIDUAL

23. In planning for computing education greater emphasis should be placed on the needs and wishes of the individual. Future employment needs are difficult to forecast with any precision, and there will be many career paths in computing. Determining the precise educational preparation most suited for any occupational group is even more difficult. In addition, community pressures and those of the students themselves seem strongly to support combining an education that assists in the personal, intellectual and social development of the individual with acquisition of knowledge and skills likely to be of value in future employment.

24. This emphasis should include more counselling and guidance for the student in making choices, including better information and guidance on many kinds on vocational opportunities.

PROVIDE GREATER FLEXIBILITY

25. Greater choice should be left to students in the construction of courses. Some EDP courses at CAEs contain very few electives; as needs exist for diverse blends of knowledge and skills in the work force, including great needs for computing practitioners who combine computing with subject knowledge, such rigidity is not well suited to immediate employment requirements. In addition, the combination of computing and other skills offers greater adaptability for possible shifts in career in later life.

26. More freedom should be provided for those undertaking post-secondary computing studies, in the time of commencement and duration of courses, and more opportunities to integrate study with their working life.

27. In particular there should be more routes to credentials, and greater ease in moving between different levels of education. The difficulties at present in moving from non-tertiary to tertiary, or from diploma to degree courses, both within and between institutions, or in combining part time study with responsible employment, are major barriers to educational access, and should be reduced.

ESTABLISH OVERALL PLANNING FRAMEWORKS

28. A broad overall framework that recognises the wide range of different skill levels and mixes needed [as sketched in Volume 3 of the full report] would be of real value in planning for computing education by all kinds of bodies at all levels of education. If generally accepted (as a guide and not a blueprint), it could help widen the scope for those who seek education to gain credit for their previous studies and work experience.

29. A consequence of this, and of the needs for greater choice and mobility, is acceptance of greater modularity in computing courses.

PLAN MORE ADAPTABLY

30. Rigid planning practices such as fixed triennial funding or slow approval processes for new subjects or units discourage adaptive and rapid adjustment to change. This is a particular problem in computing because of the rapidity of change.

More responsive planning processes (such as rolling plans), especially at the institutional and departmental levels, would help, and should be based on monitoring and feedback.

COMMUNICATE WITH COMPUTER USERS

31. Education, industry and government should interact more, and there should be more co-operation, interchange and joint sponsorship of research and development activities.

Possible initiatives could include:

* Interchange of staff, for cross-fertilisation
* Co-operative involvement in computing education
* Communication and consultation in educational planning
* Joint involvement in development projects
* Establishment of research and development centres to provide professional meeting grounds

32. Some initiatives can (and do) take place at the institutional level, and should be encouraged. Others, such as effective interchange and joint projects, require conscious assistance. This should be given.

These recommendations are vital to the vigorous growth of computing education in the areas of greatest importance and need.

The kinds of initiative suggested will require drive, enthusiasm, and much financial support, as well as encouragement, if they are to be fully successful. Half-hearted attempts to improve communication are not enough.

Recommendations on Policy in Computing Education

RETHINK COURSE LEVELS

33. There is undue emphasis at present on full degree courses or diploma courses of equivalent level. Public monies could be conserved if CAEs addressed the areas of real need rather than, in some cases, pursuing university patterns. It is also arguable whether effective practitioners can be produced without substantial practical experience in a work environment, or whether some topics in systems analysis and design (for instance) can be taught effectively to those without such experience to which to relate them.

34. It is therefore suggested that support should be given to associate diploma and other courses of shorter duration than a full bachelor's degree, covering computing and elective subjects, which would aim to produce employable practitioners whose professional preparation is, however, not yet fully comprehensive. The qualifications gained, as well as appropriate practical experience, should be recognised for admission to later courses, including "conversion" courses for those who desire it.

35. Similarly, the needs of those already employed in EDP but who lack formal qualifications in computing should be recognised, by appropriate courses, giving thorough but accelerated treatment of computing fundamentals.

ESTABLISH CENTRES OF EXCELLENCE

36. A few, but only a few, centres of excellence should be established which offer full scale vocational courses designed to produce computing specialists, and which have very substantial computing content (such as degree level courses in computing studies, information processing or EDP, as distinct from multidisciplinary courses with computing as one major subject). Such centres should ultimately be established in each major metropolitan centre and in a few regional centres, and should be adequately supported by a full complement of staff and equipment.

    The kinds of full scale vocational course that would be offered by these centres of excellence, whilst important, are not the most significant part of computing education, and it is simply ineffective and uneconomical to have too many such courses, some with low enrolments and inadequate resources.

    Among these centres of excellence may eventually develop centres of specialisation in computing, based on the skills of the staff.

HELP THE SMALL COLLEGES

37. All post-secondary institutions should offer opportunities to learn about computing and need both computing facilities and qualified staff to do so. In the long run, as much as possible of computing teaching should be integrated into the teaching of individual schools, departments and units. In the meantime it is recognised that general service and introductory courses in computing are the only means for many colleges to meet a real and immediate need.

38. Especially if centres of excellence are established in computing studies, the other institutions, notably the smaller colleges, have serious problems in providing adequate computing education. Without the stimulus provided by a large computing studies school or department, with many students enrolled in specialised EDP courses, there is an even more pressing need for strong academic leadership and effective courses in computing that concentrate on basic computing principles and practice.

39. It is therefore strongly recommended that one or more advisory centres be established, preferably based in large metropolitan colleges offering specialist courses in computing and with a full complement of computing

studies staff (that is, in metropolitan centres of excellence), to develop teaching materials and other educational resources for use by all colleges, and to advise and assist in all aspects of computing education. Such centres should be headed by senior staff experienced in computing education, but without any personal teaching responsibilities. They should concentrate on the needs for the computing education of non-EDP specialists. Among the centres' activities should be workshops and seminars for the computing and non-computing academic staff of associated institutions. Because of the wide range of concepts that arise in computing and the consequent difficulties in teaching computing effectively and well, the advisory centres should also seek to enhance the teaching skills of academic staff.

40. Special attention should be given to the development of materials for introductory and service courses in computing, which should be continuously reviewed in light of experience and of changes (such as the introduction of substantial computing education into the schools).

In particular, materials for a range of different introductory and service courses should be developed, for introduction by colleges as soon as resources permit, to meet the differing needs of students with different backgrounds, interests and areas of academic concentration.

The centres should also help those outside computing develop materials related to computing for use in their own disciplines.

41. As already indicated, the autonomy of individual colleges should not be encroached upon. Consequently the advisory centres should remain purely advisory. Nevertheless, it would help all colleges, and educational mobility generally, if a broad common framework or "plan" could be agreed upon, as the basis for probably differing but compatible modular course structures. Such a framework should be developed jointly by the educators and the interested and concerned members of the community.

CO-OPERATE WITH OTHER EDUCATIONAL SECTORS

42. The previous recommendations, as they are addressed to the ACAE, focus on the needs of the CAEs. However, there is a clear need for more effective communication between all concerned with computing education in the CAEs and

those in other educational sectors, including the universities, the secondary schools, and especially the TAFE sector. These have similar and complementary needs for computing education, for computing facilities and for educational resources generally. Co-operation should be sought with the other sectors, not only in establishing ventures such as joint educational computer networks where appropriate, and in the instructional, library and administrative uses of computers, but in the area of computing education itself. The proposed advisory centres, for example, could well serve several sectors of education, if this seemed appropriate to the authorities concerned.

SET PRIORITIES

43. The computer offers tremendous scope as an aid to educational technology generally, and may well herald the "Fourth Revolution" in education. Nevertheless, we would urge that the explicitly educational needs - the needs for education in, and about, computing, at all levels - are very much more urgent and immediate than those for the use of computers in education in other ways. Both need attention. However the priorities should be clear. Careful attention needs to be given to the costs, effectiveness, potential scope and benefits of computer applications in educational administration and computer-assisted learning projects.

Broad Policy Questions

CO-ORDINATE POLICY

44. In our report we have in several places indicated the interdependence of several different policy areas, such as those which concern education, the development of a possible local computer industry, our regional role in the Pacific, and the whole question of co-operation between the public and private sectors.

There is a clear need for greater co-ordination between these areas of policy, not only for the benefit of those directly engaged in high level policy formulation within government itself, but for all those working in policy information fields in both the public and private sectors.

PROVIDE POLICY INFORMATION AND RESEARCH

45. This project, like many others from which it has drawn useful ideas and data, is an example of a research study undertaken primarily to produce information on, and understanding of, the nature of a set of issues, as a basis for policy decisions.

There is a growing need for such "policy information", and for policy-directed research, in many areas, including education, and in particular computing education.

Further, such policy information studies would be to provide an essential basis for more adaptive planning in times of rapid change and uncertainty. (The "Morris Report" is the most striking example of a really valuable piece of policy-directed research, producing "policy information", in Australia in the past few years.)

46. We therefore urge that the Government and its various agencies should actively encourage and support the establishment of policy information research groups or "think tanks" of several kinds.

These should deal with many policy areas, including educational policy.

Such groups could well be established at national and at institutional levels, as well through autonomous groups. (The proposed secretariat for ASTEC is a good example of the kind of autonomous group at national level that is needed, in this case dealing with science policy issues.)

47. As a general rule, such information policy research groups should not be permanent organisations with permanent staff.

Some may be set up to deal with a specific problem, and then disbanded. Others, in universities or colleges, for example, might be given "seed grants" for an initial period, after which their continuance would depend upon the proven value of their initial work. Yet others, like ASTEC, dealing with large areas of major national importance, should have a continuing existence, but should be staffed by a changing group of people on secondment from government, industry, academic and research institutions.

48. Such policy research groups should have no direct responsibility for policy decisions or executive responsibility, and should be required to publish their

findings.

49. A major component of the work of many policy research groups is likely to be the development and use of models and data bases of various kinds for planning purposes.

A national policy research unit would be of great value to assist all such groups, and to serve many arms of government. It should co-ordinate and make available to relevant groups the data bases (presumably on computers), models and other work produced by others, and offer technical assistance in modelling and research methodology.

50. A policy information group specifically concerned with computing education and related matters is urgently needed, and, for example, the recommendations of the Wearing Committee report on this matter should be implemented.

Such a group could be concerned solely with computing education, or could have computing education as a major concern within a broad charter dealing either with computing or with education. A group with broad responsibility for "policy information" in computing is probably the most likely to be established quickly.

Overseas patterns, such as those of the NCC (U.K.) and JIPDEC (Japan), are not necessarily the most apt for Australia. However, as in the U.K., substantial initial government leadership and support would be needed, together with the support and practical assistance of users and computer vendors. But the temptation should be avoided of investing a policy research and service group with commercial functions that may compete unduly for resources.

Any policy information groups concerned with computing should have strong links with the advisory centres proposed in paragraphs 39-41.

CLARIFY TELECOMMUNICATIONS POLICY

51. Telecommunications developments in Australia are of crucial importance to the future pattern of computer usage generally, and in particular to the use of computers in education. Especially important is the question whether telecommunications tariffs should be used as an instrument of Government policy to discriminate in favour of, or against, sectors of the community, types of use, or the development of geographical regions.

<u>A clearer understanding of the policy issues involved is needed</u>.

Directions for Further Work

Our project has suggested many needs for further work. We single out below the most pressing.

PRODUCE BETTER INFORMATION

52. More information is needed, including <u>more statistical information</u> of various kinds. The <u>Australian Bureau of Statistics should be requested to undertake further, and continuing, collections</u> of data relating to computer use, educational demands, and the attitudes and expectations of organisations.

53. Deeper and more detailed study is needed of the underlying influences and the trends which affect the composition of the population, the labour market, and participation of education in all forms. This, together, with continuous monitoring, should provide a constant flow of information not only to policy makers but also to those individuals in the community, such as students, who need to make informed personal choices.

STUDY MANAGERIAL ATTITUDES

54. In particular, detailed studies (involving interviews in depth as well as surveys) should be undertaken into <u>managerial attitudes,</u> especially to computing, as these will be an important factor influencing future computer use.

SEEK STUDENT AND GRADUATE OPINIONS

55. Relatively little is known about the attitudes of students or of graduates, or of the experience of graduates after completion of their formal studies. <u>Much more work is needed</u> to discover these, both generally and in particular relation to EDP, if the most effective educational policy decisions are to be taken.

PART 2

BROAD PERSPECTIVES

TO PLANNING

FOR COMPUTING EDUCATION

PREFACE TO THIS PART

[The following is the original preface to Volume 5 of the report. It has been changed only in the references to "volumes" and "chapters".]

In some ways we regard the next three chapters as the most important part of the report. It is at the same time the centrepiece of our work, and the least obviously relevant to our terms of reference.

The first sentence we wrote in Chapter 1, containing our conclusions, was:

> "In any educational planning, other than purely short term, and especially in planning for the needs of a rapidly changing technology such as computing, it is essential to consider the effects of many social, economic, educational and technological influences".

This is the main theme of Part 2. To quote again from Chapter 1:

> "We cannot properly advise on computing education without advising on education at large, nor can we properly make recommendations about education at large without examining, at least briefly, education in its social context."

This explains our dilemma, in that the following three chapters had to be written, and yet they are unlikely to be fully satisfying to many readers. Our original brief was to forecast, informed by an understanding of likely changes in computer technology and use, the likely demand for various specialist people, the likely output of such people from universities and colleges, and hence the changes required within the advanced education system.

The whole of Chapter 3 is devoted to showing how, in many ways, it is quite impossible to address this brief without making many assumptions - about technology, about society and about education, and why in times of rapid and turbulent social change the most likely assumptions about these must be questioned.

What, then, are we to do? For us to attempt to write the complete international yearbook on computing education, or a definitive discussion of technology in society, the social effects of computing in the Western world, or of the purposes of higher education, would be pretentious, would far exceed our brief, and would be physically impossible anyhow. Yet these topics cannot be ignored, for the reasons presented in Chapter 3. Not only do we believe them to be of vital concern to those charged with planning for computing education, but many we interviewed, both formally and informally, during the project also considered them important.

What follows should be regarded as an attempt, first to indicate _what_ are some of the subjects that should concern educators, educational planners and those involved in computing in Australia, and second to sketch some of the issues that seem important. The sketch must necessarily be incomplete, and much of what we say is contentious. We do not expect all who read this to agree. Our aim is to provoke serious thought and discussion about fundamental questions, and to contribute to what we hope will be a continuing and enlightening dialogue.

CHAPTER 3

THE BROAD SETTING

The need for a broad setting

If we wish to obtain a clear overall picture of the needs for Australian education in computing over the next ten years, we must consider many inter-related factors. Any vestigial doubts we might have had about this were dispelled during our search conference in 1974 which confirmed the relevance of a wide perspective.

Discussions with many groups, for example, the National Telecommunications Planning group of the APO [see Australian Telecommunications Commission 1976], have strongly confirmed the necessity for such an approach, if appropriate and supportable answers are to be obtained, even to apparently simple questions concerning the future.

This chapter sets out some of the broader considerations which are pertinent to any serious study of Australia's needs for computing education.

Among the factors that must be taken into account are:

- Fundamental social changes have already taken place and are still taking place, probably at an increasing rate. These changes profoundly affect the workplace and attitudes to work, and themselves partly result from the development of computing technology.

- The aims of education, especially higher education, are increasingly being questioned, as are priorities, policies and structures, both here and overseas.

- The use of computing is not only increasing rapidly, but is becoming an essential component of many disciplines. The need for computing specialists, as discussed in the search conference, must be related to the need for a computing component in other occupations.

- Computing as a discipline or a science, and as a profession, is suffering from the problems of adolescence (or perhaps still of gestation?). There is as yet little agreement as to what the study of computing is fundamentally about, nor even whether there is a discipline of computing, or a profession of computing.

- The technology of computing is itself evolving rapidly, and there is no indication that the rapid growth that has characterised the last 20 or 25 years will slacken.

- Rapport and understanding between the different sectors of the community is quite imperfect - employers, educators and suppliers of computing equipment and services are not agreed on what computing education is needed.

- Australia, because of its distinctive geography, politics and economy, and its emerging regional role, may have differing needs for computing manpower from other advanced countries.

More important than any of these factors, though, is the complex pattern of relationships between them. These factors cannot be looked at in isolation. Rather, we should try to form a view of the total system, a model, that takes into account all these factors and their interactions.

As a simple illustration, the very fact that certain educational plans are made and are implemented affects employers, students and the labour force (after a lag), and influences future demands on, and expectations of, the educational system. Similarly, there are effects on the educational system of the practices of employers and the kinds of use they make of EDP. Likewise not only does the development of technology affect the educational system (through demands for vocational education and through educational technology), but the education system influences the development of technology after a lag.

More fundamentally, though, the recent work of several sociologists shows that it is the interactions themselves, rather than individual components, that typify the process of change in modern Western society, and contribute "turbulence" to the already complex pattern of social change we experience [see also below].

Alternative Models of the Future

THE NEED FOR AN OVERALL VIEW

We are, then, trying to predict and plan for the future, when the things to be predicted spring from a complex system of interdependent components [Ackoff 1960].

The nature of the problem, as seen by the research project, can be put in two ways:

First, any serious attempt to find answers to apparently simple questions such as "how many information processing specialists will Australia need in 1985?" requires answers to many prior questions, such as:

* In what ways will people be using computers in ten years' time?
* What changes are likely in occupational patterns, managerial attitudes, patterns of professional development, and attitudes to work, education and leisure?
* To what extent can educational bodies prepare people for technological employment?
* What do those who enter vocationally oriented courses expect of them anyhow?

Thus, if we ask these questions, we expose a whole raft of hidden assumptions about the development of computer technology, its application in society, the nature of the workplace, and the role of education in meeting manpower needs.

In other words, without an explicit model we have an unquestioned implicit one, perhaps a working hypothesis that the future will be like the past. In times and areas of relative stability this might be an adequate hypothesis, but it is a highly dubious one in this exercise.

Second, this study, since it is concerned with the behaviour of a complex system, is a systems study in very much the same sense that most information processing specialists undertake the analysis of "systems". To ignore the systemic aspects of the study, and to concentrate narrowly on a few aspects, or to attempt to predict future values of a few parameters by naive extrapolation or opinion sampling alone, would seem a sure recipe for self-deception and the production of estimates that would soon be discredited.

For example, in Volume 2 of the full report we present many statistical estimates which suggest a very strong increase in the demand for full time systems and programming staff in Australia in the next few years. Whilst this does lead us to conclude that CAEs should plan to step up their capacity to accept enrolments in specialist computing courses, we cannot simply equate future demand for such people with the expected supply as measured by completion rates from such courses. Many other factors intervene. We know that, especially in some industries, employers do not care whether their EDP staff have any tertiary qualifications, and one or two have expressed a preference against the products of EDP courses at CAEs. Further, by no means all of the graduates who enter EDP do so from computing courses, and some enrolments in these courses are from those already employed in EDP - so that they do not represent additions to the systems and programming work force.

Part of what we are saying is that, since the project is a major systems study, we begin by defining the boundaries of the system (or by distinguishing between the components within the system and the environment that determines it [Churchman 1968]). The boundaries must be set quite broadly; otherwise our model of the system will be only partial, and any solutions we derive from it will be sub-optimal and probably false.

The "systems approach" is undoubtedly appropriate to efforts to understand and forecast broad future needs of various kinds, but is especially necessary in this study, for two related reasons:

(1) The project is concerned with planning for education, which is essentially long term. Apart from the lead times in implementing educational change, those who graduate from pre-vocational courses such as are offered by CAEs may be in the labour force for another 40 years. What will the graduates of CAEs in 1985 be doing in 2025 A.D.?

(2) The project is further concerned with a field - computing technology and its application - which is changing rapidly. By 2025 A.D. the history of EDP in Australia will be three times as long as it is now.

In defining the boundaries of the "system" we are studying, then, we must clearly include a large part, if not the whole, of the "education system" as it usually conceived, as well as the whole field of computer technology and its use in all areas of work. But even this is by no means broad enough. An important part of what we are saying is that the "education system" cannot be separated from the rest of society. Many (notably, but by no means only, Illich and his followers [Illich 1971]) argue that many current problems in education result directly from a grotesque attempt to make just such a separation. Whilst we do not particularly wish to nail our colours to the Illich mast, in Chapter 4 we question an assumption that many hold about the structure and purpose of education: that the "normal" pattern for people in our society should be from ten to twenty years of full time schooling, followed by 40 or 50 years of full time employment, during which further education is limited to the minimal needs of "refreshing", "updating" and "retreading". It is highly questionable whether such a pattern is now (or ever was) appropriate for most of our citizens. In the particular field of computing education, it is grossly inappropriate. As soon as we examine needs for computing education in an overall societal framework, it becomes clear that there should be much less rigidity, and that some forms of recurrent education should be widely adopted.

We make no apology for attempting a study much more ambitious than originally conceived by its instigators, nor for delving into many topics that those who initiated the project probably never dreamt would be mentioned in this report. In many ways the approach to the study outlined here, and the attempt to relate specific needs for planning information - required now to guide immediate decisions on the allocation of resources - to a broader outlook, should prove of greater and more enduring value than the statistics and estimates in the full report, essential though these may be.

Indeed, whilst the needs of planners and policy-makers to have the best possible data on which to base decisions are not in dispute, an excessive emphasis on quantification, and a disregard of the many factors which could change the whole picture, could well give an impression of stability, precision and certitude that is ill-founded, misleading and quite illusory.

THE IMPORTANCE OF SOCIAL CHANGE

The last five years or so has seen a great deal of interest in speculation about the future, and various prophets of "futurism" or "futurology" have emerged. They speak with many voices, offer many differing views of what the future holds in store, and in some cases offer "solutions" of various kinds to the world's ills. They also proceed from many different methodological bases of wildly varying credibility, and sometimes from unstated value assumptions.

It might be thought that the project is simply climbing on a bandwagon that has become increasingly popular since publication of Toffler's Future Shock, in a simple-minded attempt at "trendiness".

It is therefore important to show why the project's concern with social change and with the future has become so centrally important, and to indicate what sort of methodological assumptions have been used.

The need for a broad view has been argued above, in terms of a "systems approach" to the study. The poverty of a naive approach to forecasting in this study, even just ten years ahead, has been established because of the inherently long term nature of education as a social function, and because of the rapidity of technological change in computing and computer use.

* But why is the process of social change so important?

* Why is it fundamental to any understanding of the system under study?

FUTURISM OR FUTUROLOGY - SOME RECENT THINKING

Our thinking is influenced by the work of Ackoff, Trist and Schon, and particularly by the recent work of Emery and others, carried out in Australia, and some of which was published as the result of a request by Qantas (and further work more recently published at the instigation and with the support of the APO). It is worth trying to summarise some of the main lines of analysis set out in Futures We're In [Emery et al. 1974; see also Emery and Trist 1965 and Emery, Emery and others 1975], especially as the style and sociological terminology of the original make it heavy reading.

Basic to the overall analysis is the distinction made between four types or levels of organisation of environments within which large, complex social systems function. Since the analysis is in terms of those properties which characterise the overall environment of systems, and the behaviour of the systems in adapting to their environments, these are referred to as "environmental levels". What is of importance in the environment is "the extent and manner in which the variables relevant to the constituent systems and their inter-relations are, independently of any particular system, causally related or interwoven with each other", or the "causal texture" of the environment.

The four levels of organisation of environments, in these terms, are identified by Emery as:

(1) Placid, Random Environment
(2) Placid, Clustered Environment
(3) Disturbed Reactive Environment
(4) THE TURBULENT ENVIRONMENT.

We need not concern ourselves here with the first two levels. What is important is the distinction between the third and fourth. A "disturbed reactive environment" contains more than one system of the same kind, each competing and interacting with the others. It thus has dynamic properties, but the interactions of the systems do not affect the overall "field" itself - in fact, the complex of interacting systems tends to be ultrastable.

The "turbulent environment", though, is dynamic in quite a different way:

> "Unlike the disturbed reactive [system] we are postulating dynamic properties that arise not simply from the interaction of particular systems, but from the field itself." [op. cit., p.28]

Emery's central thesis is that the "social fields" we now see emerging in Western societies are turbulent in this sense. The four main reasons for turbulence in modern society he sees as:

> (1) The growth of organisations so large that their actions can induce resonant processes in the environment, much like the process when a company of soldiers marches in step over a bridge. ("The induced processes in the environment take on a life of their own.")
>
> (2) "The deepening interdependence between the economic and the other facets of the society."
>
> (3) "Increasing reliance upon scientific research and development to achieve the power to meet competitive challenge."
>
> (4) "The radical increase in the speed, scope and capacity of ... communication."

Probably the <u>keystone of his whole argument,</u> as it affects the relevance of his theoretical analysis to an understanding of contemporary society and to prediction of the future, is that:

> "For organisations, these changes mean primarily a gross increase in their area of relevant uncertainty, not just complexity *per se*.
>
> "This point cannot be stressed too much. Many writers have suggested that turbulence is simply a result of the sheer complexity of modern life, in

> large part generated by affluence, with its enlargement of areas of individual choice, and by the rapid increase in the rate of change. By these criteria many periods in the past might be rated as equally turbulent as the present, and yet were coped with without institutional revolution. One has only to recall the tremendous amount of change that was taking place in individual lives in most of the world in 1945-7. ... Our cultures and our institutions constitute vast aggregates of knowledge about how people and institutions can relate and adapt to each other and to their environments - except when their social environments take on the self-moving character we postulate as turbulence." [op. cit., pp.29-30]

Having described different "environmental levels" - or basically different contexts in which complex social systems can be imbedded, in which they exhibit different kinds of system behaviour - Emery then discusses different kinds of human response to turbulence.

He identifies three kinds of maladaptive response, which he calls "superficiality", "segmentation" and "dissociation", and relates these respectively to the scenarios portrayed in Herbert Marcuse's One Dimensional Man, George Orwell's 1984, and by E. Neumann and others. Then an attempt is made to outline the requirements for "active adaptive strategies".

It is not the aim here to present a popular or simplified exposition of the work of Emery and his colleagues (useful though that might be), but rather to indicate that a theoretical and conceptual basis does exist for this central chapter in the total report, and for the central place we accord the whole setting of our discussion of social change.

It is pertinent to observe that some of the highly theoretical sociological work done by Emery and others was commissioned and published because of needs just as practical as the one that resulted in this research project: the need for a better understanding of the forces shaping the future and of the most likely alternative futures, as a basis for long term planning by large business undertakings confronting multi-million dollar capital investment decisions.

A BASIS FOR PLANNING

We do not ignore, nor dismiss as unimportant, the needs of those who must make "here and now" decisions about the allocation of resources and essentially short term priorities: these information needs, in fact, provided the basic stimulus for the commissioning of this study. However, if this report is to have any significance or value for more than a few years, and not simply gather dust alongside countless other government-commissioned reports, it must address the fundamental issues, as well as the specific ones of marginal adjustments and shifts needed to decide how best to cut up a limited educational cake. These basic issues we see as being concerned with the questions:

* How can we plan effectively and adaptively in a turbulent society?

* Where does computing education fit into our overview of the "turbulent society"?

Areas of Change

Deep-seated social, economic and technological changes are transforming the society in which we live. We have just cited sociological studies that suggest that the transformation is a fundamental one, from a "reactive" society to a "turbulent" one. Such a transformation is unlikely to be quickly reversible, and must influence our planning. Many signs of social stress already indicate that some individuals are failing to adjust to, and cope comfortably with, the changing social environment.

Planning should aim to be adaptive, therefore, in the sense that it improves our chance of changing the sources of turbulence.

More narrowly: If the incidence of change is growing, as seems likely, it cannot be ignored in planning for manpower or for education, beyond the short term.

Among the more obviously important areas of change which influence the future, as it concerns this study, are:

* Improved communications, greater mobility and increasing social connectivity, interaction and interdependence.

* A consequently expanding role for the "information managers" who use data (and normally computers) to help cope with increasingly complex planning problems.

* Growing reliance upon technology, especially computing and telecommunications technology, which have an increasingly pervasive influence on more and more aspects of our lives.

* New and more diverse organisational patterns, which are departing from traditional hierarchical forms; and changes in management styles and attitudes.

* Growing affluence in advanced economies (in terms of real <u>per capita</u> income), and resulting increases in the discretionary time and discretionary income of individuals.

* Following from this, changing attitudes to work and to leisure, and a consequent questioning of the traditional work ethic, and of the quality of employment, in achieving personal goals.

* Changes in the part played by education in our lives.

* More complex and difficult roles for governments in Western mixed economies: the growing tension between public (social) and private (capitalist) goals, and between radical and <u>laissez faire</u> outlooks, parallel the personal tensions between social connectivity and individual autonomy.

* Shifts in resource allocation and work force distribution, away from primary and secondary industry to the service and knowledge-based sectors (including the "information industry" itself), and probably - because of the acceptance of social goals - from the private to the public sector.

Because of all these influences, <u>fewer people can map out and follow a single, clear career path for the "whole of life"</u>. Increasingly, people are making abrupt changes in career, partly because of changes in technology and partly because of more fundamental but subtle social changes.

A Possible Model of the Future

Before the search conference, a simplified diagram was prepared (Figure 1), showing the major factors which influence needs for computing education, and some of the relationships between these factors.

A later diagram (Figure 2) set out in more detail the linkages between specific components of the total educational demand for computing (and their satisfaction), and the factors which influence and determine them. Both diagrams were in the form of simple component-interaction models of the kind familiar to those who use any kind of "systems approach".

Such diagrams show dramatically why a systems viewpoint is needed to unravel the planning issues involved: they illustrate some of the multiplicity of ways in which the various components are inter-related. They also comprise an informal model of the total system; and could serve as precursors of more rigorously defined, formalised models to be developed later.

The following sections in this chapter may be taken to describe the main components in this model and their linkages, illustrating the complex structure of the box in the diagrams labelled simply "Economic, Political, Social and Technological Change", and the many linkages between this and other system components.

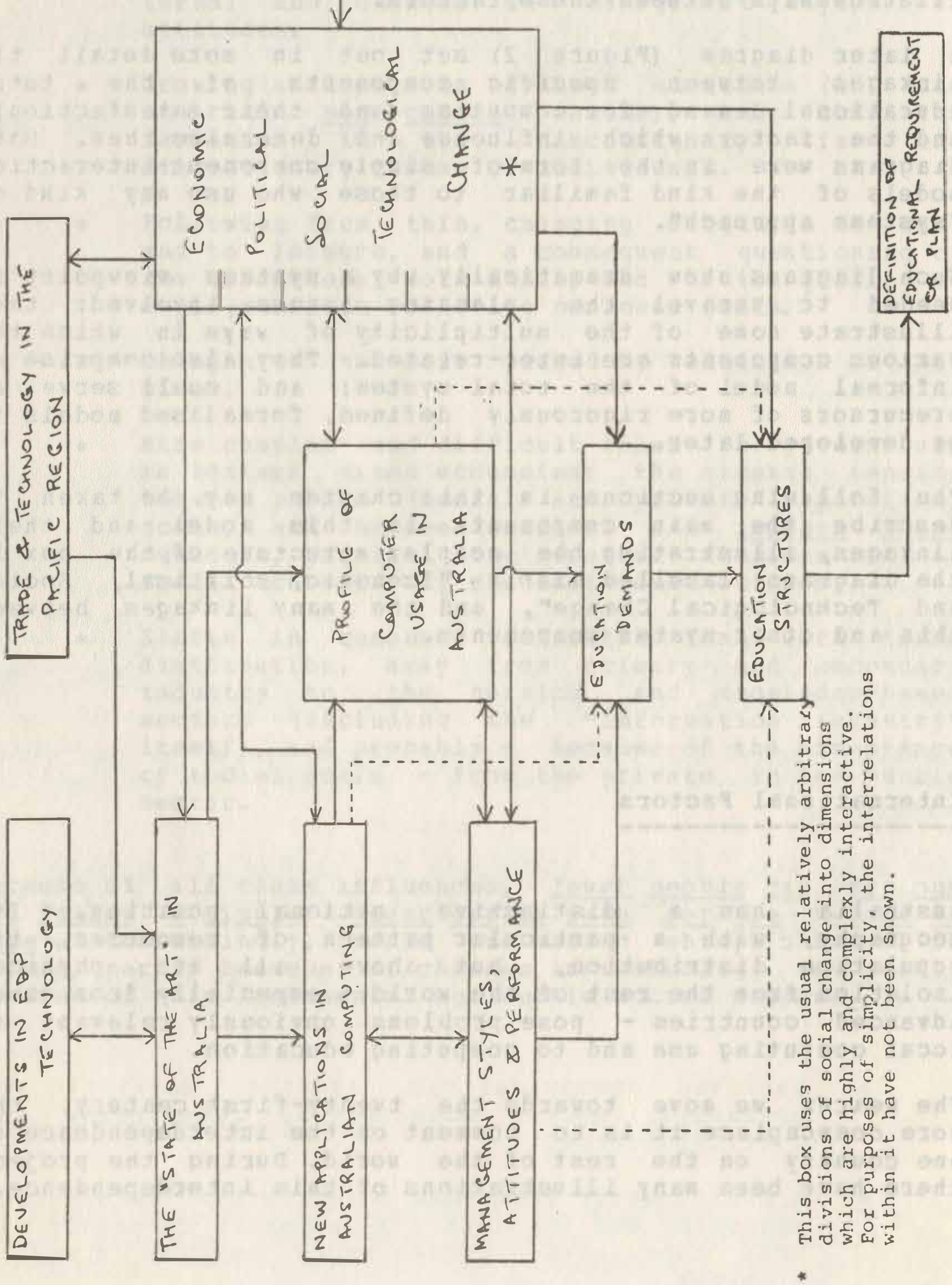
International Factors

Australia has a distinctive national position. Its geography, with a particular pattern of resources, its population distribution, but above all its physical isolation from the rest of the world - especially from other advanced countries - pose problems obviously relevant to local computing use and to computing education.

The nearer we move towards the twenty-first century, the more commonplace it is to comment on the interdependence of one country on the rest of the world. During the project there have been many illustrations of this interdependence.

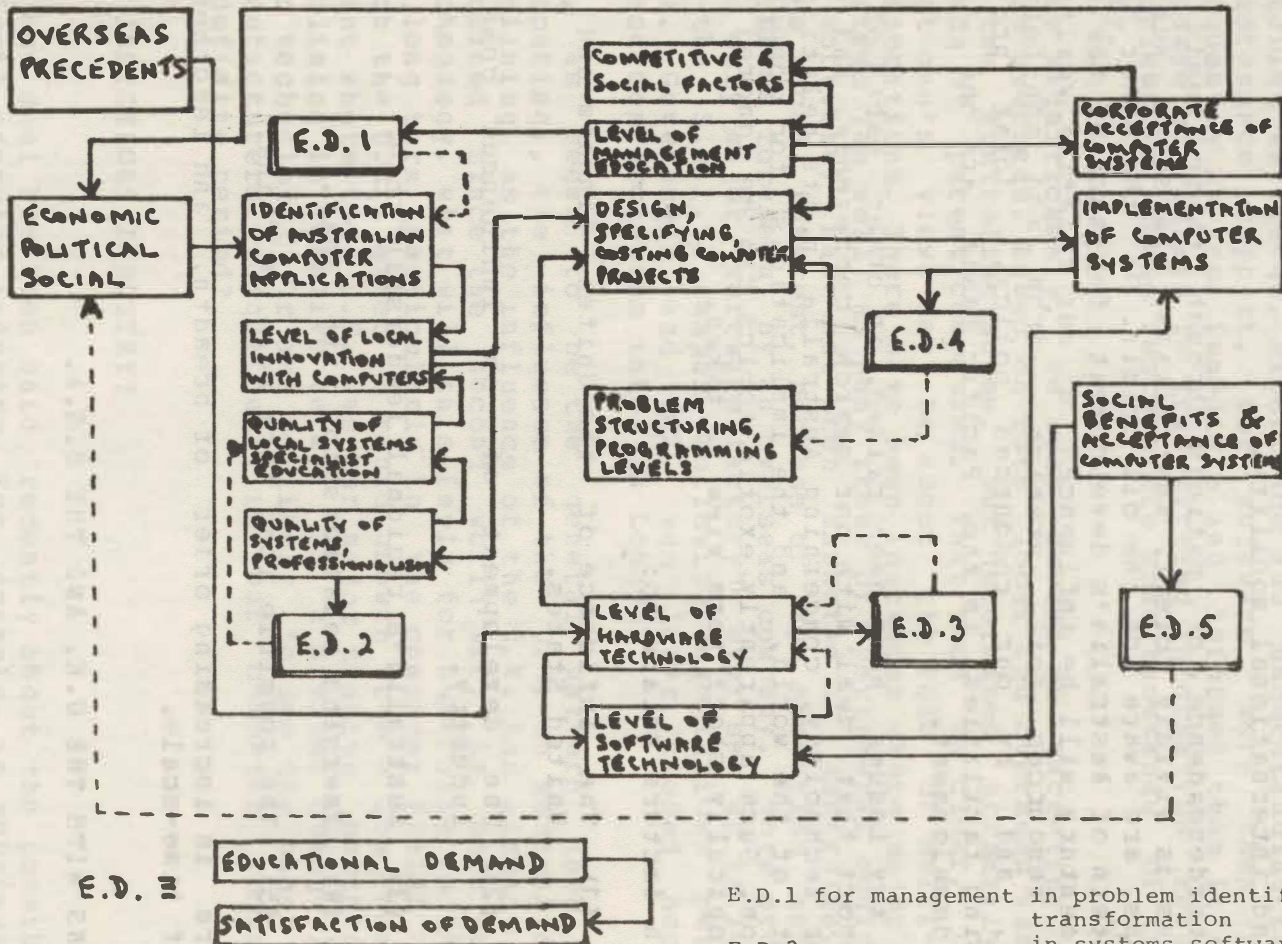
FIGURE 1: Early Simplified Diagram showing major change areas influencing computing education needs

MAJOR CHANGE AREAS INFLUENCING COMPUTER EDUCATION NEEDS - A FIRST ATTEMPT



* This box uses the usual relatively arbitrary divisions of social change into dimensions which are highly and complexly interactive. For purposes of simplicity the interrelations within it have not been shown.

FIGURE 2: Diagram developed during the search conference showing 5 major categories of educational demand for computing education, major influencing factors, and their relationships



Occurs in feedback loops, and can have a multiplier effect

E.D.1 for management in problem identification, transformation
E.D.2 in systems software
E.D.3 in computer engineering
E.D.4 in problem solving, applications programming
E.D.5 leading to general absorption of computer technology in society

The importance of overseas trade has long been recognised. In recent years Australia has observed the effects of changes in currency valuations, and has shared with its trading partners the problems of concurrent high unemployment and high inflation.

The shrinking of the world through improved communications, especially with satellite television and jet travel, brings home with great immediacy what is happening elsewhere, whether in Indochina or Watergate, and promotes much greater local and international mobility.

The interdependence of nations through their needs for resources is vividly clear. Australians, almost as much as Americans, are aware of the oil crisis. On the other hand, the pattern of Australia's development for much of the rest of the century will be influenced by our relative wealth of natural resources (oil, uranium, iron and non-ferrous metals), and by our resources policy. Joint project processing facilities in the Pacific Basin are one quite likely development.

Several key issues have been raised, in other parts of the full report that deal with our search conference, and with computer technology, concerning Australia in its relation to the rest of the world, and the implications for computing education. Such apparently exotic topics can be ignored only if a myopically short term view is taken.

The main factors relate to:

(1) The influence of the United Kingdom and the United States.

(2) The development of an indigenous computer industry.

(3) Australia's regional leadership role.

(4) Emerging relationships with Japan.

(5) The possible long term role of China.

These are in increasing order of breadth, and lengthening order of time-scale.

RELATIONS WITH THE U.K. AND THE U.S.A.

As discussed more completely in the full report, Australia made some useful contributions to the early development of computing technology (although not as profound as those of the U.S., or from Cambridge or Manchester), and three or four early systems were fabricated in this country. However, for more than a decade virtually all the hardware and most of the systems software has been imported, almost exclusively from the U.S. and the U.K.

This dependence on imported technology that has characterised Australian computer use has many consequences. "Know-how" is imported, not just in the form of machinery and programs, but also in human form. Technical support staff, from both vendors and users, make frequent pilgrimages to the Northern Hemisphere to obtain the detailed knowledge, experience and understanding they need; maintenance support, for software more than hardware, frequently is less immediate and informed than it might be, because of delays in transmitting information about system problems to those responsible some thousands of kilometres away.

More significantly, we must depend on marketing decisions made overseas, based on both local and overseas assessments of the Australian scene, but determined primarily by the needs of parent companies. That much is clear, no matter what one's views may be about the role of multi-national corporations. There have been instances where major computer systems (as well as many items of peripheral equipment and of software) have not been marketed in Australia, despite keen local interest, because of the marketing and support problems foreseen by an overseas company. More profoundly, the only major "software factory" ever set up in Australia, at the S.A.I.T. campus following negotiations between the S.A. Government and ICL, was later closed because of boardroom decisions taken in London.

If, as seems to be the general pattern (not just in computing), the influence of the U.S. on Australia is now declining, as the influence of the U.K. has already markedly declined since the second world war, in both trade and technology, what will this imply for Australia in the medium to long term, particularly in the computer field? Our trade with the U.S., after a rapid growth from a low base to the point where the U.S. was our major trading partner, is now declining in relative terms: Is a similar change likely in our technology? Or are we likely to see the names of U.S. manufacturers ubiquitously in our computer rooms for an indefinite period?

AN INDIGENOUS INDUSTRY?

A good deal has been said recently about the possibility of a local computer industry. For example, in submissions made to the 1974 IAC hearings, it was argued that the relative isolation of Australia and the availability of substantial expertise in computing made it both desirable and possible for there to be some degree of national independence.

There are many different things that could be meant by this. It could mean self-sufficiency in some or all areas, to place us alongside the U.S., the U.K. and Japan as major producers of computing technology. This might be argued on the grounds of strategic independence, the desirability of establishing a more broadly based electronics industry, the need for an infrastructure to support defence requirements, or on purely nationalistic grounds. Or we could look for an indigenous industry that fell far short of self-sufficiency, but was nevertheless much more visible than what we now have. Alternatively, like some Western European countries, we could look to some formal relationship between an overseas supplier and local initiative, with some form of government recognition and encouragement.

An industry to do what? The capital investment needed for the design, construction and marketing of major computer systems and all their supporting software is enormous, and in both the U.K. and the U.S. this has reduced the number of major suppliers over the last decade, despite (in the U.S.) anti-trust measures - and because (in the U.K.) of government recognition of the need for some rationalisation. On the other hand, one company has been established in Australia, originally to meet the needs for smaller scale and more adaptable, micro-programmed processors, and more recently has consolidated its position as a supplier of terminals, for which there is a broader and less capital-intensive market. Similarly, the possibility of local fabrication or assembly of components or peripheral equipment has been mooted at times; the scope for this is limited, though, for the multi-nationals by much cheaper labour sources elsewhere (unless there are other positive inducements offered).

Alternatively, some argue in favour of the development of a larger software industry - not so much perhaps to produce systems software, but large applications systems, especially of kinds not readily available from overseas. The Victorian TAB's "CARBINE" system for automatic betting is a classic example of a new kind of applications system developed locally in reponse to a local need, and one that has aroused great interest overseas. By focussing on specific software needs not generally well met, some strong systems houses have already emerged with an export capability. Australia could expand and develop its ability to design and implement systems of various kinds, for both local and overseas use, but the skills required are in short supply, and are not developed to any significant extent in our current university or college courses - further, there is little opportunity for those who teach computing to gain experience, for themselves or their students, with such systems.

It might be argued that the needs of a software industry are relatively unimportant compared with the needs of the great mass of users. It may also be said that courses already exist that produce (possibly too many) software experts. This would be to escape two important points. First, there may well be (as many pundits claim) a move already, away from "one-off" applications programs, in the direction of more versatile, generalised, user-oriented and user-driven, software, as well as towards tailor-made software (like CARBINE). If this is the case, then the conventional systems analyst and programmer as we now know them may be a dying breed; in relative terms, the writers of user-oriented software (as distinct from today's applications programmers) could represent a large future employment market. Second, while many courses do emphasise software, the knowledge and skills needed to write major applications software are _not_ identical to those needed by writers of systems software (operating systems, compilers, etc.); _nor_ do either universities or colleges in Australia have significant experience and expertise in the design and implementation of applications systems.

One point stands out clearly. _The rate of development and the form of development of any local industry will depend crucially upon what policies are formed, or, by default, upon the lack of any policies._ This is true in two different senses. More obvious is the dependence on government policy. For example, while few would seriously advocate establishment in Australia of a major industry producing complete computer hardware systems, as a short term goal, quite clearly this would not be possible without Government policy to promote it. More generally, it is of great significance whether there is a conscious policy, unplanned evolutionary development in reponse to day-to-day market forces, or something in between ("guided evolution"?). The Australian Government's "offset policy" whereby it requires its potential suppliers of overseas equipment to specify what they would undertake to inject into the Australian economy in return, through exports, local manufacture or other activities, is a step in this direction.

It is also true, though, that the emergence of a significant local computer industry of any kind depends upon _educational policy_ to anticipate the need, and possibly even to generate it (much as the existence of a pool of unemployed mathematicians in the U.S. at the end of the Second World War provided impetus to the use of computing, and resulted in the painstaking preparation of masses of mathematical tables). This leads us to a point we make repeatedly - the need, at some level within the planning structure, to examine the interaction of policy issues of different kinds, which within a bureaucracy inevitably tend to be considered in isolation by different departments or agencies with their own legitimate but highly specific areas of concern and responsibility.

[These questions also pose a further question which needs to be asked constantly, in relation to many different policy problems: How, and where, does one strike the delicate balance required between the need for sensible co-ordination on the one hand and the need for scope for grass-roots initiatives on the other? Plainly, there are many needs for co-ordination and for an overall view, whether it is a national view that looks more broadly than at problems of purely State or regional concern, or a "systems view" that takes into account the interactions between traditionally separate areas of policy. Equally clearly, a heavy-handed central bureaucracy that denies individual organisations and persons the freedom to make their own operational or policy decisions "on the ground" from day to day is not the answer. And of course any individual answer to this question depends on one's ideological standpoint as much as on purely technical factors.]

The whole series of questions we have raised under the last two headings are crucial to any long term planning for computing education, and illustrate the dependence of needs for computing education on international factors and on Government policies. The entire orientation of virtually all Australian university and CAE courses in computing is directed towards the application of (implicitly imported) technology. This is true not only of courses in information processing or EDP which aim to produce systems analysts, designers or applications programmers; it is true too of university courses that concentrate on operations research, numerical analysis or aspects of programming languages and systems software. Similarly, in a few courses emphasis is placed on the interfacing of data acquisition, control or other sub-systems to minicomputers or other digital systems; but not generally on the principles relevant to the design of a total general purpose digital computer system. Nowhere in Australian education are the skills developed that would be needed to undertake the introduction of a new range of computers, the design and implementation of an operating system, or even of a major applications system such as "CARBINE" or "QANTAM".

The support requirements of any serious move to an indigenous computer industry, in research, development and educational activities, would be very considerable, and need to be anticipated by several years.

AUSTRALIA AND THE PACIFIC

Australia is placed geographically in the southern part of the Pacific Basin, and increasingly sees itself in a real sense as part of the South Pacific. What does this imply for computing education needs? One possibility, as Australia and

New Zealand are significantly more advanced both economically and technologically than their near neighbours, is of a developing leadership role, not, it is to be hoped, in a domineering or "ugly American" image, but as part of increasing involvement in and concern for the region generally.

Already through ESCAP, the Colombo Plan and other means, Australia is undertaking some regional responsibilities, by the secondment or loan of staff, and through a growing number of Asian students educated here, some of whom are being introduced to computing science or information processing.

Several possibilities exist: we could increasingly provide basic education, vocational training and continuing education for those who wish to make careers in their own countries in the EDP field; we could help in building up local educational programmes in other countries; or we could provide a software development and service centre for the burgeoning computer use in the South Pacific. For any of these, the conditions are favourable: we have the experience, we have many centres of computing education with appropriate staff and facilities, we have a number of software houses interested in export opportunities, and, significantly for our less affluent neighbours, we have a good deal of practical experience in achieving solutions to real problems with computing equipment of modest size by U.S. standards. Once again, the extent to which regional questions are relevant to future planning for computing education depends largely on whether any conscious national policy is formulated.

To take a specific case, what is to be Australia's role (if any) in the development of skills in computing for Papua New Guinea? Papua New Guinea has two major institutions of higher education, both concerned with computing to some extent. Will they bear the full burden of producing the increasing number of analysts and programmers that are expected to be needed? Will the skills be imported, and if so from where? What part has Australia to play in all this? The project received enquiries from Papua New Guinea, but, as with so many factors, we can point to a potential influence on future demands for computing education more readily than we can quantify it.

[Since this section was written, the interdependence of Australia and the South Pacific in computing has been given added point by the direct and implied pleas for Australian help and involvement made at the 1976 South East Asian Regional Computer Conference.]

established in Japan by the year 1985." [Yahagi, 1974]

The work of the Computerization Committee of the Japan Computer Usage Development Institute has gained growing exposure in the Western world in the last few years following publication of English language versions of its various reports [e.g. Japan 1972]. It is of breathtaking scope and apparently unlimited optimism and idealism.

This, together with sometimes idiosyncratic English and the liberal coining of mind-boggling words and phrases, has led some to regard it as if it were an amusing but totally unrealistic piece of fancy, belonging more in the realms of science fiction than of national planning or forecasting - too naive, simplistic and "way out" to be considered seriously.

Such a light dismissal would be a mistake. Senior company executives, university professors and high level public servants, in Japan or elsewhere, do not usually get together for extensive periods and devote much effort to the writing of collective science fiction, presented as a formulation of possible national goals and the means for achieving them.

It would be a mistake also to read the work as a total blueprint for the realisation of the "information society"; indeed the reports themselves carry disclaimers:

> "... if this plan presents some suggestions as to the realisation of Japan's information society and plays its role as a corner stone of such a society, it can be said to have accomplished its mission." [ibid]

Rather, the reports should be considered as an attempt - the only attempt on such a scale - to recognise some of the fundamental changes that affect societies with advanced economies as they inevitably move to an information-based and data-dependent state, to consider the complex overall planning problems involved, and to outline how "computerisation" might be used positively to help create a new society. It is a framework, rather than a plan, although many different objectives and projects are identified, costed and outlined, covering virtually every major area of socio-economic activity. These illustrate the breadth of the "plan".

The stance taken is one of planning by "policy guidelines", rather than of a laissez-faire approach, and this, and some of the specific projects suggested, may be repugnant to some Western readers.

What is important, though, is that the work constitutes a serious attempt to look at the information aspects of social change to the end of the century, the ways in which data technology _might_ be used to promote change, and the benefits and disadvantages that would accrue, together with the fact that most of what is proposed is technologically feasible in a country like Japan if the national goals proposed are accepted.

At this point we should make it quite plain that in presenting a fairly lengthy summary of these proposals developed in Japan we are _not_ suggesting them as a model for Australia, or as a paradigm for exploration of the future, nor do we share their proponents' technocratic optimism about the likely effectiveness of several parts of the "plan". What is important is that the currency of such ideas should be known, and that they are debated. The Japanese reports comprise a scenario for the future of the more prosperous nations, and one with a high dependence upon technology. As such they arouse in some people quite violent emotions, either of hostility or of optimistic enthusiasm. Because they do so, they serve excellently to focus attention on several key questions about the part technology has to play in the future of Australia. Some of these points are picked up again later in the chapter.

It is therefore worth outlining the substance of the report:

The _aim_ is to present "a picture of Japan's planned information society" which it is proposed should be established by _1985_, together with the means for attaining this as a national goal.

The _rationale_ of the plan rests in concern with the limitations of the world's _resources_, and the view that society must move _from an industrial to an information base._ Quoting from Forrester [1971] and the Club of Rome [Meadows _et al_. 1972], the Committee takes seriously the prospect of world ruin because of resource and food scarcity, pollution and overpopulation, and urges _three main goals:_

(1) promotion of the Japanese knowledge industry;
(2) solution of social problems (in medicine, transportation, pollution and distribution), using information technology; and
(3) a planned, smooth but rapid, transition from an industrial economy to an information-based society.

Three _alternative routes_ to the new "information society" are examined: _laissez-faire_ principles, extension of current policies to promote the information processing industry, and sets of policy guidelines with targets and long range plans, prepared "as a result of deliberate and conscious government planning". The first two were rejected as likely to lead to "information pollution", by which is meant "deterioration in the quality of information" in a quite broad sense.

A conservative approach, driven from a commercial base by the forces of free competition, would tend to develop the service and leisure industries and commercial information services, and would increase leisure. Policy guidelines, on the other hand, proceeding from a social base, and directed by government initiative, would develop the knowledge industry, promote the social (medical, educational, etc.) sector of data processing, and would foster the development of individual creativity.

As advanced countries are already moving to a post-industrial information society, the full realisation of the "information society" is proposed as a national target:

> "The ultimate goal of the information society is the realization of 'a society that brings about a general flourishing state of human intellectual creativity'. Intellectual creativity may be defined as a process of exploring into future possibilities by fully employing information and knowledge with the aim of materializing such possibilities.

> "If the goal of the industrialized society is represented by volume consumption of durable consumer goods or realization of heavy mass consumption centering around motorization, information society may be termed as 'a society with highly intellectual creativity where people may draw future designs on an invisible canvas and pursue and realize individual lives worth living."

The full achievement of such a creative society is expected in the 25th century. (!) An intermediate target, the so-called "establishment of computer mind", is proposed for 1985, "that is, the total acceptance of computers in the minds of people".

The money needed for the plan would come mainly from government, spent under government supervision, but the implementation would require full use of the talents and management of enterprises in the private sector; in practice, through "conventional" joint efforts of the public and private sectors. (Perhaps more "conventional" in Japan than Australia!)

A "third sector" would also need to be created and established, comprising government-organised, but privately run, non-profit entities, including the operating bodies for many specific projects in the "information society".

Whilst government leadership is crucial in achieving "fundamental changes in various social and economic systems and practices, and in the value system" [our emphasis], the Japanese regard public involvement and co-operation as essential. A national congress for the development of the information society, immediately under the Prime Minister, with participation by all social sectors; a system of independent reviewers to provide high-level critical advice; and a citizens' policy participation system are proposed to achieve this.

Also outlined are a dynamic "target setting, policy model building and scheduling system" (TPBS) involving the linking of scenario-based models and policy functions, with feedback for evaluation, review and modification.

Four prerequisites were postulated for the information society plan:

(1) During the early stages of the plan (in the late 70s), the transition should be made from emphasis on management information to the development of social information.
(2) Sustained growth (at least 10% p.a.) of G.N.P., concentrated on the knowledge industry, will permit a rising proportion of national government expenditure to be devoted to computerisation and the information society.
(3) The government should develop an integrated computerisation and social information policy.
(4) New educational methods should be developed that encourage intellectual creativity.

The plan has four stages;

(1) 1945-70 (complete): objective - defence and space development
(2) 1955-80 (well advanced): objective - economic growth (GNP)
(3) 1970-90 (already begun): objective - improved social welfare ("Gross National Welfare")
(4) 1980-2000: objective - improved personal realisation ("Gross National Satisfaction")

Each successive stage uses a different base (big science, management, society, and private persons); reflects different value systems; and calls on different kinds of knowledge and skill (natural science, management science, social science and behavioural science).

In addition to having these four stages, the plan calls for two levels, an intermediate plan up to 1976 costing US$3,247 million, and a long term plan to 1985 costing US$64,935 million.

The intermediate plan comprises nine projects, chosen as experimental, pilot spearheads for later development in the information society, each addressing several targets in the long term plan and of a kind that could not be undertaken by private enterprise:

(1) An Administration Data Bank, co-ordinating all official statistical and administrative data, and providing information retrieval and policy models.

(2) A computer-based town, or "Computopolis", with CATV, a computerised vehicle system, an automated supermarket, and regional health control and cooking/heating systems.

(3) A regional remote control medical system in an isolated area, with an automated hospital, medical engineering laboratory, and communications-based remote health care system.

(4) <u>Introduction of Computer-oriented Education in an Experimental School District</u> (see below)

(5) A pollution prevention system in a broad region, with measurement, warning, control and communications subsystems, and a pollution prevention research centre.

(6) A "Think Tank Centre", a large high rise building in Tokyo to house <u>all</u> the nation's think tanks, public and private, permanent and temporary, with common facilities, an education centre, and provision for public participation.

(7) Introduction of EDP to about 10,000 small and medium sized enterprises, initially through assistance in preparing tax returns, leading to preparation of management data.

(8) A Labour Redevelopment Centre, to counsel, guide and retrain 1,000 middle aged or older people each year, using information on new employment opportunities.

(9) A Computer Peace Corps, undertaking at any time about ten social and technological development projects for developing countries.

Of particular interest here is the <u>educational pilot project</u>. The school district chosen would introduce computer-oriented education from kindergarten to university level, with four elements: rationalisation of school administrative and office work; individual educational guidance; computer-oriented education proper; and an educational science research centre. The main aim is to develop more individualised and problem solving approaches to education, and to compare the success of these with conventional, uniform and standardised, approaches.

The long term plan, aimed at fostering individual creativity, requires realising (by 1985) the <u>intermediate target</u> of establishing a "computer mind"; education is seen as the leading part in all major projects for this period:

(1) Formation of a nation-wide, communications-based information network, with coaxial and microwave links supporting a million communications circuits for facsimile transmission and time-sharing.

(2) Establishment of an administrative data bank, using magnetic tape and microfiche, for national and regional, government and non-government, administrative rationalisation.

(3) Upgrading of management information systems, for use at management, executive and multinational levels.

(4) Computer-oriented education, continuing from the pilot project, with emphasis on individual development, problem solving skills and the use of CAI to personalise instruction.

(5) Modernisation of health care.

(6) An integrated pollution prevention and preclusion system.

(7) Modernisation of distribution, to reduce the price of fresh food.

(8) The diffusion of (low cost) home terminals; an estimated 60,000 computer terminals would be installed in the homes of professionals, managers and small businessmen by 1980; by 1985 there might be 250,000 home terminals, priced and regarded much as TV sets are today. They would be used in the home for shopping, education, budgeting, etc., and would form part of a shift away from the use of cars to the use of computers.

(9) International co-operation, with 0.1% of national GNP devoted to computer-based international aid.

(10) Positive measures to eliminate the disadvantages of computerisation, including measures to protect privacy, eliminate information monopoly, prevent computer crime, and retrain those with technologically obsolescent skills.

A major part of all these projects is an educational programme, in many cases incorporating new educational centres open to appropriate members of the public.

The Committee is well aware of the disadvantages inherent in their proposals, and elaborate on these along with the cost and non-cost benefits of each project.

Utopian schemes may be unfashionable in the Western world, and many of the Japanese proposals are undoubtedly highly controversial. Nevertheless, it is scarcely possible to ignore this, as one vision of the society of the future, in which computing not only has an essential and major part, but in which it is seen as *the* major tool to help alleviate the world's chief problems. In presenting the Japanese plans we do not imply either that we support them or that we consider them appropriate in an Australian setting; we do, however, wish to indicate the extent to which computer-based data technology has already permeated advanced societies and is likely to do so in the future. Such technology also enters, in a quite complex way, as both cause and effect, in many social subsystems.

One of the values of the Japanese publications is that they spell out in detail what appear to be the logical conclusions of current technological trends, and try to examine how data technology could be harnessed to serve community needs in a coherent and planned fashion. If the high level of dependence on technology that is implied is repugnant to the humanistic values of some readers, then it as well to bring the value conflict into the open; we in Australia show every sign of increasing our dependence upon various forms of technology, including computer technology, and there is as yet little sign of serious discussion about alternative, less technological, approaches, and their implications for society.

CHINA

If we try to outline the most likely overall scenario for Australian society in the comparatively short term - in general, or as it impinges specifically on computing - we must clearly take into account first the current political, economic and technological dominance of the Western world, and notably the influence of the U.S. and the U.K.

Quite apart from the strong ties of trade, imported technology, and language, and strong traditional ties of history, culture, education and travel, we import many of our cultural and social values. Along with American and

British television programmes, Coca-Cola, Colonel Sanders' chicken recipe, and the assorted products of multinational corporations, we cannot (whether we wish it or not) avoid exposure to the values and mores of other English-speaking countries.

Our scenario must obviously incorporate also regional influences and the effect of Australia's geographic position on its future.

In the medium term, the influence of Japan cannot be ignored, as just discussed.

And yet ... a lingering doubt must remain that any such scenario may prove inadequate in the longer term. Is it enough to consider just the West and Japan? Even if we reject the simple view that Japan is trying to emulate the West, and transform itself into a Western style state, with a Western economy and society - even if we accept that Japan is distinctively Asian, and will maintain the integrity of its rich and ancient culture, can we ignore the rest of Asia, and notably China?

The question has two aspects.

First, for our purposes, is it appropriate simply to assume that the major influences determining the future (or, in Emery's terms, the "leading part") lie within the Western societies with which we are most familiar? Second, if this is not the case, should we look to Japan or to China in the long term to provide the emerging influences that will shape our future?

At first sight, it would seem plausible to argue that Japan, with its highly developed technology and industrial economy is likely to be a significant influence on Western (and especially Australian) futures, whereas China is not. This would seem especially true with respect to computing. Compared with Japan and the Soviet (with its undoubted expertise in computing in support of national objectives of the conquest of space and the development of heavy industry, and a great tradition of brilliance in cybernetics), China's entry to the computing field has been relatively late. Mao's objectives have been to build up, not heavy industry, but light industry and agriculture ("taking agriculture as the foundation and industry as the leading factor").

But _is_ this the whole story? China is a nation of such size, with such an ancient culture and a high degree of homogeneity, and has achieved such a radical transformation in the last thirty years, that it is impossible to ignore it. Emery argues cogently that in fact China is emerging as _the_ "leading part" in Asia [_op._ _cit.,_ pp. 97-114], and in particular he sees Mao's model of the future, in stark contrast with Soviet and Western models, as one peculiarly fitted to cope adaptively with "turbulent environments".

Where does this lead us? If China does emerge as the dominant world force in the future, not in a purely military or political sense, but through its overall effect on the societies of the world, what might this mean for Australia, specifically in regard to computing?

Perhaps a suggestion of Emery's holds the key: It lies in the evolution of a new relationship between China and Japan:

> "Under the Chinese nuclear umbrella it seems more likely that Japan will seek a modus vivendi with China. For the Japanese such a modus vivendi is not likely to be acceptable unless it allows them to be thoroughly Japanese - there is no historical reason for them to assume that this might be harder to achieve under Chinese influence. Japan may not be able to survive nuclear war with the Chinese but the Japanese are able to make physical occupation unprofitable.
>
> "Given the hard facts of the present and self-confidence in their territorial integrity the Japanese may find it easy to see a new destiny in a 'younger brother' relation with China ...
>
> "[The Japanese] will actively foster relations with China, and in some sort of partnership with China, with the rest of Asia. ... A culturally renewed Japan could expect as 'the powerhouse of Asia' to achieve the proper respected role she earlier sought in her Greater Asia Co-Prosperity Plan ...
>
> "Thus a partnership with a new Japan - a non-agressive Asian oriented Japan - must seem to the Chinese to be the key to long run peace and stability in Asia. ...
>
> "Japan's great knowledge in the fields of electronics, micro-miniaturisation and computer technology would become available to China."

Very tentatively, then, one can sketch out the key elements of one plausible scenario that does not ignore China, and that has implications relevant to our planning for computing and computer education.

Within one or perhaps two decades, if a new alliance is built between China and Japan, the global influence of China could be enormous, and Japan, in a "younger brother" relationship, will have a crucial role as a supplier of technology to China, and as the technical leader of the whole South East Asian and Pacific region, with its already considerable power and influence strengthened and reinforced by its special links with the world's largest and Asia's dominant power. Such a symbiotic relationship with China, after a history of war and bitterness, would be no more remarkable for Japan than its abandonment of three centuries of isolation from the Western world; and it would add great weight to any bid Japan might make for world pre-eminence and leadership in micro-electronics, computing and telecommunications.

This is by no means the only possible scenario. China has already developed its own general purpose digital computers, using integrated circuit technology, and while the need to establish links with other countries and to expand international trade is accepted, she has consistently followed, under Chairman Mao, principles of independence and self-reliance. As China's GNP steadily increases, and more immediate goals are attained, she could even aspire to her own regional role in computing, based on native ingenuity rather than on borrowed technology.

If either scenario became true, the implications for Australia and Australian computing would be profound. We would certainly need to consider whether in this regard we wish to be a part of Asia or an outpost of English-speaking civilisation in the Pacific. Particularly under the Emery conjecture, future developments could affect our sources of computer hardware and software, our own leadership role in the Pacific, and the form and direction of any significant local computer industry.

The further we peer into the future, the less certain we can be. However, it would be rash to assume that those who pass through Australian universities and colleges in the 70s and 80s will use predominantly Western computer technology for the rest of their careers.

IMPLICATIONS FOR THE PROJECT

Australia is an isolated country with an advanced economy, set in the Pacific. It now imports most of its computer technology.

As foreshadowed at the search conference, and discussed above, our national needs for computing education will be significantly different, depending upon whether some form of technological independence and the establishment of a distinct local industry are pursued as goals, as well as upon regional and broader international questions. These in turn depend crucially on the evolution of national policies.

Economic Change

PROSPERITY

The most obvious, continuing element of economic change in Australia is the enjoyment of greater prosperity, not only in real per capita terms, but also relative to most other advanced economies - because of Australia's advantages in natural resources. Assuming that effective government instrumentalities and programs for social innovation are set up and remain in use, this wealth will be rather more evenly distributed in future than it is at present.

The fact that much of Australia's continuing prosperity, especially relative to other Western countries, derives from the possession of scarce resources (uranium, oil, and other minerals) not only poses political and moral problems, but contains also the seeds of future uncertainty. Inevitably some form of international resource sharing will be needed, at least within 30 or 40 years, if violent (and possibly bloody) tensions are to be avoided. It remains to be seen how successful Australia's resources policy is in overcoming political difficulties while maintaining some of the benefits of our comparative advantage. It is not the place here to explore this further, nor the moral and distributional problems of our position vis-a-vis the third world, but it <u>is</u> important to point out that this is a significant factor in the total dynamics of change. Much of the following discussion is necessarily specific to Australia as an affluent Western nation, without any value judgments being implied.

The continual rise in the real per capita incomes of individuals in advanced economies, which stems mainly from technological innovation (of which computer-based innovation forms a growing part) [Smith 1968; see also Simon 1965], is resulting in a steady increase in their discretionary time and discretionary income. It is only because most individuals in industrial (and post-industrial) societies now have <u>some</u> discretionary income and some discretionary time (not accounted for by work, sleep, essential travel, etc.) that much of the recent questioning of values and attitudes, and much of the rebellion, has been possible.

Also, as rising affluence is steadily improving the real "standard of living" (in dollar terms after "indexation") of the <u>average</u> income-earner, more and more are asking whether "standards of living" measure "the quality of life". Various distributional and value questions keep arising, Galbraith having been the first popular prophet [Galbraith 1958].

Both of these questions are taken up again under the heading of "social change".

CHANGES IN THE WORK FORCE

In more narrowly economic terms, technology-induced growth is causing shifts in resource allocation and in the distribution of the work force. Quite apart from a probable shift in resource allocation from the private to the public sector in pursuance of social goals (for instance, health, education, welfare and urban development), there is a pronounced and continuing redistribution of the work force from the primary and secondary to the service and knowledge-based sectors. Not only do these sectors include most of the areas of computer-based industry; they also include many key areas for computer applications in the future.

The most significant change in the Australian work force in the thirty years since the second world war has been the growing proportion of women in the work force. As pointed out in the recent Borrie Report [Australia 1975a], this proportion will continue to grow, almost entirely because of the entry of additional <u>married</u> women, for about another decade. It seems likely that active discrimination against women will reduce, and that women will in future be employed in a greater variety of jobs: many more will be in professional or managerial roles.

Distinctions between white collar and blue collar employment have blurred considerably already, and will become even more blurred; it seems likely that retention rates into post-secondary education will continue to rise for some time, and that consequently the average educational attainment level of the work force will be generally higher, as has happened in the U.S. in the last ten or twenty years. (However, a contrary trend may emerge, and eventually dominate, if recurrent education is accepted as a normal pattern, with progressive lowering of the age for compulsory schooling, and more diverse opportunities for work and education throughout life. This could make current concepts of "retention rates" increasingly irrelevant.) If recent trends continue, however, a very likely consequence (of which there is considerable evidence already in Australia) is that the educational requirements for entry to any particular category of employment may rise - because of the use of educational qualifications by employers as a screening device, rather than because of the intrinsic educational demands of the jobs. Also, as in the U.S., unemployment rates for those with minimal formal educational attainment will be high (even by 1974-5 Australian standards), and higher than unemployment rates of the better qualified.

THE "INFORMATION INDUSTRY"

There is increasing reference to an "information industry" or a "knowledge industry". Is there such an industry, and, if so, in what does it consist, and what is its relationship to computing and computing education?

In a celebrated work Machlup [1962] made a number of assumptions in an effort to define the "information industry", in which he included such diverse activities as education, research, publishing and the media generally. On this basis he estimated that its contribution to the G.N.P. of the U.S. in 1958 was between 23% and 29%, and that its growth rate was double that of G.N.P. If the information industry plays such a substantial part in industrial societies, it is high time it was more carefully studied.

Lamberton [1974a; see also Lamberton 1971] suggests that there are several ways in which we can approach the idea of an "information industry" and of an "information revolution". First, there are overall concepts such as those of the "post-industrial society". Then, there are studies (such as Machlup's) into the contribution of information activities to G.N.P. and to economic growth; and finally, there are detailed studies into how people make decisions and use information.

We should also note that there are increasing efforts to define what may be referred to as an "information policy". Most of these, unfortunately, have concentrated narrowly on scientific and technical information (STI), often as specifically measured by some index such as the number of papers published. A recent study that tries to avoid these restrictions was commissioned by the O.E.C.D. [Anderla 1973], and before returning to the issues raised by Professor Lamberton it may be useful to summarise some of its key findings relevant to this project.

The O.E.C.D. study attempted to estimate the supply of, and demand for, STI, and to make long term forecasts of the qualitative and quantitative needs for information specialists. At the outset, Anderla distinguishes three possible concepts of "information". The narrowest, the conventional view of STI, considers only that information which is an input or an output for the research and development process.

"A broader view, which might be called socio-cultural, holds that information and transferable knowledge are one and the same thing. On this basis all information transfer should be defined as a transfer of knowledge not merely serving the scientific community, but a whole range of activities: training, education, culture, mass media, medicine and possibly certain tertiary services.

"A third school of thought which is rapidly gaining ground regards information as a resource, a resource as fundamental as energy or matter which affect all human activity, and as an indispensable, irreplaceable link between intellectual and material activities. This overall concept of information is bound of course to lead to one conclusion, namely that information must be at the service of the whole community." [p.8]

He follows each approach in turn, and by extrapolation forecasts that STI will continue to grow <u>at least exponentially</u> for 10 to 15 years, with an increase in the volume of STI by a factor of from 4 to 7 in 15 years.

Next, taking the socio-cultural (or "information = knowledge") approach, and using scenario-based and Delphi forecasting techniques, he predicts sustained expansion of the knowledge industry - basically following Machlup's definition - for 15 years. The central finding, based on the consensus opinion of hundreds of experts, is that "<u>the future of the knowledge industry</u> and all its components, without exception, <u>is closely related to the automation of information</u>". [p.69] "The unanimous view is that during the decade 1980-90 automated information will <u>entirely</u> replace the more or less manual processes at present transmitting and disseminating knowledge." [Our emphasis]

The study sketches out the sequence in which the introduction of automatic information systems is likely, compares the forecasts with manufacturers' forecasts of trends in computer costs, storage costs, and computer performance, and concludes that they are quite consistent. Further, the margin of error is quite small. A major feature of the growth of the knowledge industry, especially in the 1980s, is the spectacular increase in educational demand expected (a short term doubling of "needs" every ten years), together with extensive use of computer-based technology of various forms, changing roles for teachers, and growing use of both computer terminals and CCTV. By 2000 A.D. the study expects computer terminals to be as commonly installed as telephones are now, in O.E.C.D. countries. The number of automatic information systems is expected to increase by between 50 and 100-fold in 15 years, with declining computer costs making this possible.

From this analysis Anderla comments on the kinds of specialist needed: those who collect, validate, and process primary data; those who act as intermediaries between information specialists and end users; and at a higher level, the analysts. These must be more specialised, yet interdisciplinary, and able to carry out both analysis and synthesis. [p.88]

The O.E.C.D. study finally takes a global approach to information, treating it as a basic resource of value at all levels - societal, institutional and individual. From a morphological analysis, predictions consistent with the previous ones, based on narrower concepts, are obtained. In particular:

> "The impetus of the growth of the transfer of knowledge seems to be ensured by some independent intrinsic force, which acts synergistically with all the other growth factors. In 1985-87 the annual production of new information can be expected to be 6-7 times greater than at present, i.e. a growth of 12.5% p.a. while the progress of automation will proceed initially at less than, then at more than 30% p.a." [p.123]

From the study, it is concluded that the 1980s will be marked by <u>revolutionary change</u> because of the large scale automation of information, with consequent strong impact on many fields, including education and management. Many problems are foreseen, and positive measures for international monitoring and assessment (including modelling) are recommended, as well as the establishment of an Institute for Information Science and Technology, and the development of policies (including a charter of rights, technical co-ordination and manpower policies).

As Lamberton argues, the role of the information industry has lacked the serious study it deserves in economics. Innovation and technological change have largely been treated as an exogenous contributor, from outside the system, to economic growth. Yet the broader concept, such as Anderla's, of information as a <u>resource</u> has been taken by some as far as to claim that information is a factor of production, entering into any production or consumption of wealth, as well as a factor in decision-making.

In fact information and the information industry are at the heart of one of the two main thrusts currently challenging the orthodox economic theory of the firm [Cyert and March 1963, pp.4-21]: on the one hand, traditional analysis is opposed by those who deny that firms exist solely to maximise profits, and who claim a much greater complexity in the formation of organisational goals [see also March and Simon 1958]; on the other hand, the assumption that firms operate with perfect knowledge is questioned, and much work has been done in recent years on decision-making under conditions of uncertainty.

If knowledge is incomplete, the need for information in decision-making is clear, and new developments in communications and computer technology are transforming the technology of information, and increasing the importance of the whole "information industry". This implies a shift of emphasis in economic analysis from <u>production</u> (relevant to a nineteenth century agricultural economy) to one on <u>prediction</u> (in a twentieth century information-based society).

Lamberton's current research, starting from a functional analysis of the sectors of the Australian information industry, hopes to lead to appropriate statistics and thence to a study of the complementarities and lags involved, and ultimately to the application of input-output analysis.

Any attempt to study the information industry must lead to two main conclusions. First, <u>public investment</u> is heavily involved in most aspects of the industry and much of the marginal analysis applicable to a market economy is ill suited to address problems (especially those of valuation and pricing) in the public sphere. Second, there are many important <u>interactions and complementarities</u> involved. As Professor Lamberton says, in what could almost be taken as a text for this chapter:

> "Our need is for better theories, better understanding of the complex interactions of the economic, technological, political and sociological factors."

The emergence of a large and growing information industry would seem to have profound implications for the subject of this study, but it raises many problems - theoretical, practical and social. The twin technologies of communications and computing are the chief driving forces currently impelling its growth in modern Western societies, and the complex web of interacting components of the industry suggests that we will not reach much understanding of the future of any component (including computing or education) by studying it in isolation.

Further, Anderla's study not only makes it clear that the applications of computing to information processing and transfer are likely to increase at an astonishing rate; he forecasts the transformation during the 1980s of most components of the information industry, including computing and education, along with radical changes in occupational roles. Finally, the heavy public investment in the information industry indicates a high degree of interdependence between the policies in many different fields of governments in advanced economies.

There are deep social questions that underlie the economics of information. People do not typically regard information in any sense as a commodity like other commodities, and our social and legal systems have not yet developed clear notions about property rights in information. [Although there are pressures in this direction: witness both the lobbying of the Australian Copyright Council and some of the informational arguments about privacy put before bodies like the Law Reform Commission.] Yet "information is power". The distribution and control of information, if it is indeed a major contributor to wealth, could be as important to the distribution of wealth in the future as the distribution of capital has in the past. This could be true between nations, between sectors and industries, or between classes of individual.

GOVERNMENT/INDUSTRY RELATIONSHIPS

Part of the general pattern of increasing complexity and connectivity in modern society is the development of a more difficult role for government in many ways. This complicates government/industry relationships in Western mixed economies, and reinforces the tension between radical and conservative ideologies or, in Galbraithian terms, between public squalor and private affluence. These are similar in many ways to the tensions, on the social or personal level, between individual autonomy and social connectivity.

Social Change

FUNDAMENTAL CHANGES

Deep and fundamental changes are transforming the world in which we live. This is true in at least three different senses. First, some changes have taken place that are irreversible. Second, the pace of change is not merely rapid - the world has coped before with rapid and abrupt change - but is probably accelerating. Third, as discussed earlier, in a fundamental sense the social environment is altering in its dynamic properties and in the processes of adjustment to change that are appropriate.

One reason for the rapidity of social change is that the world is becoming much smaller because of improved communications. In Marshall McLuhan's words, we now live in a "global village". In our Western style societies, an irreversible change has probably occurred. A television set is now a normal item in most Western households, bringing the disasters of the world (and occasionally its joys) into our living rooms; we have an immediate awareness of the rest of the world never known before. Those who have been born in the last thirty years have been brought up with the awareness that nuclear annihilation of the world as we know it is a real possibility; in this sense they are different people from those of us whose upbringing was not clouded by such shadows. In the same sense, those who live today are in an irreversibly different world from that of the 19th century.

Even more generally, there is in the Western world much greater international and local mobility, and increasing social connectivity and interaction at all levels. We are, to an ever-greater extent, directly affected by the actions of others - whether the context is inflation, pollution, shortages of industrial raw materials, urban living, or the workplace. Consciousness and understanding of social change is increasing, but is still limited. One likely consequence of the growing complexity and "social connectivity" of everyday life, as it affects government, business and organisations generally, is the increasingly important role of the "information manager" in various guises, who has a growing dependence on computer-stored data and computing techniques.

Increases in the discretionary time and discretionary income of most individuals, because of increasing prosperity, have had profound social consequences. Less than 300 years ago, for most - especially those in towns - life was "nasty, dull, brutish and short": except for the fortunate few, there was no formal education, and life was almost entirely filled by constant, exhausting and often demeaning work and essential sleep. Leisure was limited mainly to booze, for its anaesthetic qualities. The income of most was mainly committed to the essentials of food, clothing and shelter. Since the days of the early hippies, our affluent societies have been aware that for some "ordinary" people it is possible to <u>choose</u> not to work (at least for a limited period, until savings or Daddy's allowance run out). Others prefer regular part-time work. Further, for a growing proportion of people there is a real choice as to how income is to be spent.

Thus on the one hand, increases in discretionary time and in discretionary income have made it possible for significant numbers of people to question accepted values and how they wish to live. First, increasing leisure and growing literacy and education have given people time to think about what they value and what they wish from life. Second, dramatically improved mass communications have made it possible for some people to become aware of the questioning, argument and propaganda of others. Third, and most important, growing affluence makes it possible for there to be a real choice. Increasingly, if someone wishes badly enough to do something, or to follow a different life style, he (or she) can now do so; he is not locked in by the stark economic necessity to follow the same pattern as his parents and grandparents, and limited to daydreams.

On the other hand, in many ways we are experiencing social connectivity - no man is an island, and we are affected deeply by the actions of others.

Inevitably, there is tension between the two, between the press for individual autonomy and the necessity of connectivity. This, combined with the rapidity of social change, is leading to extreme social tension and value conflict, with every indication that tension and conflict are growing.

Many illustrations could be given, showing that there is a new phenomenon at work in Western society in the 70s that can not be glibly dismissed as the product of a "generation gap" we have always had. Bitter conflict about Vietnam and about the moral issues of foreign policy; disillusionment with established methods for running a country, coupled with post-Watergate feelings of utter impotence in influencing the political, military and corporate power structure; violent differences between the conservationists and environmentalists and those with vested interests; Nader-style consumerism; women's control of their own fertility and the questioning of established sexual morality and the nuclear family, and the corresponding concern with the "permissive society" and opposition to such measures as the Family Law Bill; the growth of a strong and vocal "counter-culture"; the use of both non-violent civil disobedience and violent demonstrations and sabotage as forms of protest and attempting change; the use of hijacking, assassination and letter bombs as political methods; pack rape, football riots and other increasing gratuitous violence; the emergence of a "law and order" lobby; and of ultra-right wing and even paramilitary political groups; the development of commune movements of diverse bases and ideologies; the battle for, and acceptance of, student participation in university and college planning and government; the exercise of "green bans" by unions; growing questioning of religious norms - theological and social re-evaluation within churches, total rejection of any religion by more and more, and the popularity of new sects and of ancient mystical religions; rejection of economic and population growth by many as values or goals, in favour of "quality of life" (variously interpreted) --- all of these represent polarisations and tensions about emotionally charged issues and the questioning of values on a scale hitherto unprecedented in our society. They are the product of rapid, turbulent social change, <u>and</u> contribute mightily to the process of change.

There is every indication that such tensions and conflicts will continue and heighten throughout the rest of the century. Some will embrace and enjoy the results of change, but reactions to social change and stress will increasingly result also in the fragmenting of society into such groups as: the violent, extreme activist and semi-revolutionary; the superconservative, reactionary and repressive; the drop-out and the cop-out; and the ostrich groups.

<u>If dramatic social changes are occurring, educational planners ignore them at their peril.</u>

WORK, EDUCATION AND LEISURE

An essential part of this process is the change taking place in attitudes to work and to leisure. Traditional "work ethics" have been questioned; the "Protestant ethic" dies hard but is now much less prevalent. The range of options is continually increasing.

Union pressures are building towards more leisure rather than solely towards greater income, and there seems little doubt that over the next few decades most Australians in the work force will enjoy a shorter working week and longer annual holidays. Longer paid long service leave, study leave and sabbatical schemes, are also possibilities, although unlikely to be achieved by many in the near future.

Even those who feel the press for material possessions are able, in our kind of society, to realise their basic family needs at an earlier age, bringing forward the leisure-hobby-travel period. For some, paid long service leave offers the opportunity for extended travel or the pursuit of "non work" activities, instead of having to wait until retirement. For others, the distinction between work, education and leisure is increasingly less meaningful. Yet others, freed from immediate financial worry and the burden of guilt that comes from feeling that those who do not work are parasites, are able to drop in and out of active employment more casually than their parents could have found comfortable.

The nature and quality of work is also being questioned, especially as technology is making possible radical changes in the way in which work is carried out.

Because of all these influences, fewer and fewer people can (or wish to) map out and follow a single, clear career path for the "whole of life"; increasingly people are making marked and even abrupt changes in career, partly because of changes in technology and partly because of more fundamental but subtle social changes.

Organisational and Managerial Change

ORGANISATIONAL STRUCTURE

Concurrently, new and more diverse organisational structures are emerging, with more and more departure from traditional, hierarchical forms, both in the private and the public spheres.

Many different patterns are now advocated and used, including fluid project teams and task forces (as well as "disappearing task forces"), and semi-autonomous work groups emphasising worker participation [Emery and Trist 1969].

There are several key common elements in most of these:

* reduction in rigidity of both hierarchical control structure and of leadership roles;

* moves away from fixed, specialist functions for each individual towards more generalist functions (at all levels of skill: whether towards an interdisciplinary professional, a skilled worker using the skills of more than one trade, or an unskilled worker who is no longer tied to a specific piece of plant or a specific process);

* consequent greater interaction between workers, with emphasis on teams and work groups, rather than on relatively isolated specialists carrying out predefined functions on their own; and

* greater system redundancy.

MANAGERIAL STYLES

These changes in organisations are paralleled by changes in management styles and attitudes.

While about a third of Australia's work force is employed in more than a quarter of a million relatively small businesses, a third are employed by governments at various levels and another third are in big business.

Many factors, including the growing complexity of organisations, and of the world in which they operate, together with the continuing knowledge and information explosion, are making the task of the manager (private and public) much more difficult. Part of the problem is the increase in the extent and forms of interaction by organisations with their total environment - the corporate equivalent of "social connectivity" experienced by individuals.

Some commentators believe that these problems are creating a vital role for the "information managers", who help their organisations cope with this growing complexity through the manipulation and analysis of ever more, and more pertinent, information. Increasingly, both the information management and the quantitative techniques for their use depend upon computing.

Certainly we can see, here as well as overseas, greater reliance placed on the use of data banks and upon the quantitative methods of management science and operations research, especially as a growing number of M.B.A.-style graduates and others with similar orientations (including many engineers) attain management responsibility.

The progressive development of computer applications mirrors this trend. The earliest phase of computer use in most organisations has usually involved the automation of routine record-keeping and clerical functions. This is usually followed by more complex applications, with exception reporting and other aids to the simplification of middle management. The final phase that is now strongly apparent, and which often depends on successful implementation of the two previous phases, involves the use of computing (and sometimes of extensive data bases) to produce aids for senior management. These do not necessarily require "total information systems" of the kind envisaged in the early 60s, but rather make use of simulation, modelling, and mathematical techniques in the solution of problems in financial management, forecasting, the evaluation of alternatives, production scheduling, inventory control, personnel planning, and so on.

The effect of computing on managerial styles and attitudes is many-faceted; in predicting the future it is more relevant to identify the attitudes of those who will be in top management positions in ten years' time than of those who are chief executives now. In the project, some effort was made in the surveys and interviews to gain insight into management attitudes to computing, but there is a need for much more intensive study in this area.

TECHNOLOGY, ORGANISATIONS AND WESTERN SOCIETY

In the last thirty-odd pages we have touched on many contentious issues that are quite fundamental to the future of computer technology and its use in Australia, and to the need for people with computing skills. We are well aware of many conflicting views, values, ideologies and arguments relevant to these issues.

Among the key issues are:

* The role of the "information managers" in planning and coping with complexity.

* The dependence of organisations and of societies upon technology.

* The relative importance, and relative demands for resources, of the private and public sector, and of the service and knowledge-based and other sectors of industry.

It has been argued strongly by some (for example, by Emery and his colleagues) that the kinds of changes in organisations outlined above will lead to "debureaucratisation", and in turn to <u>reduced</u> dependence on information managers and computer networks. The picture we give here is certainly less bureaucratic than the one (for example) which emerged from the research project's search conference. However, we would regard it as too facile to dismiss in less than two pages, as Emery and Emery do in <u>A Choice of Futures</u> [Appendix B], "the assumption that computer development would have a major influence on human communications". They claim that the demands for large-scale computer technology historically came from the military, and that the new minicomputer, not the network, provides the (only) appropriate technology for the future:

> "If our future lay with bigger and more powerful bureaucracies ... then the future would indeed be secure for IBM and Control Data. It does not lie there and we are more likely to see the dismantling of existing centralized data banks than their further growth ... The needs that have been forecast are falsely predicted on the persistence and growth of bureaucracy. The chequeless, cashless society is based on the same premise." [Emery and Emery 1975, p.204]

We wonder whether even a substantially debureaucratised society would not require quite significant use of and dependence on data banks and computer based data to meet the needs of growing complexity and social connectivity.

This point is related to the second one. Many people, especially those who place a high value on personal autonomy and individual freedom, reject technocracy and the view of the world that they see presented to them by a supposedly value-free technology. (This is something on which we have written in our more recent work on education and technology for the APO.) Much of the "alternative technology" movement proceeds from such a value position. Yet, whatever our personal values may be, it is hard to escape the consequences of two fairly simple observations: First, much of our economic growth depends upon improvements in productivity that in turn stem largely from technological development, and, whether we like it or not, we currently live in a growth-oriented society. Economic growth is now increasingly questioned as a goal, and the Galbraithian picture of its pursuit is not a pretty one. But we do not yet know, at least at all well, how to run our affluent Western mixed economies differently. Second, a very large part of the infrastructure of our society already depends upon its computer technology. For many of our essential enterprises it is already too late to pull out the plug. Nearly every meaningful indicator of computer use in Australia continues to show a roughly exponential growth rate. We do not claim that all these curves will continue their present course indefinitely, but it is hard to see by what mechanism our present degree of dependence on technology - whether we like it or not - is likely to reduce at all sharply within the next one or two decades.

The final point relates to the apparently inexorable move into the post-industrial society. For a variety of reasons, an increasing proportion of resources is being allocated both to the public sector and to the quaternary or knowledge-based industries of the country. This may not be attractive to everyone, again for many reasons, but it is not clear by what process these trends are likely to be reversed. Even before the recent [and current] economic difficulties, Australia was experiencing a marked decline in the number of small private enterprises that previously had been so characteristic of the nation. Unless this trend, and the move towards the Welfare State, are reversed, the demands of the larger organisations that feed upon data will assure the computers and their acolytes of secure employment for some time to come.

Much depends upon our time-frame in attempting to predict the future. It is clearly extraordinarily difficult to foresee to the end of the century, and some of the key determinants over this period are ideological: what social values will prevail? However, we are not inclined to believe that there will be any marked decline in the rate of growth of computing use, in the short term at least, because of social and organisational change. There may, however, be substantial changes in the kinds of use to which computers are put.

A Basis for Forward Planning

So far in this chapter we have set out:

* To demonstrate the need to consider policy questions, such as future needs and resources for computing education, from as broad a frame of reference as possible, taking into account many interrelated factors.

* To review some alternative ways of looking at the future.

* To identify crucial areas of change.

* To refer back to the work of the search conference as a possible basis for a model.

* To discuss some of the main factors (of international, economic, social and organisational change) relevant to computing education.

MODELS AND PLANNING

It would be pretentious to describe Figures 1 or 2 or the previous discussion as a "model"; yet they could well form the basis of a useful model of the system with which we are concerned. A good model normally serves several purposes:

(1) By selecting and abstracting from a mass of complex detail, it simplifies the system under study.

(2) It has explanatory power in that it helps us to understand how and why the system behaves as it does.

(3) It has predictive value: we are better able to forecast how the system will behave in the future.

We believe that some such "model" (although not necessarily a formal mathematical one) is sorely needed as an aid to policy formulation in many areas of national concern, where policy decisions not only depend upon, but influence and determine, the future. Many policy sectors have long-term implications, including not only education, but transportation, urban planning, defence and many others, because of dependence on population projections, population distribution, capital investment over time, or cash flow. The particular case of computing education is simply one that is both intrinsically long term and subject to rapid change.

In this sense such "models", appropriately refined, could assist in planning at the national and State levels, as proposed by Mr Cappie-Wood in his Sidney Luker Memorial Lecture [1975]:

> "Planning should be seen as a truss rather than a straitjacket, a means rather than an end, a technique rather than a cult. ... planning is not a blueprint that must be followed line by line to erect a predetermined structure...
>
> "[The] net result [of central planning] should be to maximise the developmental efforts of the whole public service and ultimately the whole community. I am not thinking of inflexible 'five-year plans' ... but an adaptable, continuing process of analysis, projection and review. This will not undermine the initiative of the private sector or of individuals, who will at all stages be consulted and supported rather than directed and suppressed."

As he pointed out, much of the data needed is already available. What is needed is appropriate machinery to co-ordinate and correlate it, produce overall "plans" based on it, and subject these to periodic review. To this one should perhaps add that one needs a conceptual framework, a schema, or a set of "models" to relate the plan to, and a group of dispassionate critics to examine, test and improve the framework.

In a project such as this, it would have seemed almost a professional dereliction not to try to use the "systems approach". We suggest that such an approach could be fruitful in many other, and broader, policy and planning areas, both within and without education.

ALTERNATIVE APPROACHES TO THE FUTURE

There are many approaches to forecasting; in the project we have made some use of a form of the Delphi method, and considerable use of scenario-writing. Trend extrapolation would appear to be of value mainly in limited technological forecasts; it can take no account of complex interactions between technological and social changes, nor of "phase shifts" that take us from one trend line to another.

Model-building (in the sense of building systems, or component-interaction and information flow, models) thus seems to offer the greatest scope. It would be a useful preliminary before other techniques, such as cross-impact analysis, were used. The kind of systems model that is appropriate (starting with a diagram like Figures 1 and 2), is based on analysis of the nature of the relationships between the components. Reduction of the whole model to a pure mathematical form (e.g. to a system of equations, as in many econometric models, or a set of inequalities, as in linear programming) seems unlikely to be feasible or particularly useful, although ultimately a simulation of the model might be possible.

For use as an aid to policy formulation, system goals should be explicitly formulated (in itself a useful exercise), and provision must also be made for the policies (of governments, public institutions and private organisations) to be incorporated, as components or as parameters. In this sense the model would resemble the TPBS system proposed by the Japanese.

[There appear, however, major pitfalls in an undue emphasis on the identification of systems goals and objectives or, even more specifically, of measures of system performance. Such an approach is typical of operations research workers since Churchman [1968] and of the technology assessment movement. As Katz and Kahn [1966] say: "... the stated purposes of an organization ... can be misleading. Such statements of objectives may idealize, rationalize, distort, omit, or even conceal some essential aspects of the functioning of the organization. Nor is there always agreement about the mission of the organization among its leaders and members." Further, the systems with which we deal here are not simply human organisations but broad social systems in which a plurality of values and goals must be recognised. They are, quite fundamentally, "open" systems, in the sense of von Bertalanffy and his successors, and enjoy a rich interaction with their environments.]

If such a model is to be of value, it should select the <u>appropriate elements</u> of the system and properly represent their <u>relationships.</u> Otherwise it is unlikely to be much help in either explanation or prediction.

COMPLETENESS

The first question we must ask of any proposed model is: "Is the model complete?"

While our discussion is far from exhaustive, and a usable model would need to be far more detailed, it is hard to think of any major system elements that have been completely overlooked.

One factor that has perhaps been given scant attention is the use of resources. The most obvious contemporary illustration of the effect on computing of resources shortages is in the use of paper, at times quite profligate. How many trees must be felled each month to provide the paper for one large scale computer installation? Are paper shortages likely to magnify the trends already apparent, away from voluminous hard copy towards more on-line file interrogation, interactive computer access generally and the use of exception reporting? In the longer term, while power consumption may prove no problem with increasing miniaturisation, are computers and other electronics products likely to draw too rapidly on rare metals or other resources, and, if so, will this have any effect on the economics and even the technology of hardware fabrication?

APPROPRIATENESS

Next, we must ask if each of the elements is appropriate, and likely to add to the model's explanatory and predictive power.

Clearly technological changes, changes in the work force and the work place, together with economic change generally, all affect the place of computing in society, the profile of EDP applications in the future, and hence demands for skills. Likewise, international questions could well affect the amount and direction of computing-based effort needed.

Less obvious perhaps is the relevance of changes more specifically in the social system, and in social and personal values. It is hoped that by now this has been sufficiently argued: apart from other relationships, these must influence planning for computing education, because of changing attitudes to work, education and leisure, on the part both of "workers" and "students". Similarly, changes in educational values and in the educational systems themselves (discussed in Chapter 4) are pertinent.

QUANTIFICATION

Whether or not the model is developed in formal mathematical terms, it must be quantified to some extent. At the least, rates of change should be estimated, and some work done to determine the approximate magnitude of the influence of one component on another. The work involved would be considerable, but valuable. The quantitative data provided by the project represent a useful point of departure, but basically they indicate the magnitude of variables, rather than the form of the functional relationships between them.

A related question is that of timing. Many of the linkages between components are subject to lags, e.g. there are delays between changes in educational policy and any discernible change in practice, and yet further delays before these affect the skills or attitudes of those in the work force; and there are lags between changes in management attitudes to computing and changes in the profile of EDP usage. These lags should where possible be measured, and the factors that determine them identified.

EXTERNAL FACTORS

Clearly any model must provide for unforeseen or external disturbances or changes (through government decisions, international changes, step function shifts in technology, for instance). Policy changes should be plugged in directly to the model. Other changes should be monitored.

PROBLEMS

There are enormous conceptual and practical difficulties to the construction of an effective model. However, to prepare a systems diagram of the components of the system and their relationships, and to begin discussion of the nature and importance of these, is a major first step.

It is hoped that if a consensus develops on the view needed for planning and policy, and if a common model or loose planning framework could be used, much otherwise unco-ordinated effort could thus be greatly enhanced.

The sensitivity of any model needs to be assessed, to determine which assumptions, parameters and subsystems most influence the results, so that greatest effort (both in modelling and in policy formulation) can be devoted to these areas.

There is also a moral dilemma. There are general questions of social responsibility inherent in any collaboration between social scientists (including those people who prepare "policy information") and a public or private authority.

There is also a specific dilemma for those who indulge in futurology, as prophecy tends to be self-fulfilling (rather like stock market rumours), in that policy decisions based on forecasts tend to promote the realisation of the forecasts.

A necessary (but probably not sufficient) protection is to divorce the policy information (or "policy research" or "think tank") function completely from both the policy formulation and executive functions, and to require open publication of the fruits of policy research. In this way, integrity should be maintained, conflicts of interest reduced, and the influence of the policy information would depend on its quality and the suasive powers of those who present it. (This in turn, of course, presents the further risk, that those with the best marketing and political skills will continue to undertake policy research, and not necessarily those whose work is the most perceptive, apt and valuable. However, this risk is probably worth accepting rather than having most policy research undertaken within the bureaucracy and, for internal political reasons, not always communicated even to those working on related policy issues.)

In this respect, the research project is fortunate. Although it is a commissioned study and is required to address its terms of reference, it was not limited by these nor in what was reported. Further, it had from the outset the right to publish its results independently if it so wished. [A right now being exercised.]

Implications for Computing Education in Australia

FIRST CONCLUSIONS

In summary, then -

* Any serious long term consideration of national needs for computing education must take into account many inter-related factors.

* A view of the total system that considers the factors and their inter-relations is essential; the project is a major systems study.

* Analysis of social change processes, and an intelligent approach to futurology, are fundamental to understanding this system.

* Australia's relations with the rest of the world, and social, technological, educational and organisational change processes, are crucially relevant to this understanding.

* An appropriate model would not only help explain and predict system behaviour, but also assist in co-ordinated planning. The basis for this model exists, although much more work is needed.

* Once we have established such a framework for our thinking about the total system, we may derive policy implications of fundamental importance - rather than the comparatively superficial prescriptions of marginal adjustment one may expect from a narrow view that looks at an individual policy sector in isolation.

* We believe that this approach leads not just to major conclusions about what should be done to provide more appropriately for future needs for computing education, but indicates directions for more wide-ranging initiatives that might be taken.

FURTHER IMPLICATIONS

The further clear moral, not just for this study but for many similar areas also, is that there is a great need for more <u>co-ordination</u> and <u>communication</u> between different sectors of society and those who make decisions in inter-related policy fields, and for more <u>adaptable</u>

planning, with continuous monitoring and feedback, than has been the case hitherto.

All solutions offered should also be adaptive, so as readily to accommodate and adjust to change.

Our view and approach in this chapter permeate and direct the entire presentation of this volume and the full report. We have painstakingly avoided following a narrower course. While we recognise that our readers will have varying interests and purposes in approaching our report, we do ask them, in this spirit, and especially those concerned with long term planning, not to cull passages from particular chapters cut of context.

Our concern in this chapter is to set out as succinctly as possible the need for a broad systems view, and some of the principal determining characteristics of the system we have studied. The chief implications for computing education planning are sketched out, here and later. However, since there are many linkages between system components, there are many implications, even for the specific area of computing education. We therefore hope others may be stimulated to draw out some of the implications we have not been able to explore in depth.

The remaining topic for this chapter is the impact of computing on the society of the future.

Computing and Society in the Future

Much could be, and has been, said about the social consequences of the computer. Here it must suffice to indicate some of the main ways in which the invention and application of the computer will affect society, especially as these relate to computing education.

At the outset we must realise that most discussion of this subject has a Western setting. There are many important unanswered questions about the effect that the diffusion of computing will have on the relation between the affluent, developed Western nations and the poorer developing nations. Many of these questions are disturbing, but this is not the place to canvass them.

PERVASIVENESS

First it is clear that in our societies computers are being used in almost all areas of human activity, in ways that have a significant impact on our lives. The term "revolution" in such contexts as "the information revolution" or "the computer revolution" is over-used, yet the computer and its attendant technology is the most significant human development we have seen for more than a century, with the possible exception only - if we are pessimistic - of the atom bomb.

The forecasts of the Japanese and of the O.E.C.D. study, referred to above, both indicate a diffusion of computing through life at an astounding rate. Anderla found it necessary to devote considerable space in his report to justifying the possibility of continuing exponential growth rates, as the consequences are mind-boggling. The qualitative changes in computing use could be even more incredible. They include, for example, significant shifts in the practice of both medicine and education.

What needs to be understood is the dimension of the change that has come about because of the computer. When we travel by jet we go about 150 times, or two orders of magnitude, faster than a brisk walk, and the escape velocity of an Apollo rocket is 6,000 times (or three to four orders of magnitude) faster than a walk. Printing presses reproduce the written word perhaps a million times faster than the monks did before Caxton -- and yet a computer can perform logical and arithmetic operations about nine orders of magnitude faster than a human being.

CUMULATIVE EFFECT

That is one aspect. Another is the potential cumulative effect of computer technology, whereby one person may build upon the work of others, in a bootstrapping process.

It is not an overstatment to say that the computer affords the possibility of the amplification of our intellectual powers in exactly the same way, and in as significant a way, as the advent of steam and internal combustion engines and electric motors have amplified our physical and mechanical powers.

We are not yet very adept in building on the work of others in computing. As Dr Dick Hamming said, we must learn to stand on each other's shoulders instead of treading on one another's toes. The difficulty is partly technical, but stems partly from the "prima donna syndrome" - the pride that often prevents us from accepting what others have done, and drives us to repeat the work of others.

A real possibility, that has been present ever since Simon and Newell's work on the "General Problem Solver", and which has been investigated theoretically since the earliest chess-playing computer programs were conceived, is that of a phase shift, a totally new dimension, in artificial intelligence. If we are able to devise heuristic processes that are genuinely adaptive and self-improving, and which can operate in a broad problem domain, then there need be no theoretical limit to the capacity of such artificial intelligence systems to undertake tasks currently considered to be "intelligent" or "intellectual", and hence intrinsically human. "The way is open to deal scientifically with ill-structured problems - to make the computer coextensive with the human mind." [Simon and Newell 1958, p.9] Whether such a vision will ever be realised we do not know. At present work in artificial intelligence is necessarily concerned with understanding the complexity of countless specific types of human activity and behaviour (including verbal behaviour, picture processing, Gestalt recognition, and so on), as a necessary precondition for any later major developments. However, even the possibility of such a shift is disturbing, and transcends the speculations of most writers of science fiction.

IRREVERSIBLE CHANGE

In a more specifically educational context, Eric Ashby referred to electronics, and particularly the computer, as providing the "Fourth Revolution". According to him, the first educational revolution came with the differentiation of adult roles, and the shifting of the task of education, at least partly, from home to the school (a process, incidentally, Illich and others would like to reverse). The second revolution came with the written word, the third with the invention of printing, and the fourth with the development of electronics and the computer.

More generally, the world is changing, quite fundamentally, because of the computer, and to some extent society has already changed irreversibly, in subtle but profound ways, because of the availability and application of computers.

By no means all believe that the applications of computing to date have been generally beneficial, and Professor Oettinger, himself a distinguished computer scientist, has written eloquently about the misuses of computing, especially in education (a subject we treat in greater depth in our work for Telecom Australia). Nevertheless, whatever our views may be on the ways in which computers are used, it would seem to naive to imagine that we could at this stage pull out the plugs from our computers, or - to change metaphors - reverse the tide.

WIRED CITY

The merging of communications and computer technologies, already well advanced, brings the "wired city" concept daily closer. Although originally a phrase coined to describe developments such as CATV, growing forecasts that terminals through which one can converse with computers will be as common as telephones, in homes as well as offices, makes the term apt in describing the likely future of computing.

Many elements, including telecommunications costs, will influence the time when such forecasts become true. However, the question is almost certainly "when", and not "whether". Television has already had an irreversible effect on our lives, and arouses impassioned argument. What will be the effect of a much more versatile technology if it enters nearly every home?

SOCIO-ECONOMIC CHANGES

As probably the main component of technological change in post-industrial societies, computing has contributed, and certainly will contribute mightily, to the economic changes already discussed, and hence to more subtle socio-economic changes [Smith 1968], of which the "problem" of leisure is simply the most obvious.

CHANGES IN CORPORATE STRUCTURE

Nearly twenty years ago Leavitt and Whisler [1958] predicted that the computer would result in shifts in responsibility within organisations. The increasing automation of clerical functions and routine decision-making, combined with greater management by exception, would reduce, if not eliminate, the need for middle management, the traditional training ground for top management. Others have since argued that computer-based management games could help fill this gap.

In turn more sophisticated uses of computing are helping senior management make more informed policy decisions.

In many ways the techniques possible only with computers are providing organisations with the means to cope with increasing complexity, but at the same time their use must affect corporate structures. [In addition to the substantial literature on the macro effects of computer systems on society (within the broad field of social and technological change), there is a large and growing literature which discusses the effects of computer-based data systems on organisations, with respect to their size, degree of centralisation, accountability, decision-making style, and so on, and in relation to specific problems such as security and privacy. We can do little more here than refer to its existence.]

ETHICAL QUESTIONS

Growing use of computers to establish data bases, especially "data banks" with personal details, together with more effective means to link or combine data bases, are giving rise to natural concern for both the privacy and security of data.

While some of the concern is probably based on misconceptions, much is well founded. Many recent efforts to grasp the nettle and devise effective yet sensible legal safeguards for individual privacy are undoubtedly motivated by a realisation of the inherent dangers of computer data banks. This is true of efforts within and without the computing field, and of those which deal specifically with computers and those which address a broader range of problems.

There is also much disquiet about the possibility of undue centralisation and depersonalisation through computing. It should be made clear that criticism should be levelled at the unimaginative and even repressive designs of information systems, rather than at the tool itself, and that the computer offers unequalled scope to amplify choices, increase individual options and provide greater personal attention [see also Simon 1960]. Nevertheless there are all too many examples where the introduction of computers has been used as an excuse for reducing choice, depersonalising contact with individuals, and for bureaucratic, even tyrannical, obstruction. Perhaps the computer appeals most to would-be centralisers or petty tyrants, or perhaps systems designers tend to ignore as nuisances the end users of their handiwork. Certainly in little more than ten years, as Stafford Beer has complained, it has become part of our folk lore to blame "the computer" as the reason for the (usually human) failings of organisations and systems.

Within EDP and in management much greater attention is being given also to the security of data. Security measures are aimed partly to protect personal, confidential or classified data, but increasingly stem from awareness of the high degree of dependence of organisations upon computer systems, as well as from the increasing incidence of computer-based crime. "Computer crime" is a subject of serious study (for example at Stanford Research Institute), and is a significant, and unfortunately growing, part of white collar crime, at least in the U.S., much of which is not widely reported because of the embarrassment this might cause. It ranges all the way from malicious but sometimes effectively clever vandalism to elaborate and well-concealed fraud.

PROBLEMS FOR COMPUTER PRACTITIONERS

These wide social consequences of computer use and misuse naturally trouble those within the computing field, notably professional bodies. How does one define, and achieve, the necessary balance between technical competence and adherence to (often ill defined) professional standards on the one hand, and a respect on the other hand for the privacy of the individual, the need for security, the welfare of society as a whole, and the effective operations of the employing organisation?

Apart from the risk of adverse social effects from sheer ineptness and incompetence, there are increasing dangers of conflict of interest between social responsibility and duty as an employee, about which some programmers in the U.S. have been vocal.

One natural response, evident in Australia as in Britain, is to seek professional status for the computer practitioner, and to move towards the "closed shop" model of some of the older professions. Among other things, it is argued, this permits greater control and regulation of professional standards, and greater protection for the individual who may need to take a professional stand on a point of principle. Thus the Australian Computer Society has progressively increased its knowledge standards for admission to corporate membership, and has recently replaced its former "Guidelines for Professional Conduct" by an explicit code of ethics, with formal sanctions for their breach, so following the example of the British Computer Society.

Quite apart from the fact that computing lacks, and is a long way from attaining, the legal recognition enjoyed by medicine or law, and is moving along the path to <u>de facto</u> recognition pioneered successfully by the Institution of Engineers, Australia, there is as yet little sign of acceptance by employers (large or small) of computing as a distinct and fully professional group. Probably even more important, moves to professionalise and institutionalise computing seem to run counter to overall trends which favour greater diversification of occupational roles, and place less, not more, stock on rigid certification procedures. Until a clearer definition of the central core of the "professional" function in computing is realised (see also

Chapter 5), it is hard also to reconcile with the clearly discernible and inevitable diffusion of computing practice and knowledge through many occupations.

The situation is also confused by the identification of professionalism with unionism. In 1975 a battle was waged between three main contenders for the support of Australians employed in EDP.

THE MOST IMPORTANT CONSEQUENCE

Computing will have many social consequences. The most important conclusion from this is that <u>those now at school</u>, and those who follow them, <u>will live in a world dominated by computers</u> and their applications. <u>Some awareness of computing will be an essential part of their equipment for life in today's and tomorrow's world</u>.

CHAPTER 4

EDUCATIONAL QUESTIONS

Education in Australia

INTRODUCTION

In the last decade much effort has been devoted by the universities, colleges and employers in Australia to the development of education in computing to meet rapidly growing needs. The human and physical resources now applied to computing education are substantial.

However, most of those directly involved have inevitably been preoccupied with the immediate and often overwhelming problems of developing and providing courses, and with associated short term planning. It is difficult in such a situation to stand back and see the overall picture.

The project has presented the first major opportunity in Australia to consider the _whole_ question of computer education needs. It is therefore important not only to gain an overall picture of the total level of demand for computer education, and the composition of that demand, but also to relate this to basic questions about education in general and to questions of central importance about the place of computing in the total educational scene.

STRUCTURE AND RECENT HISTORY

The whole educational system in Australia has undergone a largely silent revolution since the second world war - not that the public is silent about education and educational issues, but that the radical transformation that has occurred in the last thirty years has not been consciously realised by the general public. The changes wrought have profound political, social, demographic and economic causes and implications.

Whilst changes in the last thirty years have been very marked, they pale by comparison with those that could take place in the remaining 25 years of the century; the next decade will probably determine the direction and rapidity of these changes.

In the nineteenth century, the six Australian colonies developed coherent and broadly similar schools systems, and it was established that education should be free, compulsory and secular. By the turn of the century and Federation, each State had an established and centralised system of government schools, a substantial network of parish schools to which a significant proportion of Catholic parents sent their children, and a number of other independent primary and secondary schools (affiliated with churches of various denominations, as well as some that were privately owned), mainly modelled on the public schools of England.

In the nineteenth century also the first universities (Sydney, Melbourne and Adelaide) were established, on English and Scottish patterns, and by 1911 each State had its own university.

Education, as one of the residual powers not handed to the federal government, remained the constitutional responsibility of the States.

In its fundamental respects the structure of Australian education did not change from the turn of the century until the second world war. School enrolments grew with the population, a few new universities were created, but in 1939 university enrolments were only 14,000.

Since the second world war, though, there has been more marked change in Australian education than in the whole of the century before. The main areas of change have been:

* tremendous growth and expansion in numbers, both through population growth and through increased participation in education.

* growing involvement in education by the national government, in the determination of policy, and in direct financial responsibility.

* increases in the diversity of educational provision.

* growing questioning of educational aims and policies.

These changes are quite staggering in scale; only if one compares the situation at the outbreak of war and now does it become clear how utterly different education in Australia is from what it was just a generation ago.

The growth in numbers in Australian educational systems since the beginning of the Second World War has been explosive. Between 1947 and 1971 the number of primary school children more than doubled, from 788,000 to 1,697,000, mainly as a result of the sharp increase in births after the war. Secondary enrolments have risen even more dramatically, by a factor of 2.43 in the shorter period between the 1954 and 1971 censuses, from 457,000 to 1,111,000. While this increase is mainly accounted for also by demographic changes, the increasing proportions of children remaining for post-compulsory education have also contributed significantly. As the Borrie Report [Australia 1975a, p.376] shows, the proportion of boys aged 15 undertaking higher secondary education has increased from 44.6% in 1954 to 83.7% in 1972, with similar but slightly lower figures for girls. Much of the change in participation rates for 15 and 16 year olds took place between 1954 and 1966. Since then, there has been a marked increase in the participation rates for 17 and 18 year olds, and the rates for girls, although still lower than for boys, have increased quite rapidly. As declining fertility in Australia is now clearly evident, and a net reproduction rate of 1 (i.e. replacement level only) is expected within a year or so, we cannot expect any further large increases in primary school enrolments, whilst increases in secondary school enrolments will be affected mainly by changes in participation rates.

In the sector of most direct interest to this project, in tertiary education, the increases are even more dramatic, the consequences more significant, and the future much more uncertain. University enrolments have doubled every decade since the war ended, rising from 14,000 in 1939 and 27,000 in 1951, to 57,700 in 1961 and 123,800 in 1971. The proportions of the relevant age groups which could be expected to attend a university before the age of 29 have doubled since the early 1950s for men, and trebled for women [op. cit., p.375]. In the early 70s, university participation rates were fairly stable. However, the establishment of CAEs as part of the tertiary educational sector made possible further increases in the proportion of the relevant age groups enrolled in a tertiary institution of some kind (university or CAE), as CAE enrolments doubled in five years from 29,000 in 1968 to 62,000 in 1973. (In addition, about 27,000 students were enrolled in teachers colleges, most of which are now classified as CAEs, so that overall there are now approaching 300,000 tertiary students in Australia - compared with 14,000 in 1939.)

National involvement in education, especially tertiary education, has been a major factor in the development of Australian education, as Encel [1971] and many others have pointed out.

Following the High Court decision in 1942 in favour of the Commonwealth Government in the Uniform Tax Case, giving the federal government virtual monopoly of income taxation, the national government has been able, through its power of the purse, progressively to dominate the direction of policy in many fields within the constitutional responsibility of the States. Of these education is one of the most significant.

Wartime financial assistance to the universities began federal involvement in the general direction of post-secondary education, and the introduction of the Commonwealth Scholarship scheme in 1950 extended it.

The Commonwealth Committee of Enquiry on the universities, under Sir Keith Murray, set up in 1957 by Sir Robert Menzies as Prime Minister, was a turning point, as it led to the acceptance of about half the financial burden of universities by the Commonwealth, and the establishment of an influential Commission (the AUC).

Not long afterwards, the Committee of Enquiry into the Future of Tertiary Education in Australia was set up, under Sir Leslie Martin, and the Martin Report was presented in 1965 [Australia 1964-65]. Its most important recommendation was the establishment of a new form of tertiary education, in the colleges of advanced education, with again approximately half the costs being borne by the Commonwealth Government.

Meantime the Menzies Government finally bowed to pressures for some assistance to schools, especially the Catholic schools, with the shrewd but essentially political introduction of secondary school scholarships, science laboratory grants, and later library grants. These avoided any really substantial increase in national government expenditure on education, while dodging between several thorny thickets in the highly contentious field of State aid to non-government schools.

Since the election to power of the Australian Labor Party in 1972, national involvement in education has widened, deepened and accelerated, and resulted in many changes, most of which are now probably irreversible.

Among the decisions of biggest impact have been:

* commissioning of the Karmel Report [Australia 1973a], acceptance of its major recommendations, and establishment of the Schools Commission

* dramatic growth in national expenditure on education, especially through the Schools Commission, in furtherance of the values and objectives laid down in the Karmel Report

* commissioning of the Kangan report [Australia 1974a], acceptance of many of its recommendations, and greater attention to the technical and further education (TAFE) sector

* the decision to set up a Children's Commission, to examine among other things the whole question of child care and pre-school education [a decision since changed by the Fraser Government]

* abolition of fees at universities and CAEs, and acceptance of the full financial reponsibility for all higher educational bodies.

[It is not appropriate here to add any comment on changes in education which have occurred since our report was written and presented, including those which follow from the change of government in December 1975, beyond remarking that there are clear differences of emphasis and style between the two governments, which are reflected in educational as in other policy. Nevertheless, whatever one's politics, one must needs agree that the period of Labor government from 1972 to 1975 has resulted in changes to Australian education which are likely to be long-lasting.]

The <u>growth in national expenditure</u> on education, especially in the areas of priority identified by major reports commissioned by the Whitlam Government, is indeed remarkable:

TABLE 1

AUSTRALIAN GOVERNMENT OUTLAYS ON EDUCATION ($'000)
(Source: Ministerial Statement [Australia 1974c])

Major Head	1971-72	1972-73	1973-74	1974-75(a)
Universities	161,338	189,767	331,463	491,267
CAEs and Teachers Colleges	55,159	72,027	192,777	326,376
Technical Education	9,983	19,128	41,444	74,743
Schools & Pre-Schools	97,195	124,134	234,495	555,448
Special Groups	14,949	28,591	46,792	68,254
General Administration, etc.	8,120	9,621	13,740	19,150
Recoveries	-466	-655	-634	-548
TOTAL	346,278	442,613	860,077	1,534,690

(a) Estimated

(Admittedly, the figures above give a rather exaggerated impression, because of the combined effects of inflation and the substantial transfer of funding responsibility from State and private organisations to the Australian Government. A more informative analysis, for some purposes, would examine the proportion of GNP devoted to education. This proportion has also risen considerably, although less dramatically, from a very low percentage by international standards some years ago; although it is inevitable that it will rise less rapidly in the future.)

The effect of greater diversity in education can be seen in many ways. Potentially the most significant changes are in the primary and secondary schools, with powerful reinforcement from the Karmel Report's emphasis on grass-roots innovation within the framework of a general set of values and priorities, and the need for accountability. With all kinds of innovation, particularly now through the Schools Commission's Special Projects and Innovations Programmes, with the growth of a variety of "progressive schools" seeking alternatives to the rigidity and structure of a decade ago, and with brand new structures even within the State education systems (such as the Matriculation Colleges of Tasmania and the new secondary colleges in the A.C.T.), approaches to school education are much more varied than they were 10 or 20 years ago.

Diversity is also apparent in the post-secondary sphere. At the end of World War 2, Australia had a largely homogeneous group of universities modelled on Redbrick or Scottish lines, and a number of poor relations in the technical colleges. Now not only do we have an official policy of two distinct "tertiary" sectors, which are "equal but different", with the universities more oriented to research and fundamental knowledge and the CAEs having an explicitly vocational function and an "applied" emphasis - we have enormous variety within these sectors. The academic organisation and whole educational philosophy of Macquarie, Latrobe and Flinders, and more recently of Griffith and Murdoch, indicate an attempt quite consciously to establish new universities which differ fundamentally from the older ones.

Likewise the differences between the CAEs are more apparent than the similarities. Apart from the fact that the majority of the 80-odd CAEs are, or were until recently, teachers colleges or other single discipline colleges, the differences in size, scope and atmosphere between the multidisciplinary colleges cannot escape even the casual observer. There are huge multiversities like the N.S.W.I.T. and R.M.I.T., with heavy part time enrolments, small but dynamic regional colleges in country areas trying valiantly to realise a vision but hampered by their small base for growth and limited resources; others again have a distinctive aim - such as Prahran which is trying to become a multi-level institution embedded through close links in its local community, within a large metropolis.

And yet pressures towards diversification continue much further.

The TAFE Enquiry and the consequent Government decision to establish another commission to inject a further $90 million in two years into the TAFE sector, and the "Open University Enquiry" both indicate deeply felt needs for greater and greater diversity of educational provision and more equal access of citizens to education.

THE KARMEL REPORT

This is not the place for a detailed discussion or critique of the Karmel Report, but it is impossible not to refer to some of its key emphases. A committee of ten people produced in a mere six months one of the most influential, most readable and most remarkable of all the reports ever produced by an Australian Government committee.

Central to <u>Schools in Australia</u> is the brief second chapter on "Values and Perspectives", in which the Committee sets out the principal values from which its recommendations and specific programmes were derived. These values are:

* Devolution of responsibility: "less rather than more centralised control over the operation of schools".

* Equality: "The Committee values the right of every child, within practicable limits, to be prepared through schooling for full participation in society, both for his own and for society's benefit. To this end it accepts the obligation to make special efforts to assist those whose pace of learning is slow."

* Diversity: "The Committee places high value on the provision of resources in ways which will not simply perpetuate existing forms of schooling, but will stimulate among teachers and the community a search for forms of learning and of relationships between teachers and pupils more appropriate to the social and individual needs of Australians at this point in time."

* Public and Private Schooling: "The Committee values the right of parents to educate their children outside government schools."

* Community Involvement: "...education in formal institutions, separated from both the home and the world of work, has proved to be an inadequate means of changing patterns of social stratification or of initiating all young people into society. Unless our conception of education broadens to enable schools to forge closer links with other socialising agencies, the possibility of providing equal life chances for children from all types of social backgrounds is severely limited."

* Special Purposes of Schools: "While the Committee prizes both diversity and community involvement in schooling, it does not do so at the cost of sacrificing the special functions of schools."

* Recurrent Education: "The Committee believes that every member of society has an entitlement to a period of education at public expense, and that those who leave school early have a claim which they should be able to take out at a later date. It prefers extended possibilities of recurrent education to a lengthening of the period of compulsory schooling. ... The concept of lifelong education covers all types of post-school education and envisages a withdrawal of people from the workforce from time to time in some cases. ... Education might then be seen as being less a separate compartment of life and more an aspect of the quality of life itself."

After discussing needs and priorities, the report then develops seven programmes for the Schools Commission to adopt in addressing these needs, for:

(a) general recurrent resources;
(b) general buildings;
(c) primary and secondary libraries;
(d) disadvantaged schools;
(e) special education;
(f) teacher development; and
(g) innovation.

The report is not a treatise on educational philosophy, but a set of reasoned recommendations to Government. It has already aroused much discussion [see, for example, D'Cruz and Sheehan] and argument as to whether it is based on appropriate assumptions and whether it will work. Whatever the final view of history about it, there is no doubt about its influence already on Australian education, and not merely on the schools and schooling.

CURRENT ISSUES

As Encel points out [op. cit., p.18]:

"In the process [of rapid expansion] the social role of education has changed. The educational system itself is under increasing strain as it tries to cope with the needs of the last part of the 20th century, through a structure which has not essentially changed since the latter part of the 19th century."

Since he spoke in 1971, Australian educational structures have indeed begun to change, but his points are still well taken, and explain much of the current debate about education.

The continuing process of <u>occupational specialisation</u>, and the built-in tendency for economic development through innovation to demand better and better trained and more qualified people [Smith 1968], explains much of the growth in university and college enrolments. In 20 years the proportion of professional and similar people in our work force has doubled, and most of the change is represented by new young graduates.

This process, together with the increasing obsolescence of much knowledge, is also adding to demands from <u>mature students</u> for education of many kinds. Mature students enrol in significant numbers in undergraduate courses at universities and colleges, as well as in postgraduate courses and through extension services, but even greater numbers seek education from other sources. The 1968 ABS Survey of Non School Study Courses [cited by the Borrie Report, op. cit., pp.381-382] revealed that 516,000 persons aged 15 or more were engaged in some kind of post-school study. Of these about 166,000 were over 24. Other institutions were meeting the needs of about four times as many people as the universities and colleges.

Affluence is offering greater opportunities for education, but on the other hand educational attainment is one of the biggest determinants of future personal income, and clearly this explains the pressures from both students and their parents for entree into universities and colleges. As Professor Encel says, education is playing "an ever greater part in the growing pattern of social inequality" [p. 26].

However, the situation is becoming cloudier as more and more young people enter the work force with new degrees and diplomas, and in the economic downturn of the last few years graduate unemployment has emerged for the first time since the Great Depression as a clearly visible problem. More generally, for some years concern has been expressed that too many graduates have unduly high expectations of their first jobs. For decades a university degree was, implicitly or explicitly, regarded as a means of ensuring a place in a prosperous and socially prestigious elite. With increasing "democratisation" of higher education, such notions are being shattered, posing the question: "An Education For What?"

Political pressures in Australia have focussed most attention on the narrow, and extremely sensitive, questions of how money is to be allocated between different sectors, public and private, and on the political control that accompanies the power of the purse. Whatever one's personal views may be on the many complex questions involved, it is not hard to see how such concern has deflected attention from discussion of the aims, content, methods, structure and organisation of education. These urgent questions have, however, at last pushed nearer to the forefront, and debate on them is now vocal, if sometimes confused.

And this is high time. The rapid growth in government outlays on education, accompanied by similar and almost as remarkable increases in the proportion of G.N.P. devoted to education, cannot continue indefinitely. [Note: This paragraph was written before the 1975 Hayden Budget halted the rate of growth of educational expenditure.] The release of millions of dollars has made it possible for many competing claims for educational resources to be met more adequately from a constantly expanding cake. The cake cannot, however, go on almost doubling every year. Before long, the rate of growth in educational expenditure must decline. Once this happens, it will be much harder to justify new demands for resources than now, and it is important that by that time there is much more agreement on priorities and the balance of needs in education.

Thus, among the issues of current concern in Australian education are the following:

* Education for what?

* How should we encourage diversity and innovation, and what constraints should be placed on these?

* What structures are appropriate for needs in the end of the 20th Century, especially with rapid change, growing specialisation, and the obsolescence of skills?

* How do we reduce inequality of access to education, and the social inequality that follows from unequal educational opportunity?

* How do we meet the needs for continuing education of all forms, the needs of mature students generally, and achieve better integration between work, education and leisure?

* What changes should be made and what priorities set because of the inevitable end of the honeymoon period of continuing very rapid expansion in educational spending?

Aims of Higher Education

INTRODUCTION

The research project's central concern with the educational implications of manpower needs has highlighted the importance of reviewing basic assumptions about the aim, nature and structure of education. Recently, the debate on both school and post-school education has intensified, making this particularly difficult and yet essential to do.

It is scarcely appropriate, or possible, to debate here the whole question of the aims of education. This has been argued since before the time of Plato. There are signs, though, that comfortably accepted and largely unquestioned assumptions, especially on post-secondary education, are under increasing challenge, both here and overseas.

We must pose a few fundamental and relevant questions. We do not suggest to have the complete answers.

KEY ISSUES

There are several distinct issues involved: generalist versus specialist education, vocational versus non-vocational content and orientation, and professional versus personal, intellectual or social goals for post-secondary education. Some of these impinge on the arguments underlying Australia's having two "equal but different" systems of tertiary education, universities and CAEs.

One could try to describe part of the argument in terms of a tension between those who view higher education essentially as vocational preparation, and those who adhere to an "old-fashioned" concept of "liberal" education, not fundamentally concerned with gaining a meal ticket, but more concerned with the pursuit of knowledge and understanding for its own sake. Oversimplifying, the argument then reduces to a debate whether the aim of education is to prepare a person for a career, qualifying him for entry into the highly skilled work force, or whether it is a preparation for life, through the broadening of the mind, through intellectual rigour, and through social experience, self-fulfilment and personal growth.

Many would doubtless say that this is a false dichotomy, that education must be concerned with both aspects, and that education for life includes education to gain a living. Surely, it would be argued, the problem is how to gain a balance between the two aims? On this view, different viewpoints could be placed along a spectrum between educational liberalism and educational pragmatism.

Such an attempt at "balance", though, escapes the point. The word "liberal", in educational and other contexts, is emotionally charged, and inexact. Its use unfortunately confuses discussion of strategies with the expression of values. Value questions clearly are involved. Here (as in many other areas) it would help if people stated their values and distinguished value questions from other questions. We may agree or disagree with others' values (on education or anything else), we may question the consistency of one set of values with another, and we may seek to persuade others to adopt our values. But discussion of values is different from other kinds of discussion (such as the best strategies to achieve a stated goal), and failure to recognise this leads to confusion.

What has happened in recent Australian discussion of education is complex, but would seem to involve:

(1) Confusion of aims (goals, values) with strategies.

(2) Confusion of several distinct but related questions about aims.

(3) The use of sophisticated argument to entrench fixed positions, based on strongly held values (or vested interest).

Let us, then, try to unravel a few of the tangled skeins of argument. To begin with, it is helpful to distinguish between several different sets of questions of educational aims; next, we should ask <u>whose</u> aims we are referring to; finally, it is important to question whether these aims are likely to be realised and whether current strategies will in fact further these aims.

GENERALIST OR SPECIALIST?

There would seem to be three main dimensions of general debate about educational objectives, on each of which most people occupy a position somewhere between two polarised extremes. The first of these is the question whether we prefer a general or a specialised education.

The ideal of specialised education is exemplified in a variety of courses in higher education, ranging from many professionally directed courses in both universities (e.g. law, dentistry, etc.) and CAEs to honours degree courses in arts, science and other university faculties, with their heavy concentration on a single subject or discipline throughout most of four years' full time study.

A more general education, on the other hand, is possible in most ordinary (pass) university degree courses (especially in arts and science), permitting a "smorgasbord approach" in the selection of subjects, subject to academic constraints on prerequisite studies and the need to pursue one or two subjects to the level of a full "major". Similarly, a growing number of CAEs are introducing "multi-disciplinary degrees", or are planning to do so.

The advocates of the specialist approach claim that only through study and exposure in depth to a single discipline is it possible to experience intellectual rigour, or to reach a level at which one can appreciate current research in, and make a critical evaluation of, a field. Further, the "knowledge explosion" in so many branches of science and technology leads to the argument that there is more than ever before that a graduate should know if he is to claim competence in any one field, and hence that greater, not less, specialisation is needed. Finally, there are vocational arguments that if one is to obtain employable skills, entry to many professional and technological fields demands a fairly highly prescribed and necessarily specialised set of knowledge.

On the other hand, those who support a more generalised approach can argue from: freedom of individual choice, and the opportunity to explore areas of personal interest; a "rounded education", rather than an unduly narrow concentration on one or two subjects, leaving the individual unaware of whole areas of scholarship and knowledge; growing needs for multidisciplinary approaches both in scholarship and the work place; and growing diversification of the knowledge and skills required in employment.

VOCATIONAL OR NON-VOCATIONAL?

The second dimension is the related but distinct question whether higher education is seen primarily as meeting an explicitly vocational need.

Much discussion of the functions of universities for centuries has emphasised the independent search for truth and knowledge, for its own sake, and the universities' two-fold role as centres of research and enquiry, and of higher education. In this tradition many have entered universities and studied classics, mathematics, philosophy or natural science, with no immediate thought of a career, and many graduates in these "pure" disciplines have later pursued successful careers in public administration or business. (At the same time, for centuries the universities have also had students of law, theology and medicine.)

The question, then, is to what extent a higher education is seen to be a preparation for a career, with the content substantially dictated by the knowledge requirements of a particular vocation, and to what extent broader (and non-vocational) considerations should determine content.

This is not exactly the same as the question whether the purpose of a higher education is to gain entry to a skilled employment market. Doubtless many have studied "Greats" at Oxford or "Arts" in an Australian university, with the possibility of Civil Service employment in mind. Similarly, while there are numerous courses in accounting in Australian universities and CAEs, by no means all of them attempt to provide the full professional training necessary to practise as a qualified public accountant (although most students of even "non-professional" accounting courses would presumably be influenced to some extent by the value of these courses to their present or future employment).

PERSONAL OR PROFESSIONAL GOALS?

The final question, while closely related to the previous two, is whether goals (of the student, of the educator, or the citizen at large) are primarily concerned with personal development of many kinds or with professional and material advancement. As with the other questions, there is a continuum of answers possible from different people depending more on their temperament, values and personal educational experience than on anything else.

At the one extreme, a higher education may be seen primarily as an opportunity for personal fulfilment - to stretch and sharpen the mind, to be stimulated by ideas, to master concepts and acquire knowledge, to explore relationships between knowledge and the practical world, to develop as an individual and to form meaningful personal relationships. Such aims could be espoused by those in specialist courses (in philosophy, physics or computer science) as well as by those in generalist courses, or by those in vocational courses (medicine or EDP) as well as those whose courses are not explicitly vocational.

At the other extreme, students and others may regard a higher education essentially in terms of its economic and social functions, whether at the individual or societal level. It provides highly qualified manpower; it raises the income potential of the student, by giving him a label as a qualified product of the tertiary educational system (independently of the aptness of his education to his employment); it meets employment demands; and it provides better informed and, it is hoped, more effective, citizens.

None of the positions taken by individual students or others concerned with educational issues, on any of these three dimensions, is right or wrong. They are essentially values questions.

Further, it is not helpful to confuse the three dimensions with each other. As suggested above, although there are certain correlations between them - for example, someone who places high emphasis on professional goals is more likely to emphasise also vocational and perhaps specialist courses - every combination of views on the three different dimensions is possible. Finally, these educational values questions should not be confused with issues concerning strategies (or means-end) questions.

In the following section, though, it is argued that no matter what one's position on these values questions, certain approaches to educational planning and certain kinds of course structures are inept in times of rapid social and technological change, especially in computing education.

IMPLICATIONS FOR THE PROJECT

In this report we wish to focus attention on overall community needs, and to avoid sectional or unduly short term questions. Nevertheless, as the next ten years will be a period of transition, we must begin with the situation today, and indicate practical ways in which we can plan for a better overall result.

Planning for Higher Education

THE BASIS OF EDUCATIONAL PLANNING

How, then, should we plan for education? Clearly resources must be allocated, and choices made. On what basis are educational policy decisions to be taken?

The first and most obvious point to be made is that we cannot even begin considering this question unless we agree on some values and goals. Next, we can hardly fail to observe the diversity of goals that obtain in a modern pluralistic society such as ours.

The report of the Commission on Post-Secondary Education in Ontario [Ontario 1972, pp.29-30] adopted two overriding goals, "social responsiveness" and "quality", in an attempt to embrace the diversity of goals a wide range of people have for educational systems. It went on to consider, and reject, three possibilities for overall approaches to educational planning: the creation of a master plan, the use of manpower projections to determine educational needs, and cost-benefit analysis. Master plans were dismissed first as unduly rigid and unable to respond to society's needs.

MANPOWER FORECASTING - LIMITATIONS

The Commission went on to say [pp.30-31]:

> "The lure of general manpower planning is more difficult to resist. Many people believe that it is possible to design our educational system on the basis of projected manpower needs. Why should we not produce just the number of lawyers, teachers, technicians, and typographers we require, and divert surpluses into other educational areas of continuing job need? This is a well-meant and sensible-sounding argument. It assumes that we have the ability to forecast accurately the future job needs of our society that manpower-designed education would require; that we can define the 'right' educational prerequisites for occupations, fix the number of bodies that would be adequate, and apply this not only to an uncertain present but above all to a still less certain future. The fact is, as the Commission's study Manpower Forecasting and Educational Policy says, 'there is no satisfactory way of specifying the appropriate educational background for most occupations, much less project them'.
>
> "Even if such a scheme were possible, there would be sound reasons for rejecting it. Basically, it is inimical to our cherished freedom to choose. We believe that it is preferable to respond to the uncertainties of the job market through a flexible system that permits individuals and educational programs to react to changing needs than to adopt a program of manpower planning linked to a system of rigid certification. What happens to the person who does not fit a predetermined educational slot? Where is there an opportunity for social criticism, innovation, and change in a society geared to a utilitarian acceptance of occupations as they are or are ordained to be?"

This does not, of course, imply that attempts to understand the forces that may determine the future, or to peer into the future to try to gauge the broad nature and dimension of likely employment needs, as we have done, is a total waste of time.

It does, however, set out clearly some of the problems and limitations of manpower planning approaches. Apart from the very real difficulties in forecasting what the future will hold, especially, as we have argued, when it is shaped by so many different influences in exceedingly complex ways (particularly in a field like computing), we cannot pretend that there is one and only one educational background that properly prepares a person for a particular occupation or role. The very fact that the state of computing in Australia and other countries is reasonably healthy bears tribute to the adaptability of man - because computing education has a brief history there are few over the age of 30 or 35 in the country, and very few in positions of responsibility in computing, with any formal educational qualifications in their chosen field. We can predict trends and broad future needs, and we should inform both educational planners and students of these. We cannot give precise values to all our predictions, nor can we usually give a clear dissection of future manpower requirements by the type or level of educational award required, because - in the jargon of the educational economist - the substitution possibilities are too great.

Further, even if we had perfect information about a future that is at times murky, we could not without coercion achieve a perfect balance between employment needs and the aspirations of those seeking employment.

Finally, while it would be naive in the extreme to deny that vocational preparation and employability are relevant to post-secondary education, it would be foolish to assume that they are the only aspects of importance in education, or that they are for everyone the most important ones.

There is now a vast literature on manpower forecasting and manpower planning, but we shall avoid the temptation of quoting extensively (and selectively) from writings on the economics of education, and instead refer interested readers to the bibliography. Views are certainly divided, but the weight of opinion falls mostly on the side of those who reject narrow or rigid manpower approaches. In a field as dynamic as computing, it is clearly impossible to predict needs with any precision at all far into the future. To do so would be to predict the behaviour of a complex multivariate system with many interdependencies, which could be done only by making innumerable assumptions, any of which could prove wrong. Some quantitative indicators are clearly needed to guide policy, but these should be obtained not so much from once-for-all long term forecasts as from continuous monitoring coupled with adaptive planning procedures.

COST-EFFECTIVENESS

What, then, of the techniques of cost-benefit analysis? Can they help us in the process of educational planning? Indeed, they probably can, but not necessarily at the level we are concerned with here, or in the research project.

As Blaug has pointed out [Blaug 1968, 1969], the questions considered by the relatively new field of the economics of education fall "rather neatly into two classes" - those concerned with the economic value of education, and those concerned with the economic aspects of educational systems (such as internal efficiency).

Work on _education as investment_, or the formation of human capital, has given insight into the economic processes whereby education contributes to economic growth. However, while it helps explain these processes, it does not yet seem to have produced any tools suitable for planning purposes, except perhaps to indicate the total level of educational expenditure that could be justified by a specific economic goal. It is for these reasons that we should eschew this approach in educational planning, rather than for any emotional resentment at the apparent coldness and sterility of treating people as "capital", an "argument" that could equally apply to almost any application of economics to policy problems.

Similarly, while _cost-benefit analysis_ does offer some useful tools, they do not generally help us with broad national problems in educational planning. There is much evidence that, as a traditionally labour-intensive activity, education is experiencing static, if not declining, "productivity". Further, the capital used in education is underutilised - with expensive buildings and equipment lying idle in many schools and post-secondary institutions for nearly half the year and nearly two-thirds of each day. Cost-benefit techniques may well help find better solutions - that give better rates of return on investment, or improve the marginal productivity of the factors - to problems at an institutional level, and problems of efficiency. Technology may greatly help us to improve our educational efficiency in many ways, and in particular we may expect computer assisted learning of various forms to improve the effectiveness of education and of teaching at all levels. (By saying this, we in no way wish to endorse Skinner's approach to CAI, based on reinforcement.)

But however useful in dealing with problems of internal efficiency, cost-benefit analysis, as the Ontario report says [_op. cit._, p.31], if it deals purely with direct _economic_ costs and benefits, is partial and too limiting. Clearly a wide range of social benefits and costs is involved. Even to specify what these should be and how they should be measured introduces a host of fundamental questions about which there is likely to be little agreement. In fact this would seem to take us right back to questions of social values. We thus seem to be a long way still from constructing an adequate calculus which we could apply to any broad educational planning.

EDUCATIONAL GOALS AND THE BASIS OF PLANNING

Let us now relate some of the thinking in the previous section on "Aims" to the questions of what educational <u>structures</u> are needed.

It was argued that a variety of different personal objectives can be pursued on each of the dimensions: generalist versus specialist education, vocational versus non-vocational education, and personal versus professional goals. If this is true, then present structures, evolved during relative stability, seem less and less appropriate in meeting <u>any</u> of these objectives in times of rapid change, especially in fields such as computing.

For, although change is to some extent promoting greater specialisation, not only are there some contrary trends but the kinds of specialisations needed are themselves changing. This is especially true in computing where it would be a bold man who would write a set of detailed job descriptions for the world of 20 years hence, when today's graduates will be in mid career. Thus, to the extent that we adhere to a "front end" model of education, with most formal education undertaken before entry to the work force, it does <u>not</u> necessarily follow that a specialist education is the best preparation for a specialist career, paradoxical though this may seem. Nor does it follow that specialist courses should be rigid or defined without options, in view of the many subspecialisations that are emerging, especially in interdisciplinary fields or at the intersections of disciplines.

Similarly, a primarily vocational or professional objective in education need not imply a rigidly prescribed course or one which emphasises technique rather than fundamental knowledge. Changes in occupational patterns, the emergence of new fields of work, and changes in how work is done, even within the more traditional and conservative professions, are pointing increasingly to the need for sound foundations in one or more disciplines in people's initial higher education, as well as for opportunities in later life to study specific subjects or techniques of current professional or vocational relevance.

Thus we suggest that for many, particularly the many who will be involved substantially in computing, a higher education in two or more different disciplines, with a high degree of choice from a range of options, may be appropriate, regardless of the objectives of the student, or of society. Certain minimal academic constraints may be needed on the choice from the smorgasbord to avoid the more extreme dietary problems, but these constraints should be fewer than is often the case at present.

This solution is at marked variance from that proposed by many. Instead of saying that there is more and more chemistry, or law, or computing, to learn, and that we must therefore subject students to ever more concentrated and specialised diets of one major subject, so that they may be properly accredited as competent organic chemists, lawyers or computer scientists, let us acknowledge that this will soon be, if it is not already, an impossible aim. We cannot expect to teach a university or college student all that he may ever need to know in any one subject, nor should we try to do so any more. Even if we could teach him all that currently appears important, who is to say what he will need to know in ten or twenty years' time, with advances in knowledge and possibly shifts in his career? Likewise, let us not delude ourselves that there is necessarily any one fixed quantum of knowledge that uniquely provides the only, or best, preparation for all, even in one discipline or occupation, nor that we can define course content now in relation to the substantially unknown needs of employment in 10, 20 or 30 years' time. Rather, let us try to identify the basic knowledge, concepts and skills relevant to each subject and vocational group, and impart these. This should stand the graduate in better stead than being crammed with vast stores of knowledge in an attempt, like the Red Queen, to run faster and faster in order to stay still.

THE MEAT IN THE SANDWICH

Among the questions not often asked are: "What do the students want?", and "What do recent graduates think about education and their own recent educational experiences?"

We tried to find out some of the answers (see below under "Student Viewpoints"), but far too little has as yet been done to sample student and graduate opinions.

As the meat in the educational sandwich, students must be relevant to the planning of both employers and educators, especially - of which there is some evidence - if their aspirations are not completely congruent with either perceived employment needs or the plans of educators. A paternalistic approach to education is scarcely appropriate, and unlikely to prove effective.

ADAPTIVE PLANNING - THE NEED

From the analysis of patterns of change in Chapter 3, several conclusions were drawn relevant to the planning of post-secondary education in Australia:

* It is no longer possible to consider the various

change agents affecting education in isolation from each other. They form an interdependent and dynamic system.

* We can no longer plan at relatively long intervals for a whole period of time. In a real sense planning must be continuous.

* Assumptions that the future will be like the past, or that the future will be stable, at least over the medium term, are not necessarily true.

* We must monitor changes as they take place, and anticipate change, to inform the planning process.

When we try to relate this to the thinking of (say) the Martin Report, there would seem to be an implicit assumption that the future will be relatively static, and society relatively stable. Further, it seemed to be assumed that traditional structures, and traditional planning mechanisms, mainly focussed on the individual institutions, would be adequate. In particular, it was apparently assumed that the role of the tertiary institutions in providing vocational preparation for those entering the work force did not need fundamental questioning.

None of these assumptions seems valid in the society we are now in, or in the society of the future.

Consequently, many of the planning mechanisms now used (such as triennial funding rather than rolling plans, and the slow approval processes needed for course changes) seem to be inept to our times, and even inimical to responsive planning. [Prophetically, this was written before the introduction of "rolling triennia" as the basis for planning by the four commissions that fund education at a national level. It is not yet too clear how these are likely to work in practice.]

Indeed it would seem that educational bodies are generally slow to perceive and react to change; even that they are insulated from change. Far from accepting an adaptive planning base, as a norm, they are all too often inhibited from adaptive response in many ways.

Governing bodies usually represent established interests and pressure groups, and tend to produce compromise. Their agenda usually focus on specific issues, which does not encourage the definition and review of objectives in relation to social needs, nor the monitoring and assessment of processes in relation to objectives.

Prevailing community attitudes, at least as most vocally expressed, often reflect experiences 20 or more years old, can be out of phase with current educational practice, relate to passe measures of achievement, are usually evoked by short term issues and concerns, and emphasise content rather than process in education.

Curricula are also usually defined almost exclusively in terms of content, often reflect a rather narrow departmental vision, and because of cumbersome approval and accreditation systems (at least in CAEs) tend to be rigid and monolithic, and lack modularity, portability between institutions, and are difficult to modify.

Staff are frequently themselves the products of static and non-adaptive systems. Selection, promotion and reward systems tend to reinforce the academic qualities valued most by those who are traditional in their orientation. Attempts to monitor teaching performance have met with considerable resistance.

These comments may seem unduly harsh, and certainly they do not apply to all staff or with equal force to all institutions. As generalisations, though, they are probably valid.

POSSIBLE MEANS

The need for adaptive planning in education seems clearly established. As with so many aspects touched upon by this report, the needs are quite general throughout education, but are seen particularly sharply and with great urgency in relation to computing education - because of the rapidity of change in computing. In some ways computing education needs point to more general needs, and may act as a litmus test for much educational thinking.

An integral part of any adaptive planning must be the means of monitoring actual and anticipated change. Such monitoring should include:

* observing various forms of change that are taking place;

* assessing the perceptions which both those within and those without the educational system have of the system, and their wishes and aspirations;

* attempting to place these findings in some kind of rational or analytical framework;

* anticipating likely or possible future change; and

* relating all this to educational policy questions.

Our intensely practical involvement with the real world problems experienced by both those who teach and those who use computers, and employ those who have been taught, has forced us to ponder about the deeper problems of educational planning at large. The almost chaotically rapid development of computing has resulted in many acute problems which we discuss, and gives rise to some of the more extreme forms of breakdown in traditional educational planning mechanisms.

Because of the fundamentally different, and more rapid, changes now taking place in society in general and in education in particular (discussed in this and the previous chapters), it would seem that quite new approaches to educational planning are called for. The structures that worked in a comparatively static world may well fail to suit a more dynamic one, as we have suggested in the last two pages.

It is one thing to point out a problem, but another to suggest the means for overcoming it. To comment on broad educational policy issues and suggest new planning frameworks is to go well beyond our brief, but with some diffidence we would like to throw out a suggestion that we believe deserves consideration.

We suggest that the monitoring functions discussed above could partly be carried out by a network of different groups or agencies, at both national and institutional levels, with a charter to undertake policy-directed research.

Any such group, at whatever level, should have substantial autonomy and independence, and in particular should be free of political constraints (including, as far as possible, informal pressures from political power figures).

Most importantly, the groups should be excluded from <u>any</u> executive responsibility. There should be complete separation of the policy review or policy research and information function from the active planning and executive roles.

On the one hand, these research groups or "think tanks" should have wide access, at all levels, to sources of information and ideas. On the other hand, they would be <u>required</u> to publish their findings openly.

By giving them wide freedom but removing them completely from any direct planning or executive role, the groups would be free of any possibility of becoming part of the conventional power structure. They would justify their existence, and would be required to justify their continued existence, by the value of what they produce, and would be influential mainly through the persuasiveness and cogency of their findings and arguments.

Thus the various groups would provide material, freely available, for national and institutional organisations to use in their own planning. They would fall somewhere between purely "academic" research groups and conventional policy groups within the machinery of government.

They could be either short term task forces that disappeared on completion of their tasks, or long term, continuing, permanent bodies in some cases, but with membership on short term contract or secondment.

At least one or two groups should be set up at a national level, to look at macro level problems; preferably more than one group to provide more than one point of view and some healthy intellectual competition.

National levels groups in particular would need some secretariat; desirably the senior members of the secretariat (as in ASTEC) would also be on secondment from a variety of institutions.

This suggestion is in many ways similar to that of the Wearing Committee [1974, 1976] for educational policy research groups.

THE PITFALLS

Several dangers could be anticipated with the creation of such groups:

(1) They could be become subservient to political power figures.

(2) They could be involved in an executive or planning role, and become either too powerful or too preoccupied with day-to-day concerns to be effective.

(3) They could be hamstrung, or a mere piece of window dressing.

(4) They could run out of steam.

It therefore seems important that such groups should:

have absolutely no decision-making power;

be outside any functional organisation structure;

have no, or few, limitations on their terms of reference;

have complete freedom to publish, and be required to publish; and

be manned on a short term basis.

Continuing Education

INTRODUCTION

The importance of continuing education in computing has been recognised from the outset of the study, and deserved its special place in the terms of reference. It has emerged very clearly that the needs for continuing education in computing are considerably greater, yet receive less attention, than those for "first entry" education at the undergraduate level. This is true now, and will apparently continue to be true.

The growing complexity of organisational living, together with the continuing knowledge and information explosion, are resulting in increasing obsolescence of traditional skills, including those of many generalists. (These include many computer systems and programming staff with limited training.) Shifts in career paths, and needs for retraining in new specialties, are more common.

However, continuing education, in computing or other subjects, is not just a matter of providing refresher and updating courses. More fundamental shifts in emphasis are called for, and need to be related to recent discussions of "continuing education", "further education", "lifelong education" and "recurrent education".

Recurrent education has received much attention locally and overseas, and both the Karmel and Kangan reports gave it considerable support. It is not a single concept, but comes in many variations; however, they all represent a new outlook on the nature and needs of education as a whole, and a challenge to the view that education as a preparation for life and for employment is basically undertaken in the school and immediate post-school years.

As the structure of the work force, the patterns of skills needed, and individual career paths are subject to more rapid change, the view of tertiary education as a period of preparation for a career of 40 or more years is becoming less and less appropriate. Limited subsequent refresher and updating courses have never been really successful, and are increasingly inadequate.

Acceptance of the concept of recurrent education could imply:

* a break between secondary schooling and formal post-secondary education, as a norm

* flexible interleaving of formal post-secondary education, and even late secondary education, with full time employment for many people

* periods of full time education and/or part time education in various forms for many people throughout life ("permanent education")

* major restructuring of the school system.

Related to such changes, and of especial importance to computing, could be a shift in emphasis in all levels of education, including post-secondary education, to one on the acquisition of basic skills (such as problem solving) and on "learning to learn", rather than on the acquisition of detailed, specific knowledge and skills - this would be achieved continuously through recurrent education over the whole of life.

Acceptance of recurrent education as a goal would be a radical change in thinking about the aims, nature and structure of education. It also assumes, and faces, the challenge of rapid social and technological change.

Increasingly, recurrent education will be seen as a responsibility of employers, as well as of educational bodies and the individuals themselves. If work, education and leisure need, as many claim, to be better integrated, then this is inevitable. Thus recurrent education also requires us to consider, as centrally important, especially for computing education, the establishment of close working relationships, communication and co-operation between industry and educational bodies. (This is discussed at some length under "Links with the Community" later in this chapter.)

CONCEPTS OF RECURRENT EDUCATION

As set out in the O.E.C.D. study on the subject [O.E.C.D. 1973], recurrent education has rapidly become a common denominator for many proposals, the essence of it being that we should "break with the present practice of a long, uninterrupted pre-work period of full-time schooling" [p.7], together with the alternation of education with work, leisure and other activities. It is seen by most proponents as offering a consistent strategy for educational change.

The reasons for a move to recurrent education, while varying in importance between writers, include:

* greater social equality

* needs for "permanent education" to provide continual adjustment to social and occupational change

* "deschooling" because of the divorce of formal education from work experience

* growing alienation with secondary schooling.

Educational expansion has failed to provide the expected equality of educational opportunity or social equality, either between or within generations.

The growth of knowledge and the knowledge industry, and the development of many forms of on-the-job and other work-related training as well as of informal education, all indicate needs for individuals to adjust to a rapidly changing world. "Lifelong learning" [see Faure <u>et al</u>. 1972] emphasises the need for continuous openness to new situations of many kinds, the assimilation of knowledge and experience, throughout the whole of life, to enable people to be masters of their own destiny in, and to adapt to, a world that is no longer static. Recurrent education, within the concept of "lifelong learning", specifically looks to needs for organised, structured and deliberate learning, rather than more generalised needs.

All advocates of recurrent education share Illich's [1971] concern for an alternative educational future, and many would agree with his criticism of the destructive effects of the over-institutionalised school and its constraints on the individual. However, in general, recurrent education proposals involve a <u>radical restructuring</u> rather than a demolition or dismantling of educational institutions.

The lengthening of compulsory education and the growing trend for more and more people in developed countries to remain longer and longer in the formal educational system is accompanied by clear signs of disaffection, unrest and alienation, not only on the part of post-secondary students but also of secondary students [See for example, Appendix B to the Campbell Report [Australia 1973d], which describes the attitudes of secondary students in Canberra.].

Throughout most discussions of recurrent education there are two clear themes: adaptation and emancipation. On the one hand, the educational means must be provided to help everybody to cope more successfully with a less stable and more fluid society - what is taught should also help him adapt, by "learning to learn" rather than learning a set of recipes. On the other hand, the individual, it is hoped, can be liberated from some of the many traps in which social change may ensnare him.

RECURRENT EDUCATION AND SOCIAL CHANGE

The main features of any programme for recurrent education have been briefly described already. It is clear that the underlying diagnosis of the social situation, one of rapid change, and the prescription, of greater flexibility, less institutional rigidity and more emphasis on adaptability, are exactly those already expressed in quite general terms in this report.

However, it is also clear that the acceptance of recurrent education also implies very substantial change in the community, in its institutions, and its social values. It is not advocated (by most at least) that the entire educational world should be stood on its head overnight, to achieve the innovations and changes sought. Rather, it is suggested that we should embrace the concept of recurrent education as a general educational strategy, and regard it as an overall framework for the re-orientation of educational policy. This will necessarily be gradual - just how rapidly we should or could attempt to move towards recurrent education is not generally agreed.

THE IMPLICATIONS OF RECURRENT EDUCATION

Apart from the immediate programme of restructuring to make education more "recurrent", there are some obvious further implications for education:

* If many students seek <u>temporary</u> employment (or other non-school activities) immediately or shortly after completing compulsory education, the aims and curriculum content of compulsory education need review - This implies identifying more closely the basic knowledge and skills desirable.

* Less rigid educational structures and practices are needed on almost every conceivable dimension.

* Greater modularity in post-secondary curriculum design, greater portability of credentials and qualifications, and less emphasis on traditional certification and accreditation procedures are needed.

* Greater integration of general and vocational education, and of formal and informal education, are needed, including easier part time study opportunities.

IMPLICATIONS FOR COMPUTING EDUCATION

While a very strong general case can be made for recurrent education as an overall strategy, the case in specific relation to computing education is particularly compelling.

The processes of change that form part of the rationale of recurrent education are nowhere more evident than in the development and application of computing technology. In no other field than computing - and its ramifications for many occupations - is it more obviously inappropriate and infeasible to attempt to impart all the knowledge and skills a person needs during immediate pre-work education, leaving only "topping up" for later on. Nor can there be many fields where the need to draw together formal education and work experience is greater.

Since recurrent education is a total strategy, affecting all of education, it cannot be implemented piecemeal for a single discipline or occupation. However, it could help shape the thinking of those concerned with computing education to adopt recurrent education as a framework, and to help show the way with many specific initiatives.

<u>The Role of the Institutions</u>

MARTIN, WARK AND BEYOND

Since this report was commissioned by the ACAE, and was prompted by the need for guidance in decisions relating to the CAEs, we could scarcely fail to reflect on the situation in Australia with two "systems" of tertiary education.

Since the Martin Report and the creation of the CAEs there has been much speculation and comment on the roles of the universities and CAEs. What have the CAEs in common that they do not share with the universities, and how relevant are the comments of successive reports and ministerial statements to the situation today? Most of the CAEs were not originally established as such, and many are proud of their ancient and unpretentious origins, as technical colleges or earlier as mechanics' institutes, before the process of evolution made them institutions of higher education. Other were teachers colleges, but without the degree-granting status of universities, while other CAEs have been established de novo.

It has been said, cynically but probably not without some truth, that the original political reason for the creation of CAEs was to provide for educational expansion more cheaply than by simply creating more universities. Be that as it may, now that the academic salaries in CAEs are generally set in parity with those of universities, it is not now true (if it ever was) that a CAE student place is significantly cheaper than a university one. If the differences are not now primarily in cost, if the CAEs award degrees (albeit only after reference to outside bodies or committees on course content and level), what are the differences? Is it simply that Heads of School and of Department do not have the title of "professor", and are the CAEs, like their counterparts in the U.K. of a decade ago, likely to become universities in name? If so, is it inevitable, as some suggest, that they become second class universities?

EQUAL BUT DIFFERENT?

In terms of the now celebrated phrase, CAEs are meant to be "equal but different". Wherein, then, does the difference lie?

Even the official publications of the Australian Department of Education seem to have some difficulty in reducing the differences to understandable terms:

> "The differentiation between the two kinds of institution cannot be expressed by any simple principle. By the nature of the work they do, there is bound to be an overlap. ... The Australian arrangement should not be viewed as a binary system of tertiary education, but as a unified system offering a wide range of courses at a variety of institutions to students with different abilities and interests. ... However, there are certain basic differences between the two types of institutions." [Australia 1974d]

The basic distinction, of course, is made that the courses of the colleges are more specifically vocational, applied and oriented to the practical needs of industry and society, and are less concerned with research or the fundamental study of disciplines in depth for their own sake. A common rejoinder to this is, that to be consistent, the professional courses at universities, in medicine, law and engineering, for example, should be taught at CAEs.

Nevertheless, there is some degree to which an explicitly vocational flavour permeates the CAEs more completely than in the universities.

There are also other differences observable in general, although exceptions could be found for them all. Research is not accorded the same priority in CAEs, in terms of either budget or academic time, as it is in universities, and the teaching loads of many CAE staff are considerably heavier than for many in universities. Many CAEs place considerable emphasis on effective teaching and on teaching skills in staff selection and promotion, and there is a atmosphere of concern for teaching in most CAES which does not, unfortunately, seem as widespread in the universities. The CAEs make relatively greater provision for part-time students than many large metropolitan universities. Whereas study leave, usually to undertake research, is available as a right to permanent university academics, its counterpart (staff development leave, industrial study leave, and the like) is not a right for CAE staff, but must be sought and granted; further, both staffing and funding in most CAEs seem to be unable to provide the same level of leave as the one year in seven of the universities' sabbatical schemes.

SOCIAL CHANGE AND OUR INSTITUTIONAL STRUCTURES

One can scarcely help wondering whether the differences between universities and CAEs have anything much at all to do with the officially endorsed emphases: on the one hand, universities (quite apart from their long history of producing highly vocationally oriented graduates for various professions) are recognising increasingly their interrelationship with and responsibility to the community at large, and the need for "relevance"; and on the other hand the colleges, if they are to produce technologists and others with skills that are not obsolescent by graduation, and not just technicians (especially in rapidly changing fields), see a greater need for solid and rigorous foundations in fundamental disciplines, to provide a basis for future, and in many cases unpredictable, needs.

Do the differences, then, consist more in such things as the relative emphasis on research and teaching, the provision of part-time study opportunities, and so on? Or is it, as some university spokesmen would claim, that the universities maintain an internationally accepted standard of scholarship, and have a special and traditional role in the preservation and promotion of knowledge and of culture, and as a critic of the society around it?

AN ARRAY OF INSTITUTIONS?

In the last few years there has been increasing comment that now that the differences between individual universities and between individual CAEs seem greater than the differences between the two systems, it would be better to think of there being an "array" of post-secondary institutions, rather than two or three "systems".

To describe the function of the CAEs simply as to provide more specialised, and explicitly vocational, education is inadequate, whether in general or in computing, and is not a very accurate description of what is actually taking place. One of the more exciting curricula in computing today is the honours course of the University of Manchester Institute of Science and Technology, a technologically oriented university - it would be impossible to categorise either the Institute or the course as in a university or a CAE pattern. The course, while differing from that of most Australian university computer science courses, is a substantial honours level academic course, yet one that seems equally suited to providing practical and effective practitioners for industry as to producing postgraduate material. It is a pattern that could well be examined by both universities and CAEs in Australia; and this confounds any simple distinctions between the two systems.

A particular, and general, problem is that the press of the CAEs for academic recognition is making them look more and more like universities. This is a natural, and probably inevitable, consequence of the "equal but different" policy. So long as CAEs remain "different" as a <u>system</u>, they will strive to be accepted as "equal". This shows in their reluctance to put forward diploma or associate diploma course proposals, rather than full degree proposals, in the undue emphasis sometimes placed on Ph.D.s and narrowly "academic" criteria in the selection of staff, rather than on appropriate industrial, commercial or government experience, and at times in courses that seem excessively theoretical (more so than some university courses).

The very existence of a binary (or pseudo-binary) system is blurring the distinctions between the two sets of institutions, and reducing diversity, rather than increasing it, in those dimensions where it is most needed. If the two distinct systems were replaced by a genuinely diverse "array" of institutions, at least some specific problems would be removed, and the risk of CAEs becoming second class universities lessened.

The kind of thinking going on is indicated by the following report of a workshop group that considered the topic "Diversity in the Organisation of Tertiary Education in the Australian Federal System", at the 1975 HERDSA Conference:

"The creation of greater diversity in forms of tertiary education was clearly the central feature of the Martin Report. The system envisaged was organised on a State basis though financially supported by the Commonwealth Government, thus recognising overtly the constitutional realities of the States' responsibilities within the Australian federal system.

"The advent of total funding of tertiary education by the Commonwealth together with associated developments, including rapidly accumulating problems of rationalisation and co-ordination, now however raises the question as to whether the organisation of tertiary education which was developed in response to the Martin Report is today the most appropriate mechanism for achieving the goals of post-secondary education.

"In view of the rapidity and the nature of the changes which have occurred not only in tertiary education, but also in technical and further education, it seems opportune and indeed urgent for a comprehensive review to be undertaken to evaluate progress and to assess future desirable developments in post-secondary education. The review might well address itself to aspects such as:-

(i) desirable developments in the structure and governance of post-secondary education at Federal, State, and regional levels, having regard to constitutional and established rights and responsibilities;

(ii) the desirability of establishing a permanent, independent research and planning agency to publish reports in response to existing and emrging needs in post-secondary education;

(iii) the creation and preservation of diversity within post-secondary education: and

(iv) the resolution of conflicts arising from the recommendations of numerous recent ad hoc enquiries".

This is one of many similar calls for an overall review of post-secondary education in the last few years, and it seems likely that before long such a review could be made. [The Prime Minister has now, late in 1976, announced the appointment of a Committee of Enquiry into Education and Training.] Meanwhile enquiries with broad terms of reference have been set up to examine post-secondary education in W.A. and Tasmania. [These have now reported, and further enquiries have begun into post-secondary education in Victoria and S.A.] To some extent the power of a State Government to change the overall structure of post-secondary education is limited by federal funding and federal co-ordinating mechanisms, but a probable outcome of any national enquiry is greater diversity, as suggested by the term, an "array" of institutions.

Links with the Community

INTRODUCTION

Over and over again during the project, the need for much closer links between educational bodies and the community at large has been raised. Such links are urgently needed, of many kinds, with government and private EDP users, manufacturers, and many other sectors of the community.

This subject has been a constantly recurring theme. It is one that naturally occurred to us in considering the brief and one that we could not have escaped. It emerged as a key topic from the search conference, and was spontaneously introduced into both informal discussions and in many structured interviews.

PROBLEMS

Education is a concern of the total community. Discussion of educational objectives, problems or policies arouses widespread interest. The quite remarkable degree of interest, involvement and support the project received from the whole community is evidence of this.

Computing education involves students, educational bodies, industry and employers, the individuals professionally engaged in computing, government and the community at large. It has therefore been disappointing to see just how wide the communications gaps are, especially the one between educators and employers. There are of course many significant exceptions, but the degree of criticism on both sides, for whatever reason, must reflect a lack of contact, and hence of mutual understanding.

Our brief is concerned with computing education. It is probably true that the problems of miscommunication and non-communication are more extreme in a new and rapidly growing field than they are in other fields. However, while we speak specifically of problems and possible solutions in computing education, there may well be much that is more generally applicable. Certainly, some of our suggestions should not or could not be considered only in relation to computing.

MESSAGES TO THE PROJECT

Many people and organisations seized the opportunity presented by the project to put across a point of view, often one very strongly held. Countless times people opened with remarks like: "At last we have a chance to say what we've been trying to say for years ...", or "Would you please tell 'them' that ...".

We received many bitter complaints and harsh criticisms from both sides of the fence. Disillusionment by employers with educational bodies for what is regarded as "lack of relevance", and for turning out "the wrong sort of people" was commonplace, and more detailed examples are given elsewhere in the full report. Both sides frequently felt that the other had little understanding of or sympathy with the real world problems they faced: Employers felt that many educators had insufficient idea of what the needs and stresses of a real world EDP organisation were. Educators also, however, felt that many employers had little sympathy with their problems, demanded the wrong things of the educational system, and failed to realise what higher educational institutions were trying to do.

Communications breakdown is not universal or absolute, but is general enough and serious enough to cause much concern. In the extreme case we found employers who preferred not to employ those with tertiary qualifications, and one very big employer group (represented by a large group of experienced and responsible senior computing professionals and EDP managers) said it would prefer to recruit anyone but those with degrees or diplomas in EDP or information processing from the CAEs in its State.

OBJECTIVES

It is therefore urgently necessary, for all parties, for those in education, industry and government to interact and communicate more. This will require new and more diverse arrangements and structures that will facilitate co-operation, interchange and joint sponsorship in educational, research and development activities. (These will require definition and acceptance of mutual responsibilities.)

Our objective in such initiatives should be to make the work of all parties more effective: to lead to better, more informed, more effective teaching of greater relevance to society's needs; to better use of computing in industry and government, informed by sound understanding of computing developments; and to help society generally in various ways.

Having established what the problems are, and what our objectives should be, we should consider both the kinds of groups between which there should be better relationships, and questions of ways and means: what areas of contact are possible, and what initiatives should be taken?

KINDS OF RELATIONSHIPS

There are at least four groups with which those concerned with computing education in institutions of higher learning should have closer relationships:

- government
- industry and employers
- other sectors and levels of education
- the general community

The government, at all levels (national, State and local), represents by far the largest group of users of computing in the community, and hence is the largest employer group. It is also intimately concerned with educational policy and funding, and with so many areas of policy related to computing and education that much closer links are clearly desirable.

Private industry is likewise not only a major user of computing services and employer of computing staff. It also includes the vendors, software houses and others in the "computer industry" itself, who are familiar with overseas developments, are engaged in technical innovation, and have daily business and professional contact with users.

There is far too little real contact also at present between those in different sectors and levels of education. Not only all too often is communication between universities and CAEs quite limited, but both have inadequate links with the TAFE sector and the secondary schools. (Again, of course, there are notable exceptions, but as a generalisation this would seem true.)

Finally, links are needed with the general community in many ways. In their roles as end users of computer systems, as students or parents, citizens at large are ill informed about, and too little involved in, even alienated from, universities and colleges. They often do not seem to know what these bodies do, or what courses are available - in particular, many of the general public lack an appreciation of the role and academic level of CAEs.

AREAS OF CONTACT AND TYPES OF INITIATIVE

There are many ways in which better interaction could be achieved, but among the types of initiative possible are:

* interchange of staff and consequent cross-pollination

* co-operative involvement in educational activities

* communication and involvement in educational planning, and consultation by academic staff to industry and government

* joint involvement in development projects

* establishment of research and development centres to provide a professional meeting ground

* explicit communications and public relations exercises.

CO-OPERATION IN EDUCATIONAL PLANNING

Most CAEs or State co-ordinating bodies and some universities have some kind of advisory committee structure, drawing on the experience and knowledge of outside individuals, but the extent of real co-operative planning is nevertheless limited.

Some committees, for example in State bodies, make heavy calls on the time of non-college staff, but as these committees form part of a hierarchical decision-making and approval process they may not succeed in establishing close interactive links at grassroots level between outside experts and those actually involved in teaching. Other committees, more specifically advisory, may either serve primarily as window dressing for the college or for a variety of reasons fail to make their full potential contribution.

Many factors, such as infrequency of meetings, heavy day-to-day demands on academic staff, or the other commitments of busy committee members serving honorarily and part-time, may be reasons. Structural changes and explicit support will be needed to achieve effective and worthwhile dialogue.

JOINT EDUCATIONAL ACTIVITIES

Many kinds of educational activity could profit from the participation of both academic staff and others. Often a particular unit, module or even a few hours of a CAE or university course could well be taken by somebody from outside with particular knowledge and expertise. However, this is comparatively rare. Apart from the employment of part-time tutors and others of low academic status, part-time staff are normally used only as an ad hoc expedient to meet problems of vacancies, staff leave or other exigencies, rather than as deliberate policy.

On the other hand, many organisations that run in-service or continuing education courses could benefit from the involvement of academic staff in their planning and presentation. However, institutional rigidities, the needs for academic departments to plan well in advance, and other teaching commitments would frequently prevent this from happening under present conditions, even if both sides were open to ideas of greater involvement in joint activities.

Some might even question whether "in-house" courses would be a "proper" activity for tertiary level academic staff; in fact, their very involvement could ensure that the courses are not only effective in meeting user needs, but also of high academic quality, deserving some kind of recognition in a more flexible and modular system of gaining credentials.

The educational activities of both formal and informal educational sectors could profit from greater mutual involvement, but this will need new structures and policy to permit and encourage it.

RESEARCH AND DEVELOPMENT

Another largely neglected area of contact between sectors is that of consulting. Whereas in the U.S., academic salary levels (and the lack of tenure for most posts) virtually force academic staff to obtain either visiting appointments or consultancies, during the long vacation if not otherwise, the Australian tradition is the opposite. Most staff are tenured, salaries assume full-time, year-round employment, and because of the dangers envisaged in "moonlighting" and neglect of academic duties, most appointments restrict, sometimes severely, the extent and nature of private and consultative work that can be undertaken.

However, some employers have suggested to us that, in computing at least, college academic staff should be required to undertake consulting or other outside practical work in industry or government, to ensure that their knowledge and experience remains up to date. Such changes could be introduced if institutions so wished (with the support of funding bodies), and the educational bodies could themselves take the initiative to find appropriate placements or consultancies, and if needbe could collect payments directly from the bodies using their staff's services on a part-time or short-term basis. (Some even suggested to us that active consulting or industrial experience should be a condition for re-appointment, and coupled this with the suggestion of a system of fixed term, rather than permanent, appointments. However, such a change, even if considered desirable, could scarcely be introduced in one discipline alone, or without regard to the rights of those already permanently engaged.)

Even more radical a departure from current practice but of great potential value would be the establishment of joint centres of various kinds to undertake research and development.

In Australia there have been relatively few and rather tentative moves in this direction. Some universities and colleges have legally separate companies (such as Unisearch and Technisearch) to develop and exploit commercially the innovations of research workers, especially where these lead to patent rights, but these, although bringing academia and the practical world closer together, are essentially spin-offs rather than joint ventures.

We also did have for some years a major "software factory" housed at the S.A.I.T. campus, and while not a joint venture in the sense of involving academic staff in the daily development work of the factory, the value to both parties was considerable.

There are many overseas models we could turn to: a Max Planck Institut, the technological universities of Europe with their close consultative contacts with industry and government providing the impetus for much of their original research, or the many research and development institutes which have grown from U.S. universities. (For example, the Stanford Research Institute, although now a separate corporation, began its life as a research institute within Stanford University. Similarly, the variety of technological companies that has sprung up around the M.I.T. because of close links between a centre of technological learning and industry, and in some cases from joint projects, is legion.) More generally, countless North American universities and their staff undertake a large proportion of their research and development work under contract from government and private bodies. In Australia, with a high proportion of research and development financed from public sources, and much of this channelled through agencies such as CSIRO, and with academic research mainly funded through the Australian

Research Grants Committee, this pattern is uncommon.

The potential benefits to both the educational bodies and to government and private sponsors of joint research and development could be vast, especially in computing. The stimulus to academic staff of major practical problems to attack, with access to appropriate resources, and the opportunity to keep at the forefront of technology could be great, both for the professional development of staff, and indirectly for their students. The benefits to the sponsors of the part-time involvement of academic leaders are obvious.

Not every major academic centre could necessarily justify a joint centre, but those that are established could offer excellent places for workers from other institutions on study leave or in vacations.

While it may be open to argument to what extent the research and teaching of universities and CAEs should be explicitly tied to expected vocational needs, certainly whether any coercion should be used that would infringe on academic autonomy, any joint development projects would necessarily be practically motivated. This would encourage, not force, post-secondary teachers to concentrate on those aspects of computing of greatest relevance to Australian needs, and where appropriate to involve their students in the continuing work of joint projects.

In Chapter 3 reference was made to the needs of an indigenous industry (if one emerges), and to the fact that much current post-secondary teaching fails to address the specific needs of the country, now or in the future. If positive steps are taken to encourage an Australian computer industry - of whatever form - it would be mutually advantageous for some university or college staff to take part in its development through joint projects. It would certainly help alert computing departments to likely future needs, and keep them aware of the main stream of local activity.

Even joint projects <u>not</u> directly concerned with a local industry, though, but with the applications of computing, could be of great benefit. Major applications systems that break new ground, as the Victorian TAB and Qantas' message handling and reservations systems did, could well be appropriate development tasks for a well staffed development group, and there is no shortage of applications, including many of less vast scale, that could be tackled. Given the support of users, and a degree of co-operation between themselves in determining requirements, there are also many application packages that could be developed by a strong group associated with a university or college, for particular industries or sectors of government (including local government).

The proximity of such development to a college or university, and the active participation of academic staff, could go a long way towards overcoming the real problems at present of exposing students to real world computer applications. At present practical experience is often limited to simplified problems, at times simplified to the point of unreality, supplemented by case studies. Some colleges (e.g. Bendigo Institute of Technology) go to much trouble to find projects for senior students through placement with local organisations, but this requires a lot of effort to establish and supervise; many colleges cannot or do not attempt it. Even where student contact with joint projects is second hand, the stimulus through the staff should be considerable, bringing them closer to the leading edge of modern developments.

INTERCHANGE AND CROSS-FERTILISATION

In Australia, unlike the U.S., we have a tradition, albeit one that is slowly changing, of academic tenure, permanent career appointments in the Public Service and many other bodies, and of fairly rigid barriers between academic, government and private employment.

Whilst the alternatives have their pitfalls too, our traditions do deepen the communications gap between sectors of the community. There is also the very real danger that those appointed to teaching posts, possibly because of their practical experience, may progressively lose touch with the practice of what they teach over a period of 30 years or more. This danger is particularly acute in the CAEs which do not as a rule undertake major research in the same way as universities, and where, unlike the universities, little or no allowance is made for research activity in allocating teaching loads.

Every form of interchange and cross-fertilisation needs to be encouraged, and in a fast-growing field like computing one year of study leave in seven (assuming this were possible for all, which at present it is not) is simply not enough. In addition to opportunities for study leave for academic staff, spent here or abroad, should not the experienced computing staff of industry and government have the opportunity to spend a spell with a university or CAE? It could not only refresh the thinking and teaching of an academic group to have someone from the world of affairs work with them for a year or a semester, but there should be great eventual benefit to the user organisations through fresh ideas gained from those with more detachment and opportunities to keep abreast of their field.

Such interchange will not happen without positive encouragement, promotion and assistance. Many of those who criticise educational bodies for lack of relevance would also be loath to part with a senior member of staff for six or twelve months -- a frequently expressed fear is that their staff would not come back! Yet another problem, of course, for many individuals would be the risk of missing out on promotion or advancement in their absence.

Yet another possible innovation is the use of joint appointments. While these are a rarity in Australia, is there any reason in principle why someone should not hold two concurrent part-time appointments at an academic body and in a public or private organisation, to the benefit of both? Such an arrangement would be especially appropriate for the staff of joint research and development centres, if these are established.

NEW STRUCTURES

The main reasons preventing innovations of the kind suggested are simple: lack of positive enthusiasm, and the rigidity of our present structures.

If there is real interest in achieving better communication, co-operation and cross-fertilisation, this will have to be fought for.

Further, there must be willingness to look beyond our existing institutional frameworks, which currently make any departure from usual practice a major bureaucratic battle. Tenure, full-time appointments, restrictions on consulting by staff or restrictions on the short-term engagement of outsiders, or limitations on off-campus educational activities are none of them sacrosanct. A more fluid policy could permit individual ideas and cases to be considered on their merits.

WHAT IS NEEDED

The communications gap, and the relative isolation of most educational bodies from the world of practical computing, are not necessarily or even usually the fault of those in the institutions, who often do a great deal within the constraints that bind them to try to overcome the problem.

Dedicated and stubborn support and encouragement are needed. This must be given by the institutions themselves, but even more by the State and national co-ordinating bodies. Most of the changes and initiatives will require a modification of current policy, or some funding, and usually both. The encouragement and financial support needed should be given. Half-hearted efforts are not enough.

Student Viewpoints

THE NEGLECTED ELEMENT

It was a matter for some concern that our terms of reference, although requiring us to seek the views of both employers and educators on computing education, did not specifically require us to solicit the views either of students or of recent graduates. It seemed to us essential that some effort should be made to determine these.

Even if one were to adopt a highly authoritarian view of education, which few would hold in these days when student participation is growing - even if this still arouses controversy in some academic circles, while being labelled "tokenistic" by some dissatisfied students - it is hard to see that student and graduate viewpoints can be ignored. If, for example, the perception of the students of what they are doing at university or college, and their reasons for entering vocational courses differed markedly from those implicit in the plans of the institutions, surely we should need to think again what the supply and demand estimates meant? Similarly, the experiences of recent graduates on entering the work force would seem to have some relevance to course design and would be worth feeding back.

In the end, apart from a number of informal contacts with students that occurred coincidentally, we did three main things: we had discussions with officers of the Australian Union of Students (AUS) to obtain the official views of the elected representatives of student opinion, we had frank and open discussions with a group of about 25 students just completing degree and diploma courses in EDP at the Caulfield Institute of Technology in late 1974, and we obtained results from the only intensive study so far undertaken of the experiences of graduates and diplomates from CAEs.

THE OFFICIAL STUDENT VIEW

Discussions were held with both the President and the Education Vice-President of AUS. AUS sees its role very much as a union, and its concerns are essentially political and social. The office-bearers would be ready to admit that their views, and the policy of AUS, do not necessarily reflect fully the views of the over 100,000 tertiary students they represent: student apathy still exists.

One of the general questions canvassed with the AUS officers was that of the aims of higher education. In particular, we were interested in their impressions of what the reasons of the students themselves were for attending university or college - to what extent are these vocational and material, and to what extent are they more concerned with personal goals and a wish to obtain "an education" (in any sense) for its own sake? Our discussions reinforced our view that there is a very great diversity in the reasons why students undertake tertiary education, and in their aspirations. However, we gained a strong impression that a growing proportion of students continue to university or CAE from sheer inertia, because it is increasingly the accepted, natural and "logical" thing for a student to do after completing Higher School Certificate or Matriculation.

The official, and carefully evolved, views of AUS on general educational philosophy and on immediate problems are set out most fully in their submissions to the AUC and the ACAE [Aust. Union of Students 1974a, 1974b]. A number of the points touched upon, whilst important, deal more with student welfare than with educational policy or academic issues (such as housing, child care, counselling services, union and recreational facilities, loans, and the needs of handicapped students), and are not of direct relevance here. Much of what the AUS says on moves towards greater educational equality and increased access to tertiary education is in accord with what we have already said about the need for more adaptive and less rigid planning structures, and for acceptance of recurrent education as a goal. In its submission to the AUC, it points out the socio-economic factors that inhibit access to universities, and hence the goal of higher education in promoting greater social mobility, because of the application of current selection processes.

The first, and key, recommendation of the AUS to the AUC is:

> "A.U.S. urges the A.U.C. to undertake a thorough examination of alternatives to selection procedures with the aim of promoting universal accessibility to universities, and to encourage any attempt at broadening admission policies." [Australian Union of Students 1974a, p.5]

In support of this, AUS points to the very limited provisions of universities for the admission of non-matriculants, the lack of any cogent evidence that success in matriculation examinations is an effective predictor of success at university, the need for "opening up" of the universities generally, the usually unquestioned "lock-step", sequential educational process which discourages deferment of university courses, the difficulties of transfer between universities (and in some cases the virtual impossibility of transfer from CAEs to universities), the lack of positive encouragement of part-time and external studies at universities despite evidence of a heavy demand, and scope for greater community access to university facilities.

It is also interesting to note, in relation to our own comments earlier, the extremely strong opposition of the students' union to manpower planning:

> "A.U.S. is concerned that the Government's assumption of financial responsibility may lead to the adoption of manpower planning. If enrolments in the sciences continue to drop and demand for humanities-based courses grows, the temptation to introduce a form of manpower planning may become great. A.U.S. is opposed, both morally and realistically, to any such suggestion of manpower planning. As we argued for universal accessibility to universities, we also believe that there should be universal accessibility within universities to all courses. Too often quotas are imposed to prevent 'surplus' in a profession, in order to safeguard income for the profession as a whole.
>
> "Apart from moral objections to Governments or industry determining the number of workers in any field, manpower planning is notoriously unreliable. As in the case of the increased number of geologists trained during the mining boom, conditions change so unpredictably that such planning often creates more problems than it solves. Again, to quote from the Ontario Commission on Post-Secondary Education, 'there is no reason to assume that we are able to predict the occupational structure of our future society with any greater degree of success' and 'basically, the problem is how to develop our educational system in such a way as to be able to provide both the immediate application of acquired knowledge and skills, and at the same time, prepare the individual for a lifetime of changes - including occupational changes.'" [op. cit., p.6]

AUS further takes issue with the AUC's cautious attitude in its Fifth Report towards interdisciplinary studies, and argues that "the original organisation of universities around a concept of 'unity of knowledge confined to a few disciplines' has been outstripped by the expansion of knowledge. With increasing specialisation and differentiation, this concept of unity was difficult to maintain and there is now a pressing need for integration."

[op. cit., p.7]

In its submission to the ACAE, AUS deals with the fundamental question of the role of the CAEs. It says:

"We are opposed to the present binary system as continued by the government, and even more so to the trinary system as conceived by the government of Victoria. We feel that tertiary education should be treated as a whole because the differences between colleges and universities, always unclear, are becoming harder to define. This will be so as long as the 'competition ethic' set in motion by the binary system is continued. We feel that CAEs should not be considered as an alternative to the university system but complementary to it. We would, in light of this total education view, recommend the combining of the AUC and the Commission [the ACAE] at the earliest possible time ...

"While CAEs may well focus on vocational training we reject any orientation of CAEs to provide fodder for industry. In recent years CAEs have recognised the need for more generalised courses, and there has been a move towards providing liberal arts within CAEs. The high demand for these courses is an indication of student disillusionment with the current vocationally oriented courses. We are of the opinion that it is important that technology courses include studies on the environment from both a social and a scientific approach, with emphasis in relation to the discipline being studied." [Aust. Union of Students 1974b, p.1]

They go on to say that "In the ideal system we believe that there should be no distinction between colleges and universities and that there should only be one type of tertiary institution offering a large variety of courses at different levels. Since this is obviously an impossible proposition given current circumstances we must look at relationships within the current system." [ibid]

They then deal with several specific issues they regard as crucial if the "poor brother" image of CAEs is to be shed. These include completion of campuses (as many CAEs have split campuses during present developments); the need for regional CAEs to be developed as community colleges, offering liberal arts and teacher education as well as existing courses; the incorporation where possible of small single discipline colleges into larger ones, because of the educational, social and cost advantages seen; and, again, greater flexibility in selection procedures to provide more open access.

Of particular relevance to this project are the reccmmendations on academic matters:

"The Commission has previously recommended that up to 10% of a colleges staff should be on study leave at any one time. We support this fully but feel that this figure cannot be achieved in some colleges due to several factors. Staff involved in lecturing in highly specialist subjects or low interest courses are in many cases unable to take leave because without them the courses cannot be offered. We recommend that the Commission makes provision for a form of backup system that will provide replacement staff to colleges in these positions. It could be provided by having a pool of 'floating staff' or more likely by an arrangement for loaning staff from college to college. This system would be invaluable for the smaller non-metropolitan colleges who have no hope of providing for absences." [op. cit., p.4]

This has particular point, as we have indicated, in computing studies, especially for the smaller colleges offering EDP courses.

The AUS' recommendations on three other points dealing with CAEs bear quoting in full:

On staff selection:

"There has been a trend in CAEs to employ staff with even higher academic qualifications. The ability to communicate to students [an] understanding of the course material is, we feel, a higher prerequisite for a CAE lecturer than a high academic qualification in a probably specialist area. ... We also feel that ... it is difficult for a graduate of a CAE to get a lecturing position within a CAE. We would recommend that positions in CAEs are offered on the persons ability to communicate their knowledge and not on the ability to accumulate it." [ibid]

On staff training:

"... we are concerned with the lack of inservice training in lecturing techniques provided in CAEs. Some colleges have lecturer training schemes which are not used because staff are either too involved in administrative matters or are not interested in learning how to lecture. ... Students at several colleges have conducted lecturer evaluation surveys which have found that a large number of students are dissatisfied with their lecturers abilities and would rather work alone than attend lectures." [ibid]

On teaching methods:

"We feel it is important that the CAEs do not adopt the lecture as the only means of teaching." [ibid]

On degree courses:

"In our previous submission we [said] there appears 'to have been an almost unholy haste in some states and fields to introduce degree level courses. Our fears have been confirmed ..." [ibid]

On accreditation:

There are many problems in ensuring recognition of qualifications, and in transfers between colleges, from colleges to universities, and even within individual colleges in transferring from diploma to degree courses: conversion courses should be provided if degree courses are approved.

On course structures:

"We feel that the structures of most courses in CAEs are extremely inflexible, usually consisting of a set of subjects all of which are compulsory with one or two optional subjects. This philosophy means that students are forced to become qualified in what those that approve courses believe and not in what the student really wants. The student who is forced to do subjects in which he is not interested or which he feels of no use to him is the one who will become embittered with the system.

"It is of the utmost importance that the Commission recommends that freedom of choice of subjects and provision of facilities for interdisciplinary subjects is made a priority in the next triennium." [op. cit., pp.5-6]

INTERVIEWS WITH STUDENTS

Late in 1974, after the college year had finished but before examination results were posted, we met a group of about 25 students at the Caulfield Institute of Technology who had just completed the final year of either the degree or diploma course in EDP. These represented about half of the two classes.

Caulfield was chosen as one of the colleges with well established EDP courses that enjoyed quite high repute. Members of the Institute staff arranged the meeting for us, for which we are most grateful. All students were invited, and a comfortable room was made available for the evening for frank and relaxed discussion over refreshments. For most of the evening, college staff were absent, to remove any possible inhibitions they might cause. (Although it is very doubtful whether anything substantially different would have been said with staff present.)

After opening introductions and a brief explanation of the project, a completely free and wide-ranging discussion followed, on the basis of "no names, no pack-drill", and that no individual statement would be attributable. Questions touched upon included the reasons why the students chose the courses they did, their expectations in doing so, their experience in obtaining employment, their views on the course, and changes they thought desirable. Much of what was said has been taken into account elsewhere, rather than specifically reported here.

The most important, and totally devastating, single result of the discussion was that <u>none</u> of the students then on the point of graduating had embarked on the EDP course because of a strong wish to become a programmer or EDP practitioner. Few, if any, had a particularly clear idea at the time they enrolled of what a career in EDP meant, or a course in EDP would include. Some had consciously chosen the course on the basis of advice they had received; others found themselves in the EDP course for less explicit and direct reasons (including one who had been enrolled in the EDP course by mistake but decided to remain!).

It was clear that all had enjoyed the course, and that there was extraordinarily good rapport and mutual respect between staff and students, which, together with the relatively small size of the student group, undoubtedly explained the very strong and warm group identity. All were already set to enter employment in EDP or closely related fields (most had received many job offers), but <u>few were sure that they would remain in the computing field for more than a few years.</u> Some had already formed ideas as to how their careers might develop, out of EDP, into related fields or eventually into management.

GRADUATE EXPERIENCE

Relatively little has been done on any significant scale to relate the work experience of graduates (or diplomates) of Australian universities and colleges to their education, or to obtain the views of recent graduates on the education they had.

The major source of information available to us has been the results of the Career '72 and Career '73 studies undertaken by Miss Lenore Cox, Kenneth Myer Research Fellow at the

Victoria Institute of Colleges (VIC), who has examined the employment destinations of 1972 and 1973 graduates of the colleges affiliated with the VIC [Cox 1973a, 1973b, 1974a].

While indicating that in general those completing VIC degree or diploma courses found jobs that matched their training fairly well, and that overall there was no indication of an oversupply of graduates, Career '72 produced some results that tend to be contrary to accepted thinking about Australian tertiary education. Frequently graduates had work experience, often in areas related to their course, before beginning their studies, and, although most undertook courses on a predominantly full-time basis, most also did at least some of their course through part-time study. The variety of exceptional cases - through part-time study, re-entry to education after a break, and the small group seeking a second qualification - tend to reduce the importance of the immediate school leaver with no work experience studying full-time as the paradigm CAE student.

Miss Cox commented of the "typical graduate":

> "The graduate considered that his college lecturers were competent in terms of their professional/industrial experience. He felt that the staff was interested in individual student progress. He was reasonably satisfied with the content of his course, thinking that it was not over specialised although he was likely to wish there had been an opportunity for more personal development at college.
>
> "He was less likely to express satisfaction with the method of presenting material at college.
>
> "He also expressed some doubts about the quality of the link between the college and the real work situation and was fairly certain that employers and employing authorities were not well informed about courses offered at colleges of advanced education.
>
> "The aspect most closely related to the graduates' attitude to both employment and college, as measured in this survey, was his status as a student. Age and sex had less bearing on attitude to college, though sex of the graduate was related to attitude to employment." [Cox 1973b, p.5]

Unfortunately, although there were more than 1200 participants in each stage of Career '72, the numbers from EDP and computing courses are scarcely sufficient to give a good sample on which to base general conclusions.

MORALS

What conclusions, then, can we draw from these rather scattered pieces of information?

We certainly do not have a sufficiently good basis from which to draw clear general conclusions. Both the interviews we had at Caulfield and the data from Career '72 relate only to Victoria, and may not be generally applicable. Further, the Caulfield interviews might not indicate what would have been found elsewhere, even in Victoria, nor did we attempt any accurate or statistical measurement. We simply gained an overall impression of the prevailing opinions and attitudes of graduands. The AUS view is authoritative as the official voice of students, but may not be representative.

However, two implications at least can be drawn from all this. It is not appropriate to assume neat and simple connections between vocational education, employer needs or demands, and student wishes. Just as neither employer needs, nor stated employers' demands, can be translated exactly and precisely without some transformation into needs for educational "output", so we cannot necessarily assume a one to one correspondence between current or potential enrolments in courses and a wish for a particular form of employment. The Caulfield results, while surprising and not necessarily typical of all institutions, do show clearly that the link between student wishes and vocational output is tenuous and complex.

We may also see from the Cox study that, even in purely vocational terms, much remains still to achieve better links between educators and employers.

NEEDS FOR FURTHER WORK

Much needs to be done, through questionnaire-based surveys and carefully designed interviews, to sample and measure the opinions and attitudes of both students and graduates. What sort of people study at universities and CAEs? Why do they go there? What do they expect? Are they satisfied with what they find? How important are the vocational and non-vocational elements in all this, and how do they see the link between education and employment?

We do not have adequate answers to these questions. They are not, of course, the only ones relevant to educational planning and policy, but without taking them into account we risk making decisions based on partial, or - worse - erroneous, information. More centrally, we cannot base plans on the assumption that all have a common view of the nature and purpose of education, if a large proportion of those actually "receiving" education turn out not to share this view.

Needs for Counselling and Information

Several recurring themes in this chapter, if taken together, lead to important conclusions. In various places in this report we have argued that:

* Long term manpower planning, in its more rigid forms at least, is not only undesirable but extraordinarily difficult, especially in a field that is changing as rapidly as computing.
* The motives of students for undertaking post-secondary studies are varied, but usually include a vocational element (without this necessarily being dominant for most students).
* Communication between employers and educational bodies needs substantial improvement.
* Greater freedom of choice should be given to students in the selection of subjects studied in their courses.
* The biggest need in computing employment will be for those with a multidisciplinary background that includes substantial study of computing as one of two or three major disciplines.
* Because of the rapidity of change, especially in computing, we should aim to produce versatile graduates, with solid basic foundations, rather than highly specific and sometimes dated knowledge of techniques, which is more appropriately obtained when needed through programmes of continuing education.
* Students frequently have very inadequate information before and during their university or CAE courses about the range and nature of employment opportunities.

It would seem to follow that a vastly improved flow of information is needed to secondary and post-secondary students and those already in the work force, to inform them of the range of educational and employment options open to them. This will be especially desirable if CAE courses are loosened up through an increased number of elective subjects, and if links between certification and the employment market become more tenuous. In turn this implies an increasingly demanding role for agencies such as the Commonwealth Employment Service, as well as for careers advisers in schools, and suggests a further area for fruitful co-operation between industry, government and education. The challenge is general, but once again is particularly acute in the computing field. How many school careers advisers or district employment officers are well informed about computing and employment opportunities in EDP?

The point is extremely well made by the Ontario Commission on Post-Secondary Education, and we again quote from The Learning Society:

> "A post-secondary system which places the development of human resources high on its scale of social concerns should cater to the learning needs of its citizens at all stages of their lives. As a special obligation, it should also assist them at critical life junctures in relating the inreasingly complex and changing worlds of education and careers. If such help is to be readily available, coherent policies will be required in two important areas. First, a continuous flow of reliable and up-to-date information should be generated on the full range of post-secondary educational options and alternatives as they pertain to existing and prospective job and career opportunities. Second, data of this kind should be communicated to individuals at appropriate times and in suitable places through a flexible information network.
>
> "The difficulty and undesirability of deterministic long-term manpower and educational planning ... do not preclude considerable innovation in this general area. Basic changes are feasible that would provide more accurate manpower forecasts and predictions. Much can be accomplished by improving our system of information and planning on a practical short-term basis, and by identifiying the multiplicity of groups that need help in relating a wide spectrum of educational options more firmly to career or job opportunities.
>
> "In Part Two, Directions for Change, we propose a set of measures that should help individuals to adjust easily to the changes in skills, occupations, and knowledge that an uncertain future will surely demand. Closer links between education and work, as well as expanded programs of continuing education, should multiply opportunities for individuals to master - and not be overwhelmed by - economic and social perturbations. Equally, a loosening of connections between formal educational qualifications and employability should make the labour market less rigid, permitting skills and knowledge to be used more readily where they are needed.
>
> "But if a challenging and new approach to career planning is to succeed, a centralized information system also is needed to gather and generate data on education and jobs, and to distribute them to the

public. Such a service is essential to the effective working of a complex and decentralized economy and system of post-secondary education. It is an indispensable instrument of indicative manpower forecasting which seeks to anticipate trends in manpower needs and, unlike treating manpower planning as a engineer's blueprint, is compatible with our social and political institutions and values." [pp. 95-96]

CHAPTER 5

CENTRAL ISSUES IN COMPUTING EDUCATION

This chapter discusses a number of central and connected topics of crucial importance to the project, because they concern what computing is all about. Many were raised generally at the search conference; they were also discussed repeatedly throughout the project, in the structured interviews and in informal talks, and overseas in July and August 1974 by Barry Smith.

In relation to expected developments in the use of computers, and in relation to the approaches to solving problems and performing tasks in information processing, and to the development of a discipline or methodology of "computer science" or "informatics", we must ask:

* What are the nature and special characteristics of any such discipline or methodology?
* To what extent is it a discipline in its own right and to what extent an approach of general applicability?
* At what level in the educational system is it appropriate or desirable first to introduce computer-based or computer-related ideas and methods?
* What balance is needed between concentration on specialist <u>training</u> in the computer area and the diffusion of computing ideas, methods and understanding through a variety of fields?

Time and space scarcely permit treatment in depth of all these topics, and we can scarcely expect here to give a complete and definitive treatise on computing education. There is much that could be said, and we must ask our readers to show forbearance if sometimes we discuss a topic in detail and at other times merely suggest ideas, or point to the work of others.

The Informatics Emphasis

CONFUSION

There is, to put it mildly, lack of general agreement as to what is important or central to computing. It is not even agreed universally whether there is a discipline based on computing that can be recognised as a discipline or study in its own right, what any such discipline or subject should be called, whether it is a branch of some other field of study (whether mathematics, administration or engineering) or whether it is essentially an interdisciplinary study, nor is there agreement on what such a discipline or study includes. Such confusion and disagreement is perhaps not surprising. Computing is a relatively new field, and as a subject for formal academic study and teaching in the universities and colleges is only about 20 years old. A brash youngster, it lacks as yet the widely-accepted basis of theory, the coherence and substantial literature of older fields. No wonder, then, that it is in a state of uncertainty and shows some defensiveness, like (say) sociology 20 years ago.

POLARISATION?

At the same time, the confusion has been compounded by the widely held view that there are two distinct branches of computing, both in theory and practice, referred to popularly as "scientific" and "commercial", and reflected in academic courses and departments by titles like "computer science", "computing science" or "information science" on the one hand, and "information processing", "data processing" or "EDP" on the other.

Such a dichotomy would not only separate the "scientific" and "commercial" applications of computers, but would place in one category the more obviously "academic" branches of computing and in the other the more obviously "practical". Thus computer science is often regarded as comprehending logical design, numerical analysis, the theory of programming languages and their translators, and more esoteric subjects such as automata theory and artificial intelligence, whilst "information processing" includes systems analysis and system design, and all topics that deal with the storage, representation and manipulation of data, including most aspects of files and file processing, and of information storage and retrieval.

Such a division into discrete subfields is not necessarily very helpful. It certainly militates against any sense of identification in a common field of endeavour. At gatherings of computing practitioners there often seems to be little more in common than the fact that all work in some way with computers, and that most have some programming ability. It would seem that the split between "commercial" and "scientific" is neither apt nor useful. There are growing areas of computer applications that do not neatly fit either category, such as real time commercial and message-handling systems; commercial applications increasingly draw upon operations research, statistical or other "scientific" techniques; and growing numbers of "scientific" applications involve complex data handling and file structures. Further, this categorisation conceals the features of all computing that (at least to us) seem common and central.

PROBLEM-SOLVING

What has emerged from the research project is that the primary and central emphasis in computing should be one on problem-solving. This is an emphasis that has been placed by many others, especially since the first IFIP World Conference on Computer Education in Amsterdam in 1970, who refer to the subject or field of "informatics" ("l'informatique"): "The science of the systematic and effective treatment, especially by automatic machines, of information seen as the medium for human knowledge, and for communication in technical, economic and social contexts."

According to this view, there should be a basic orientation towards the recognition and description of problems, and approaches to problem solving. These include the algorithmic approach and the so-called "systems approach", which seeks to identify component segments of a problem together with their linkages and inter-relationships. Also of fundamental concern are effectiveness and structure, and the structure, representation and information content of data.

A strong case can be made that it is these concerns which are, and should be, central to all who work in computing, whether as theoreticians or as practitioners, on applications conventionally labelled as "scientific" or "commercial". Neville Holmes of IBM Australia in some recent papers [Holmes 1974] has developed some interesting and suggestive ideas about problems and problem solving, and the place these have in many domains and in the everyday practice of computing. It is because computing is intrinsically concerned with the recognition, definition and solution of problems that the "systems approach", and both algorithmic and heuristic methods of problem solving, loom so large for many computing practitioners.

As we have ourselves argued [Smith 1970a, 1970b, 1970c, 1971a, 1971b], computing is also essentially concerned with considerations of effectiveness and of structure. Some years ago Perlis developed a computer science course that dealt in turn with the structure of machines, the structure of data that can be represented and stored in machines, the structure of algorithms, and of languages for expressing and performing algorithms. Concern with effectiveness, with structure, and especially with data, is central, as computing is always ultimately linked to the real world, of machines and of problems which human beings wish to solve with the aid of computers.

INFORMATICS

Such an emphasis is entirely consistent with the emphasis now placed by those who speak of "informatics". Originally a word coined in the French language because of the lack of an equivalent for "information processing", "informatics" now typically carries the connotations we have given it above.

In this sense, although informatics may be regarded as a subject or discipline in its own right, albeit an infant one, like mathematics it is important for most students, not so much for itself, but as a tool of very wide and general application. It is the "informatics approach" that is important for most, rather than the academic study of informatics.

It is also in this sense that informatics has been taken very seriously in France, not only at post-secondary level, but in secondary schooling as well. To quote from the Charge de Mission a l'Informatique [Mercouroff 1973]:

> "To demonstrate these procedures examples can be found in all educational disciplines and the methodology of informatics must be made part of the teaching in each discipline. For these reasons it has been taken as a working hypothesis that the introduction of informatics in secondary education should not take the form of a new educational discipline but should be applied across the disciplines already taught."

The "informatics approach" has been described by Hebenstreit [1971], who sees it as an operational attitude towards real world problems very much like that of a design engineer. It is a discipline concerned with the building of models in a broad, but fairly well-defined, sense. In terms of its methodology, one could say that it was concerned primarily with two things - the manipulation of symbols on the one hand, and syntax, and the distinction between syntax and semantics, on the other. To quote from Hebenstreit (in relation mainly to school rather than post-school education):

"From what we have seen the only possible justification for teaching [informatics] is the shortening of the process of learning by experience, which means by the student himself of his own correct model of the outside world.

"From this point of view we should not transmit information, but use information to teach models which make this information coherent.

"This means that we have to help each student to build, by himself, inside his own mental structures, starting from his own model, a coherent model of the outside world so as to give him the possibility of more and more successful action in this activity, whatever this activity might be."

And again:

"It is out of the question to teach models instead of facts, to have lectures on models and so on. We still have to teach facts, but the difference between teaching just facts to memorise, and the method which inserts these facts in a coherent model is the same difference as between learning by heart a set of random words and learning these same words set in a meaningful text."

While Hebenstreit's writing is abstract, in the finest French tradition of rationalism, it is not hard to see that what he is saying is in the same spirit as what we have just said. To solve problems, rather than mere puzzles, usually involves the analysis of systems and the identification of components and interactions, from which a model of some kind may then be synthesised or built. The emphasis on the operational nature of informatics, its similarity with engineering design, and its concern with real world problems, mirrors what was said about computing being involved with questions of effectiveness. The manipulation of symbols and the study of syntax and semantics (some would add pragmatics) reflects the essential concern of computing both with data and with structure.

If we view computing as informatics, and if we see informatics in the kinds of terms that Hebenstreit suggests, then, apart from possibly forming a discipline in its own right, it represents a fundamental approach, an operational attitude, to problems in all intellectual domains, which may prove relevant to a great deal of education and of intellectual activity. In Hebenstreit's view, for the secondary schools this implies not just the inclusion of extra topics somewhere in the syllabus, but a fundamental rethinking of how <u>all</u> topics should be taught. (A rethinking which has begun in France with the physics curriculum.) For the research project, and for post-secondary computing education, this view of computing as informatics influences <u>who</u> should be taught and <u>what</u> should be taught.

THE EMPHASES NEEDED

Whether or not the reader fully accepts the view of informatics that we have briefly compressed from Hebenstreit's paper, it would seem clear that the emphases suggested - on problem solving, systems and models; on data and symbol manipulation; on structure; and on effectiveness - should permeate all teaching and learning of computing. This applies especially to the vast majority of students who will use computing as a tool to help them tackle problems from a great variety of fields. Just as many now study mathematics and statistics, but few become mathematicians or statisticians, so we may expect that many will need to have a working familiarity with computing and the informatics approach, although few will become computer scientists.

Correspondingly, in this view, one should consider as quite secondary concerns for informatics: numerical mathematics, computer hardware, specific languages (except as a means to an end), specific techniques, or the search for aesthetically pleasing elegance.

There is little doubt that informatics or computing can be validly regarded as a discipline in its own right, and that the foundations and structure of such a discipline are, very slowly, emerging. The "informatics emphasis" makes it appear much more likely that this will be a branch of engineering rather than of mathematics, or that it will evolve as a major study in its own right with a distinctive flavour, like engineering, because of its fundamental preoccupation with finding effective solutions to practical problems that involve the processing of data.

Regardless of this question, computing is already of substantial importance, even essential, in many other fields. The important general conclusion follows, that all levels and sectors of the community are involved in education in computing. This is probably true in two different ways.

Firstly, because of the rapid penetration of computing into almost all fields of human endeavour, some basic understanding of computing, familiarity and comfortability with computing, and competence in the direct or indirect use of computers will soon be essential for a very large proportion of the population, both in their everyday life and in their employment.

Secondly, the informatics approach to problem solving potentially represents a powerful and practical tool of wide applicability, and one which should be available to all, including many students in secondary school. Some would even argue that, as skill in problem solving is <u>the</u> basic intellectual skill, informatics should assume a central position in education.

Computer Science and Informatics

WHAT <u>IS</u> COMPUTER SCIENCE?

To a large extent this question has already been canvassed in the previous discussion of informatics. For very early definitions we refer the reader to those of Fein [1961], Gorn [1963 and 1967], Forsythe [1967], and Newell, Perlis and Simon [1967], and for more recent debate to the proceedings of the Stony Brook conference [Finerman 1968] and the Vienna symposium [Stetter and Weinmann 1971], especially the English language contributions of Atchison, Laski and Gotlieb.

Atchison [1971], who has been a major contributor to the ACM Computer Science Curriculum, points out that the common body of ideas embodied in all the early definitions "lies in the Representation, Structure and Processing of Information".

IS IT SCIENCE?

Laski [1971] and Gotlieb [1971] both address the question whether informatics is science. Neither uses the term "computer science" in their papers, but from the context they seem to equate informatics and computer science. Both conclude that informatics is a science. Gotlieb justifies this on the basis of three criteria - "a connected body of observed facts and demonstrated truths, gathered in the form of a literature"; "a structure based upon general laws and theories"; and "mechanisms for formulating and testing hypotheses and for discovering new truths and theories". He qualifies his finding, however, by saying that "what is missing as yet in informatics are general principles and theorems which play central roles in the subject - such as the conservation laws in physics and chemistry or the relation between channel capacity and bandwidth in communication theory". Consequently, although important concepts are now recognised as central to informatics, since "formal theorems and principles about these concepts have yet to be stated, ... in this respect informatics must be viewed as a science in its early stages".

IS IT INFORMATICS?

From the previous paragraph it is clear that at least some professors of computer science regard informatics and computer science essentially as synonyms. On this basis, then, "computer science" may be regarded simply as the historical (and perhaps slightly misleading) name of the subject that enjoys greatest vogue in the U.S. and the U.K., even though the subject is more concerned with information than with the computer itself as an information processing device. (It does not necessarily follow that all professors of computer science would agree in the emphasis that we have suggested as characteristic of the "informatics approach".)

DOES IT MATTER?

The point of this discussion has been to explore whether there is, or should be, a dichotomy between what are popularly regarded as "computer science" and as "information processing". Our belief is that there is not, and need not, be such a dichotomy.

That many believe that there is a real distinction between the two, however, is not only demonstrable but is reflected in different kinds of course which, by and large, are offered in Australia by the universities and by the CAEs. Thus in its 1973-75 Report [Australia 1972a] the ACAE said:

> "University degree courses in computing science cater well for those requiring to use the computer as a tool in a scientific environment or in scientifically oriented numerical analysis, operations research and the like, but there is still a substantial requirement for courses which will provide a thorough understanding of management and other information systems, information system design and information processing, and the ways in which computer hardware and software can be devised, configured and operated. Such courses, at the higher level, would be appropriately placed in colleges of advanced education." [para. 6.35]

One particularly pragmatic view has been advanced, that computer science is established as a discipline <u>because</u> it is an observable fact that there is now a significant number of university departments and courses in the subject, and that if one wishes to determine what computer science is, one should do so by finding out what these departments teach and carry out research into. On this basis, presumably one would define computer science as a congeries of many things, including numerical analysis, automata theory, logical design, formal linguistics, and so on, as well as many subjects more obviously connected with the work-a-day lives of most practitioners of computing. From our interviews with employers, clearly most do _not_ want their EDP staff trained in computer science as it is perceived by some Australian universities.

On the other hand, we note that, apart from the fact that universities tend rather to concentrate on the more "pure" computer science, and CAEs on the "applied", there are several universities in Australia whose computer science or information science courses serve well as a vocational preparation for an EDP career [and which are now recognised by the Commonwealth Public Service Board as an appropriate basis for appointment as a computer systems officer.] Likewise, the honours computer science course at the University of Manchester Institute of Science and Technology is conceived to be equally appropriate for those who wish to embark on an academic research career and for those destined to be EDP professionals.

Of course we do not deny that fields such as numerical analysis or the theory of computability form part of the totality of "computer science". What we do suggest is that the central concerns of computer science should be the same as those of informatics, and that these also form the most important part of the training of would-be EDP staff - information and data, systems and models, effectiveness and structure. The very existence of courses such as that in Manchester gives weight to this suggestion.

NOTE ADDED IN 1976

[Some of those who have seen the original six-volume version of our report completed in 1975 have taken us to task for what we wrote about "computing", "computer science" and "informatics". In particular, we have been criticised for loose usage of these terms [Whitaker 1976]. To some extent, the problem stems from a lack of any general agreement on the use or meaning of _any_ of these terms.

The issues and arguments involved probably deserve full treatment in a separate paper. However, until this is written, I should like to assert (without justification) my views on these points, as developed in the last twelve months:

Whether "computer science" is a "discipline" would be a trivial and sterile question to ask (especially if one favours a multidisciplinary, or interdisciplinary, approach to the study of many problems), were it not for the light that asking this question can shed on the more important questions of what it is important to teach to those who study computing for vocational reasons of one kind or another.

It is probably not worth defending the proposition that informatics is a "discipline" (unless one simply equates "informatics" and "computer science" as synonyms). However, in the sense in which Hebenstreit writes, it is well worth developing and refining the "informatics approach".

The informatics approach should thus not be considered as simply the same as the field of computer science. It is highly relevant to computing and to "computer science" (or at least to that substantial part of computing practice which is concerned with the solution of real-world problems, including the whole field of information systems or data processing). However, the informatics approach is relevant to, and of value in, many other fields also.

The informatics approach is fundamentally concerned with the solving of problems, in the sense of building and then using models. It thus shares the same parentage as general systems theory. The emphasis of informatics, however, is not so much on theory as in applying concepts, principles and methods that are appropriate to any problems involving complexity and that do not depend on the specific nature of the phenomena concerned, a way of thinking about problems, and a way of looking at the world. It is general systems thinking, rather than general systems theory. [Klir 1972, pp.1-18; Weinberg 1975; Beer 1975].

The informatics approach is thus subject to the same kinds of criticism and offers the same attractions as general systems theory. In particular any claims for generalised skills in problem-solving will meet the suspicion of the psychologists about the assumption of a general transfer of skills, and of those who prefer monodisciplinary approaches. On the former point, it would seem that the evidence since Thorndike [1913] is not all one-way or clear-cut [see, for example, Bruner 1959]. ... B.W.S.]

Moves towards professionalism

TWO OPPOSING TRENDS

Parallel to the confusion as to what it is that is central to computing and to computer science (discussed in the previous sections), there is also disagreement whether there is a profession of computing, and if so what this is. There are at present two sets of trends observable that are leading computing in opposite directions. On the one hand, there are some definite trends towards the "professionalisation" of computing. On the other hand, there are quite pronounced contrary trends: Quite apart from the debate, which we do not wish to enter here, as to what comprises a "profession", some commentators question whether the very concept of a "profession" is any longer particularly appropriate. In times of growing job mobility, with the emergence of new subspecialisations and cross-disciplinary fields, and with some weakening of the links between certification and employment, is it not now running against the main currents of social change to institute new professions on the patterns of the old? Specifically in the computing field, while some see the emergence of a profession of "professional programmers", or computing specialists, others, including some authoritative figures, predict the gradual disappearance of programmers as a distinct occupational group (see also below).

THE BRITISH EXPERIENCE

In the U.K. the tendency towards the professionalisation of computing has been strong.

A significant factor in this was the move some years ago by the British Computer Society (BCS) to regrade all its membership. Those who are regarded as fully professional are in the grades of Fellow and Member, and for admission to the Member grade one must now have passed, or gained exemption from, Parts I and II of a formal examination that approximates in standard to that at the end of a major university course in computing of two or three years' duration.

What is important is not only that the BCS envisages itself as a professional society, with the formal apparatus of examinations, the use of distinguishing letters by qualified members, and a code of ethics, but that it has received substantial employer acceptance. Since the central government now largely restricts employment in certain categories to those with the qualifications of the BCS, and other large employers have followed this lead, the profession of computing has been considerably established as a fact in Britain.

U.S. EXPERIENCE

Practice in the United States is quite different. The major scientific and professional body serving computing, the Association for Computing Machinery (ACM), has not made any decisive moves towards professionalism or specific knowledge standards for its members. The Data Processing Management Association received some encouragement from those who regarded the ACM as too narrowly academic, but the establishment of a Certificate in Data Processing (which some envisaged as providing a qualification comparable to that of a Certified Public Accountant) has received relatively little recognition or support.

An entirely different pattern from that in the U.K. has thus emerged, and employers of EDP staff seem to pay little regard to the membership of "professional bodies", as distinct from the educational qualifications and experience, of applicants.

AND IN AUSTRALIA?

The Australian Computer Society (ACS), as the major relevant professional body, has been moving deliberately towards the establishment of professional standards and explicit knowledge standards for admission to its corporate grades of membership (Associate, Member and Fellow). These standards have been introduced progressively over the past few years (but without regrading those already admitted to membership), with a system of examinations and accreditation of courses. In this, the British pattern, rather than the American, has been followed.

However, as yet there is relatively little sign of employer recognition of the Society's membership standards as a qualification; in most respects the employment market is as fluid as in the U.S. Likewise, although some universities and CAEs have taken the trouble to ensure that their courses are accredited as meeting the ACS standards, so that those who have completed the courses are exempted from ACS examinations, by no means all have done so.

There are, though, two other factors at work.

First, following a detailed review by a team within the Australian Public Service of the work performed by those in positions that require the application of knowledge of computers and computing techniques, a set of position classification standards was prepared for the new set of five levels of classification of Computer Systems Officers (replacing the previous structure of six levels of "Programmer" positions, from Assistant Programmer to Principal Programmer). No academic qualifications were prescribed for entry to the Computer Systems Officer group, although evidence of appropriate knowledge and ability would be required, and for new entrants at the Grade 1 level this would normally be through appropriate teriary level studies. In defining the "basic knowledge" expected of a Computer Systems Officer, reference was made to the first two years of the B.A. course in Computing Studies at the Canberra CAE. As the Australian Public Service is both a major employer of EDP staff and also is widely regarded as a pace-setter in EDP salaries and conditions, this set of position classification standards could prove influential, especially if it is interpreted as an initial move in the direction of the professionalisation of the computing field. (It also is a useful and informative document that defines in some detail the nature of the work performed by those who are computing specialists, and the various levels of responsibility involved, together with the knowledge normally required for the work.)

The other major factor, as yet unresolved, is the issue of unionism. In the last few years, three major unions have vied for the allegiance of those employed professionally in the EDP field, including programming and systems staff, and are seeking to represent these staff groups in the arbitration system. Of these, one is a union formed specifically to represent the "computer professionals" in industrial matters, which sought to restrict membership to those qualified for admission to the ACS. The parallel here of course is the successful unionisation of the professional engineers, and their obtaining new industrial awards in the "Engineers' Case". The professional union that won these benefits was sponsored and assisted by the professional institute, although legally distinct from it.

It is probably still too early to predict with any confidence the outcome in Australia of the many conflicting moves that affect the extent to which computing specialists are recognised as a distinct professional group. We cannot, however, ignore the relationship between this issue and the issues discussed earlier in the chapter.

Patterns of Community Needs for Computing Qualifications

FUTURE COMPUTER USAGE

From the material elsewhere in the report (see, for example, the summary in pages 12-15 above), it is clear that computer usage may be expected to expand very considerably in the years and decades ahead. Hardware costs will continue to fall, making more and more computing applications feasible, and computing will become easier and more accessible. We may thus expect, at least for a decade or two, continued, even explosive, growth in the number, and power, of computers installed. This in turn will lead, not merely to a proliferation of computing, but to a growing range of applications of increasing diversity and sophistication (although not necessarily increasing complexity for the user).

This section considers what the consequences of this will be for the overall pattern of community needs for computing skills and qualifications, especially those relevant to the planning of higher education.

Since the gap between the supply of and demand for appropriate and effective skills seems likely to be so great that there is little immediate prospect of bridging it, it becomes even more important to establish the <u>balance of community needs</u>. In this way, even though resources may be limited, those which are available may at least be used to best effect to meet the most urgent and pressing needs.

TWO DIFFERENT POSSIBLE OUTCOMES?

Two quite different end results are possible: either the emergence of needs for new kinds of computing specialists, and new specialisations; or the definition of basic computing skills which will be required by all, so that computing ceases to be a specialty for some, but becomes part of the background of everybody.

It is hard to quantify these broad statements about future computing use. Two key factors in determining the rate of these developments are likely to be management and professional attitudes and styles, and educational policies themselves - especially with respect to the computing education of professionals in fields other than computing.

COMPUTER SCIENTISTS VS. PRACTITIONERS

Although we have been at pains to point out in several places the limitations of the statistical and quantitative data we have obtained, and the care with which these should be interpreted, several key conclusions emerge strongly. These conclusions, which represented the consensus view from the search conference, were heavily reinforced by the results of the surveys and the structured interviews, by the understanding that follows from looking at the total picture of interacting change elements (as sketched out in Chapter 3), and from the discussions held with several hundred people from all sectors of the community. These conclusions are put forward in increasing order of importance.

A very careful balance is needed between the supply of "high technology" computing specialists and of practically oriented "medium technology" practitioners of computing. For as long as can be seen ahead, the proportion of those who will be engaged full-time in the practice of computing (for its own sake) who will need advanced training in any kind of computer science will be quite small. Those whose tertiary training is almost exclusively, or even primarily, in computing are likely to be needed mainly for work in research and development. There is a definite need for research-oriented, high calibre computer scientists in Australia, but the demand represents a very small proportion of the total demand for tertiary trained workers in the computing field.

WHAT KINDS OF PRACTITIONERS?

Those who are to be computing practitioners (including programmers, analysts, data processing managers, and so on) should be exposed in some depth during their education and professional training to other disciplines, rather than to more advanced, or more detailed, areas of computing. Practitioners of computing, by definition, are involved in the application of computing to specific problems. There is a growing need for subject area expertise, and so a multi-disciplinary education is in many ways more appropriate for a computing practitioner than a highly specialised, vocationally directed course. The "double major" course is therefore likely to be more appropriate for those who wish to enter computing: in which computing and some other discipline are studied, in depth, throughout the period of tertiary education, as well as, possibly, supporting areas of study. Some introduction to interdisciplinary approaches would also be valuable, rather than a purely multi-disciplinary education, and the "informatics approach" could provide a basis for this.

An alternative to the double major degree, of growing attraction, is the double degree, or degree and graduate diploma, approach, or equivalent approaches which may evolve as recurrent education is accepted as a pattern. In many cases the student who is exposed to a limited amount of computing and informatics as part of his first tertiary course, and subsequently receives further education in computing after some practical employment experience, may prove a very valuable member of the work force. More specifically vocational and practical elements, such as systems analysis, may more meaningfully be presented to a student who has both a basic grounding in computing and some work experience.

It will be seen that such an approach is totally consistent with what has been said in the previous chapter about recurrent education. The more that we move towards more diverse ways of intermingling work and educational experiences throughout life, the more effective is our education of computing practitioners likely to be, and the less troublesome such problems as how one can best teach the principles and practice of systems analysis and design to undergraduates who may lack any experience or understanding of the nature and needs of organisations, offices or industrial operations.

A "mixed major" approach will also help preserve some of the innterdisciplinary character of computing, and provides the graduate with more career options. It is far from clear how many graduates in computing or data processing who enter the work force in 1985 will wish, or be able, to remain computing practitioners until 2025 - this involves forecasting trends in an occupational category over a time period almost twice as long as its present history. The previous remarks (in Chapter 3) about the impact of social change on the work force are relevant here.

COMPUTING TECHNICIANS?

A further observation which is strictly outside the project's terms of reference nevertheless seems important. There has been very little attention given to the likely needs for technician or sub-professional staff trained in computing or informatics, whether they work full-time in the computing field or are involved incidentally in computing. Nor has much systematic thought yet been given to whether any of the work currently done by "professionals" could in future be performed by technician level staff, although some observers predict the demise of the programmer as we now know him. One would normally expect the needs for technicians to be at least as great as those for technologists in any field, possibly much greater. Any systematic and total view of computing education that is able to look across present structural boundaries should address this problem.

Historically, the group most commonly regarded as the technicians of computing have been the operators, both of computer systems and of data preparation and data entry devices. Relatively little general training has been given these, except by large installations "in-house" and by computer manufacturers, mainly because so much of the knowledge needed until now has been highly specific to the particular hardware and operating systems used.

In earlier years, some organisations established subordinate positions of "coders", who wrote and tested the actual program code under the direction of more experienced programmers, but this approach has (probably rightly) fallen into general disfavour. Similarly, the Australian Public Service for some years had an occupational category of "Programming Assistants" (not conceived as coders), who provided low-level technical and clerical support for experienced and fully trained "Programmers", and who often advanced themselves to become Programmers after further training. However, this category has now been abolished since there is no longer considered to be any common or rational basis for such a separate classification or job description.

It may nevertheless be expected that, as the nature of computer systems work evolves, a sub-professional or technician category will again be needed, and appropriate formal and practical training will be needed for it.

In this regard, it should be commented that the natural academic desires of most CAEs to institute full degree courses in computing or EDP are not necessarily always well matched by the realities of the needs of the market place. For many computing tasks, both now and in the future, a diploma or associate diploma course could prove sufficient. In addition, if the rigidities at present in many course structures could be reduced, it would make excellent sense for those who had gained such qualifications that fall short of full degree standard to undertake "conversion courses" after a period of practical experience, with due credit being given both for the formal educational qualifications already held and for work experience. Further, there may well be before long a largely unsatisfied need for post-secondary but non-tertiary courses in computing. (A few institutions such as the Caulfield Institute of Technology have long offered a Certificate course, but these are few and far between.)

These concerns for the sub-professional computing specialists were shared by some of the employers visited, who asked whether more emphasis in discussions of computing manpower should not be placed on operations and maintenance staff. Some organisations, particularly those which now depend crucially for their entire operations upon computer systems, are extremely conscious of the important role that computer operations staff play. Quite apart from the vulnerability of such organisations to major disruptions, through sabotage, power failure, major equipment malfunctions, or gross operating errors, the effectiveness and the efficiency of sometimes highly expensive capital equipment can be greatly influenced by the alertness, knowledge, anticipation and prudence of operators, despite continuing attempts to reduce the dependence of operating systems on human factors through better human engineering. It is therefore surprising that greater attention has not been given to the training requirements of the groups concerned.

THE NEEDS OF THE NON-SPECIALISTS

Under the major heading below, "The needs of the 'other disciplines'", we discuss the nature of the needs for computing education for non-specialists, and some of the problems that commonly came to our attention with courses in computing for those with non-computing backgrounds.

However, in trying to indicate the balance of community needs for computing education, to which limited resources must be allocated, we would insist that relatively greater emphasis should be placed on the needs for understanding, familiarity and competence in the use of computing by professionals and sub-professionals outside the computing area, than on the specific needs to produce various kinds of specialists in computing and data processing. All levels and sectors of the community are involved in computing education: there are few disciplines taught by tertiary bodies whose students will not need some significant practical (and theoretical) grounding in computing. Virtually all university and CAE students should receive some significant education in computing. In some disciplines most students should have a good deal of computing, and in virtually all disciplines and tertiary courses there should be an option for some to include up to a full "major", so that those who wish to are free to develop as computer-oriented engineers, systems librarians, biomedical computing specialists, or quantitative workers in econometrics, operations research, urban planning, and so on. Nor is the need for significant computing education in any way limited to that part of post-secondary education currently labelled in Australia as "tertiary".

We would therefore strongly urge that one or more centres should be established, within CAEs, to study the teaching and learning problems of non-computer specialists, who need to study some computing, to develop and disseminate appropriate course materials, and to assist those, computing specialists or others, who must teach computing to those in other specialisations.

COMPUTING IN SCHOOLS

The most consistent message given to the research project from all quarters (despite the fact that the terms of reference were restricted to needs at tertiary level) has been the importance and urgency of introducing some computing studies or informatics to primary and secondary students. Two main reasons have been put forward to support this: the effects of computers in society and their growing effect on many areas of life make some familiarity with computing an essential part of one's equipment for living in our contemporary society; and the characteristic approach of informatics to, and its emphasis on, problem-solving is of central importance, wide applicability, and intrinsic educational and intellectual value. Despite the growing, but still limited, efforts already in Australia to introduce computing to schools, if it is accepted that all schoolchildren should be taught some informatics, the implications are profoundly significant. The consequent needs for the study of informatics in teacher education represent the most significant single conclusion of the project.

A little more is said below about computing studies in schools, although this subject really deserves full scale treatment in a research project of its own.

We are, however, disconcerted by one fact. It is no exaggeration that amongst every group we spoke to, with only one exception, the importance of computing studies in schools and the needs for teacher education in computing were stressed more than any other single area of need. This was true of EDP users, university and CAE teachers of computing, and other practising computing specialists. The one exception was that, apart from a few notable individuals and institutions, those in teachers' colleges and schools of teacher education in CAEs showed less awareness of, and concern for, the place of computers and computing in the schools than any other group. We consider this alarming.

We urge the need for a deep and serious study of the place of computing in Australian schools and, in the meantime, suggest that all sensible requests for resources for computing education in teacher education should be granted.

CONTINUING VS. BASIC EDUCATION IN COMPUTING

Finally, regardless of what general conclusions the community may reach about recurrent or lifelong education, following any of the models that have been suggested, the needs for continuing, continuous and recurrent education in computing, for all categories of people we have examined, are likely to be much greater than those for basic or "first entry" qualifications at the tertiary level.

More is said below about the various kinds of continuing education which are needed. We do wish here to reiterate that, of all the areas of need for computing education, <u>those for teacher education and for continuing education are by far the greatest</u>.

Needs of the schools

Under this heading we amplify the brief remarks already made on the introduction of computing into primary and secondary schools. Our concern here is, of course, with computing studies, and the teaching in various ways of, or <u>about</u>, computing and informatics, and not with the distinct but overlapping question of the <u>uses</u> of computers <u>in</u> schools for various purposes.

Our principal aim is to discuss the underlying rationale for introducing computing studies into schools, and we do this mainly by selected quotations from Australian and overseas sources.

COMPUTERS AND SOCIETY

The fundamental cause for the concern shown about computing education in schools by most people, including us, is because of the effects that computers are having, and will have, on the society in which we live. This is something we have written about in Chapter 3, but to quite from a Viennese trade union official [Margulies 1970]:

> "The computer has created a qualitatively new situation which cannot be comprehended by adding up the established installations or multiplying the performance factors. The increasing spread of the use of computers leads to man's developing new ways of behavior and thought for which the present social

> situations and our system of education are insufficient. The computer technology of our time may justly be considered part of the 21st century but our society and, particularly, our educational system are still anchored deep in the 19th century ...
>
> "This discrepancy between new possibilities of information and man's increasing capacity for decision on the one hand, and the lagging authority to decide on the other, create a dangerous state of tension, to which other factors also contribute, factors such as the growing urge for creative ability, rising level of education and development of the personality for which there is little opportunity within the hierarchy of a modern enterprise ...
>
> "For this reason it is one of the most important tasks of computer education to train people not only in the use and utilisation of these new tools but - first of all - to ... make everyone aware of the hazards and benefits inherent in the computer."

It is not enough simply to treat the computer as part of a continuing process of technological change without recognising an order of magnitude, or qualitative, difference. The computer, potentially at least, as we have already argued, offers an amplification of human intellectual power likely to be of even greater significance to society than the amplification of human physical power provided by the steam engine, and the harnessing of electricity and natural fuel.

The cumulative effects of computer-based technology may profoundly affect the rate at which changes occur, so that traditional mechanisms for societal adjustment prove inadequate. Further, because of the pervasive influence of the computer throughout many areas of human activity (at least in our affluent Western societies), and the real possibility of fundamental advances in artificial intelligence, it is quite likely that there will be irreversible changes. As with the development of nuclear weapons, the world can never be quite the same again, but the changes because of the computer may be more subtle. The basic social concern is that such changes should not be allowed to occur while the majority of citizens do not even understand how this could be so.

COMPUTING EDUCATION IN SCHOOLS

Many of these arguments have been advanced in Australia since the late 1960s, and in Europe and North America even longer:

"The social problems just discussed need to be understood and resolved, but cannot be understood without some elementary knowledge of computers ...

"A good case can be made out ... that some understanding of computers should form an essential part of the general or cultural education of the secondary student, and that - in the same way as we would probably all agree that all should be literate, have basic arithmetic skills, and some understanding of elementary science and of social issues - all should have a basic realisation of what a digital computer is, what it can and cannot do, and what sort of things are done to put a job on to the machine." [Smith 1969b]

Or again:

"The prime goal should be that all secondary students, and not only the mathematically gifted or those who choose computing as an option, should gain a basic appreciation of what computers can and cannot do, how problems are presented to them, of flow charting and decision table methods, and of the role of the computer in society." [Smith 1969a]

Or to quote an English schoolteacher:

"There are two main needs to be met:

1.1 Every future citizen has a right to be taught the basic concepts of computers in order that he or she may not feel excluded from a branch of knowledge which will permeate modern society and revolutionize our way of life.

1.2 It is necessary to prepare the future leaders of Government, industry and the professions for their roles in a world increasingly dominated by information processing.

2 In amplification of these needs, it is evident that computers can be socially and intellectually divisive. There is a grave danger that the ability or inability to understand and use computers will widen the gap that exists between 'brain' workers and manual workers ... The dichotomy in society, between those who instinctively appreciate what machines can do and those who react against them, exists at all levels from the highest to the lowest." [Pegg 1970]

The same writer concludes:

1. All pupils should be given the opportunity of taking, as part of the main curriculum, a general course of computer studies. Only by this means can the divisive effects of the computer be eliminated.
2. The education of the country's leaders should include the study of computers as problem solving and information processing tools, and should also contain the examination of sociological and economic effects ...
3. The opposition to computers because of their inherent dangers must be overcome, so that they are accepted as normal and unmysterious. It is particularly necessary to convince educationists of this." [op. cit.]

INFORMATICS AS A SECONDARY SCHOOL DISCIPLINE?

The other strand in the argument concerns the value of computing studies as an intellectual tool and educational experience in its own right, seen either as a general basis with applicability in many areas or as an optional discipline in its own right.

Pegg also spoke of this:

> "At the Western European Symposium held in Heathrow in March 1969 it was agreed that a general knowledge of what computers can and cannot do should form part of a student's general education, that, as the use of computers involves logical abstraction and demands precise communication, it would form a study in its own right, and that computers should be presented as problem-solving tools in a variety of fields, both scientific and non-scientific. This agreed recommendation provides a compromise between those who hold that computer education should form a study separate from other disciplines and those who believe that it should be ancillary to the present subjects in the curriculum. I take the view that computer education should cover a fairly lengthy time span and that at certain stages it should be taught as a subject in its own right and at others it should be used as a problem-solving tool to assist other disciplines."

The emphasis on problem solving is an important one that we have already stressed. In its submission to the Working Committee on Colleges in the A.C.T. (the Campbell Committee), the Joint Steering Committee on A.C.T. Secondary

School Computing Courses said, in 1972:

> "We believe that the approach to problem-solving which is the chief characteristic of work in computing and computer science is of great value and importance to everyone, certainly to all who reach the senior years of secondary schooling. What is of value is not so much the detailed content or material covered as the attitude imparted to the solution of a variety of problems through a particular approach characteristic of the computer field, often referred to as the 'algorithmic approach'. It is this which is common to almost any good elementary course in computing, even though superficially such courses may appear to differ substantially in content ...
>
> "We also believe that computing, if imaginatively taught by those who know the subject, can offer as much intellectual stimulus as existing subjects, or rapidly disappearing subjects such as classical languages or Euclidean geometry. There is no doubt ... that computing appeals mightily to teenagers - to the extent that neglect of other studies is a problem to be faced. The study of computing and practical experience in the design and construction of algorithmic solutions to problems should normally develop several important qualities: these include precision and accuracy (computer programs which have errors normally just don't work), logical and analytical ability (in the preliminary analysis of the components of a problem), and a concern for structure and effectiveness (including efficiency, generality, simplicity and elegance of methods used)."

OVERSEAS RECOMMENDATIONS

Many overseas groups made recommendations in the late 1960s and early 1970s that show a common concern with these questions.

The Report of an Interdepartmental Working Group of the Department of Education and Science (Great Britain), Scottish Education Department and Ministry of Education for Northern Ireland said in 1967:

> "It is evident that an increasing knowledge of the principles and potentialities of computers will be required at all levels of the educational system."
>
> "The educational system has the responsibility of providing ... an introduction to computer concepts and principles at various levels within the general educational framework."

The Western European IFIP Symposium on Computer Education in 1969 recommended:

"1. It is now important that computer studies should be available at least as an optional subject in all secondary schools.
2. As soon as possible, computer studies should be included in the general education of all students.
3. In planning the growth of computer facilities, provision should be made for the necessary computer access for secondary school students."

The Centre for Educational Research and Innovation of OECD organised a seminar in Paris in 1970 on Computer Sciences in Secondary Schools. Among the recommendations from the final plenary meeting were:

"1. The advent of the computer has serious scientific, cultural, social and economic consequences. Already the first three of these consequences make the introduction of computer studies at the secondary school necessary. The fact that for several Member countries a sizeable and growing proportion of their Gross National Product can be related to computers and their applications, only adds strength to this.

2. In the first place there should be an introductory course in computer studies in the early stages of secondary education. This could be used to advantage in other subjects or form a basis for specialised education.

3. In general education computer studies should be a means not an end in themselves. They will help the pupils better to understand the world in which they will live. They should therefore contain such applications as to make clear the true significance of the computer in society.

4. The school curriculum in all studies is already overcrowded. An introduction of computer studies either as a separate field of study or within another subject will require careful consideration of the curriculum as a whole. In this connection a very important property of computer studies is its ability to create in the pupils an organisational, algorithmic and operational attitude which is desirable for many lines of study.

5. The advent of the computer influences many academic subjects. Application of the computer to other

disciplines where relevant should preferably be developed within the framework of those disciplines. Contact between the teachers concerned and those with competence in the field of computing should be promoted.

6. A basic course should take into consideration that the algorithmic approach to problem solving is a basic aspect of computer science. Examples presented to pupils should be taken not only from mathematics but also from other fields according to the interests of the pupils. It is important that during this initiation period pupils have access to the computer. Substantial agreement was reached that high-level programming languages should preferably be used but that with this limitation the choice of language is of secondary importance. At the same time the programming details should not be allowed to dominate the course." [O.E.C.D. 1971]

Similar recommendations came from the final plenary session of the IFIP World Conference on Computer Education held in Amsterdam five months later:

"To education authorities: that they provide an early introduction to informatics as an integral part of general education in secondary schools and primary schools."

"In view of the profound social and political implications of the widespread use of computers, authorities should provide general education in informatics to all. This informatics education is distinct from that appropriate for those who will apply informatics to other disciplines, and for those who will contribute to fundamental developments in informatics."

There is thus a very substantial body of responsible overseas opinion, as demonstrated in these recommendations from several international conferences, that strongly supports the views we have put forward earlier on the underlying rationale for computing studies or informatics in schools. Many further similar quotations could be given. These views cannot be ignored. Developments in Australia in computing studies to date have been limited, diffuse, and hampered by lack of resources, as well as by a lack of recognition by senior educational policy-makers of the issues at stake. Despite some early pioneering work in South Australia, and recent imaginative innovations in Tasmania, despite also the fact that <u>some</u> computing studies can be found in <u>some</u> schools at least in each State, we are a long way yet from general recognition of the kinds of principles contained in the recommendations just quoted. This also is substantially the finding of the Wearing Report. What is needed most is greater real dialogue about the issues between all those concerned, leading to a clearer understanding of objectives, as well as the development of resources, the evaluation of alternatives, the dissemination of information, and the triggering of initiatives.

By comparison with other parts of the world, certainly with France, Scotland, the Netherlands, parts of the U.S. and of England, and with Ontario, Australia lags a long way behind in the introduction of informatics to schools. In relation to the potential of informatics as a general approach, and to the opportunities to introduce young minds to problem-solving, this is a great pity. In relation to the possible social effects of computing on the society in which these people will live, it could prove a disaster. The arguments put forward, and which were put to us very forcibly over and over again during the project, are not new. They have been heard for at least seven years. But while other parts of the world have made seven years progress in the teaching of computing in schools, by and large we in Australia have repeated the same experience seven times over.

[Since this was written, a conference with representation from each State of Australia, held in Hobart in May 1976, has made strong recommendations to the Directors-General of Education for the support of computing studies. These recommendations emphasise "computer awareness for all" and the needs of teacher education and of curriculum development.]

INFORMATICS AT PRIMARY LEVEL?

Most attention has been focussed, both in Australia and abroad, on the introduction of informatics at the secondary level, but the question should be asked: If it is appropriate and desirable to introduce some teaching of computing and exposure to computers in schools, at what age can this most effectively and desirably be done? In particular, since there have been some quite successful experiments in the Boston and Palo Alto areas of the U.S. to introduce some computing at an early age, should one consider starting at primary level (resources permitting)?

In terms of the major goal of a basic awareness of computers because of their social significance, there would seem to be no reason why the process of exposure to computers could not start quite early, including some forms of use of computers. The main emphasis of the work of Dr Seymour Papert at the M.I.T. Artificial Intelligence Laboratory has been with young children, applying computers to models and philosophies of learning drawn largely from Dewey, Montessori and especially Piaget, and this promises great interest.

As far as the other aim is concerned - of introducing students to the quite general power of the problem-solving approach of informatics - one probably needs to distinguish between the experiential and the abstract forms of learning. Some of the approaches to problem-solving such as flow charting may well be premature to introduce before early or middle secondary education, or at whatever stage powers of abstract reasoning are sufficiently well developed. However, many more concrete activities, including simple programming, can demonstrably be learnt quite successfully by children of primary school age. It would seem likely that these could provide a foundation of learning experience for future, more abstract, learning, in a somewhat similar way to that in which early, simple teaching of mathematical concepts and operations provides a basis for subsequent learning of more sophisticated, advanced, and abstract concepts.

INFORMATICS AS A GENERAL TOOL

One of the reasons why the previous question is of particular interest is because of the wide potential range of application for some of the relatively simple concepts and approaches of informatics. For example, the simple form of a decision table could be used as an economic method of teaching irregular verbs (in any language) or various concepts in social studies, while flow charts could be used as a method of explaining many problem areas, in the sciences, mathematics and other disciplines.

Clearly, one could use informatics as an integrating basis and intellectual tool in teaching, to be used as and when appropriate, because of the power, simplicity and economy afforded. How early in the learning process this would be sensible to attempt clearly depends to some extent on the answer to the previous question.

Needs of the "other disciplines"

The project specification explicitly included an assessment of the demand (and supply) levels of professional and sub-professional people in disciplines other than computing that are taught in the CAEs, and who require more than a common introductory course in ADP.

As a very considerable proportion of the high total outlay of colleges (and universities) on computing facilities and related services is undoubtedly devoted to the education of such people who are not primarily computing specialists, this is quite understandable. However, it takes little reflection to realise that a large, and growing, proportion of students in _many_ different courses are included.

In fact, the terms of reference pose two questions that are very hard to answer except quite generally. First, what is the likely future pattern of computer use, and which kinds of professional and sub-professional people are likely to need computing skills in the next few years?

Second, we must ask: Of these groups of people, which have needs that can be satisfied by a "common introductory course in ADP"?

The answer to the first question must be that _most professional and sub-professional_ people _will_, very soon if not already, _require_ some _computing skills_ and appreciation. This is the answer given in 1967 by the Pierce Report [United States 1967], and it would seem to be even more obviously the correct answer today.

There are a few apparent exceptions, a few professions on which computing would not seem to impinge greatly. For example, it might be asked, what of those who study music or art? This was the immediate reaction of a few of the specialist CAEs which received our questionnaires. However, although it is unlikely that computing studies will become a central part of a musical education, increasing use is being made of computing by serious musicians in many ways - for synthetic (but nonetheless creative) composition by computer program, for more versatile effects in synthetic production of music, and in musicological studies. Similarly, and even more dramatically, computer art is rapidly achieving a recognised place as a serious branch of art, with a variety of new art forms available. At the other, more applied, end of the creative spectrum, it is now impossible to exclude computing studies from the curriculum of those in design courses, as computing permeates many aspects of industrial and commercial design.

Apart from these less obvious (and perhaps more exotic) examples, we can see a clear need for substantial computing studies for those in applied science, engineering, architecture and design, business studies, commerce, administration and management, librarianship, teacher education, surveying, town planning, and also for those, whatever vocation they hope to pursue, who wish to study accounting, statistics, psychology, sociology and other disciplines that are greatly influenced by computing today.

If one were to place a literal and highly quantitative interpretation on the terms of reference, then, the project could be seen as a manpower forecasting exercise, not just for computing personnel, but for almost every field of professional employment. Such an approach would have been beyond the resources of the project, and in any case would be of doubtful value, for the reasons discussed in Chapter 4 under "Manpower Forecasting" and the general heading of "Planning for Higher Education".

What of the second question? For how many of those who need knowledge and skills in the use of computers is an introductory course appropriate?

It certainly <u>is</u> true <u>at present</u> that the needs of many students in diverse fields are being addressed by introductory courses of the "Computer Science 1" or "Computing 101" variety. Clearly this is a relatively economic way of providing the opportunity for many students to learn some computing, if staff are limited, and for some colleges it may still be the only way of trying to meet the need with the staff currently available.

However, <u>quite severe problems</u> can arise in the training in computing of those who are studying other disciplines. It is clearly apparent that <u>many of the introductory service courses at both universities and CAEs fail to impart real mastery or understanding of computing</u>. The problems are particularly acute for those who are enrolled in non-scientific courses such as librarianship, business studies or teacher education, often because of the lack of a formal mathematical background in many students, and the frequently heavily mathematical orientation both of the staff presenting the courses and of the course material used. However, the problems are not confined to these students, but are found also with many who take computing units as part of engineering or science courses.

The problems encountered include:

* <u>Teaching and learning difficulties.</u>

  The time required and the difficulty experienced in mastering basic concepts of computing, algorithmic methods and elementary programming vary greatly from student to student, and this variation does not seem to be entirely related to the native intelligence of the student. The teaching of introductory courses in computing particularly requires great sensitivity and imagination on the part of the teacher, the ability to obtain and interpret feedback from students, especially at the beginning of courses, and extensive use of tutorials or workshop sessions for personal discussion of difficulties both with the formal classroom material and with practical work. These problems exist to some extent in all computing courses, but are particularly troublesome in introductory courses.

* Relevance to curriculum aims.

Common service units designed to provide a general background for several disciplines are not always appropriate to the specific curriculum requirements of all courses; units oriented specifically to vocational or subject interests will often be needed.

Thus it is likely to be much more effective if students of librarianship, for example, were taught the basic computing they need by the librarianship staff, and if the material was related closely to the common ground of the students than if all library studies students were sent to enrol in "Computing 101".

There are parallels in many ways with the teaching of statistics. In most universities and colleges, there are departments which specialise in statistics and offer full sequences of units in statistics for those who require a sound professional training in the subject. On the other hand, students of psychology, for example, are usually taught the statistics they require for work on the design and analysis of psychological experiments as part of a psychometrics module in the psychology course. This ensures relevance to the subject matter. Psychology students do not, for example, as students of psychology, need to know how to use a randomised block design for an agricultural experiment, or prepare a stratified sample design for an economic survey, although these are proper topics in a course on statistics. Similarly, the budding librarian does not need to know much about numerical methods, but does need a sound grasp of file processing and retrieval methods.

* Relevance of practical work.

Even where the formal content of courses in computing for those in different disciplines may have much in common, it may be necessary for different kinds of class exercise and other practical work to be provided to ensure relevance and cohesion within the total course structure.

There are many examples of students whose chief difficulty in computing practical work has been in understanding the exercises and sometimes in mastering sufficient algebra to be able to tackle them. This is a particular problem with the use of heavily mathematical examples for students with limited mathematical background. There are many non-numeric examples that can be used for those who neither have, nor need, such a mathematical background.

All these problems just discussed are compounded by the shortage of resources, the consequent need for compromise between different and sometimes conflicting course objectives, by the presentation of courses by a single department which may have a particular, and possibly narrow, orientation, and by the lack of suitable course material for certain kinds of student.

The needs for "computing specialists"

Even the specific question of the needs for those who regard themselves (and are regarded by the community) in some sense as "computer specialists" is far from simple. At least four distinct questions arise:

(1) What <u>balance</u> should there be between the supply of specialists and others with a computing orientation, but who are not primarily or purely "computer people"?

(2) What is the <u>quantitative</u> level of demand likely to be for such specialists?

(3) What occupational categories or <u>specialties</u> are likely to be needed, within the broad group of computing specialists?

(4) What <u>education</u> and <u>training</u> should computing specialists receive?

The first question has been discussed already in this chapter; the second is one of the major questions for the whole project. The third and fourth questions demand more attention.

There is no doubt that the expected rapid growth in the use of computers and computing in Australia will result in a need for, and also depend on, a considerable expansion of computer oriented education and training. This expansion will not be a purely quantitative one; there may well be needs for new kinds of computing specialists (as well as needs for computing knowledge and understanding on the part of many who are not primarily concerned with EDP).

NEW SPECIALTIES

To predict what particular specialist groups of occupations will develop and grow within the broad group of computing specialists is extremely difficult. This in turn requires informed guesses about both the future direction of technological developments in computing and computer applications and about the outcome of the conflicting moves we have discussed, towards and away from professionalisation.

However, some general comments can be made. A distinction first needs to be made between work which directly deals with the design, development, implementation and maintenance of computer-based systems (applications development), and various supporting specialist work. On present indications, at least two-thirds, and perhaps three-quarters, of full time computing staff are directly engaged in applications tasks.

Within this broad applications area, it seems inevitable that the trend towards new subspecialties will continue, especially in those application fields where substantial subject matter knowledge or expertise is required. This trend is particularly marked in fields of scientific and technological applications, where substantial exposure to a particular discipline is virtually essential for any senior computing practitioner. We thus have the emergence of specialist computer applications fields concerned with structural engineering, biomedical applications, meteorology, statistical analysis, and in many fields of pure science. This trend may be expected to continue. We also see increasingly specialist concentrations in other fields than the natural sciences and technology - systems librarians, social survey computing specialists, and many specialties in linguistics provide examples. A likely addition in Australia before long could be the legal systems specialist. However, even within the broad applications group often lumped together as "commercial", there is a growing tendency to look for, or to develop, computer systems specialists with detailed knowledge, whether obtained from formal education or by work experience, of particular industries (banking, insurance, construction, manufacturing, etc.) or of particular functions (cost accounting, stores and purchasing, statistics, personnel, etc.).

For these increasingly specialised applications areas, the benefits of the "mixed major" education we have advocated for those who enter from universities or CAEs should be obvious.

The relatively few full time computing staff who do not work in applications, but in supporting <u>specialist</u> fields, cover a wide range of areas. These include software (of various kinds), communications, management and planning, data management, operations, training and standards activities.

Of these those who develop and maintain software comprise the largest single group, and would account for the largest single need for those requiring more advanced computer science backgrounds than most people who work in applications (apart from those who remain in a purely academic or research environment). Most medium or large scale installations would require a software group, or at least a single software specialist, although the nature of the work may vary considerably. In some computer installations the work of a software section may comprise mainly the maintenance, updating and minor modification of standard software (operating systems, compilers and other translator programs, and standard "package" programs) provided by the vendor, together with the investigation of software and apparent software faults, and contact with the vendor's technical support staff. Such specialists usually require much more detailed knowledge and understanding of the precise operating characteristics of the computer equipment, an ability to understand and to write in machine or assembly language, and a generally stronger hardware orientation.

Other software specialists, especially in large organisations, are needed to design, write, test and maintain generalised applications software of especial value to the organisation that is not otherwise available, for use either by applications programmers or by general (non-computing) staff. These specialists need many of the same skills as systems software specialists (especially if they are, for example, developing real-time systems), but usually also require greater understanding of the applications needs of their organisation and its clients.

Communications specialists are a growing group, sharing many of the characteristics of software specialists, but requiring particular familiarity with both the hardware and the software aspects of computing and data communications systems. While there is little doubt that the absolute numbers of communications specialists needed will increase fairly markedly, it is difficult to estimate with any precision their relative growth in Australia. This depends not only on the growth rate of telecommunications-based computing (which in turn will be influenced by a number of policy questions to be decided by the APO or by government, as well as by purely technological developments), but also on the pattern which develops in the industry in the evolution of "teleprocessing", as this will to a large extent determine the division of detailed technical responsibility between carriers, networks such as general purpose and special purpose computing utilities, and individual computer users.

EDP management is generally a function that is filled either by the most able computing specialists with a potential for higher, managerial responsibility, or from executive ranks by those with an interest in and the adaptability to handle the EDP function. It is a function which will become increasingly important for a large proportion of computing staff if, as we predict, the number of small EDP users increases at a more rapid rate than the total number of organisations using computing. In larger organisations, and notably the Australian Public Service, there is a growing tendency to separate out the long-range planning and strategic design function as distinct from the overall management and applications development roles, and this is normally undertaken by the most technically able and experienced staff, who need to be familiar with a variety of technical aspects of computing as well as with the applications needs of the organisations.

Operations and operations management, especially in larger installations, tend to be another specialised area, requiring in the more senior ranks a blend of technical knowledge and administrative and supervisory skills.

The recent growth in the use of data base management software has also given rise to data base management specialists. Their function is sometimes partly operational, if they are charged with aspects of overall control and maintenance of a data base, but also requires detailed familiarity with the particular software facilities used and their underlying principles.

Standards and training also loom large in the bigger organisations, such as major Public Service departments, but tend largely to be carried out by able computing staff who demonstrate interest in and aptitude for them, rather than on the basis of any particular experience or formal training.

THE DECLINE OF PROGRAMMING?

Some comment at least is needed on one particular controversy: "Are programmers, as a distinct occupational group, here to stay, or will they gradually disappear?"

This is a question about which opinions, even between "experts", is sharply divided. There is, however, a strongly held view, shared by some well-respected figures, that at least within a decade or so the applications programmer as we now know him will be obsolescent. According to this view, technological improvements, especially through more powerful and general software that is increasingly oriented to the end user, will greatly diminish the need for the applications programmer. In the past, and largely still today, the "user", often ill-informed about computing, has specified his needs to a technologically informed analyst who then translates these into terms which he or she or (more usually) a programmer can implement. It is claimed by some that, just as we have moved from primitive and agonisingly detailed machine language coding, through assembly languages, to high-level procedural languages, and more recently to some more truly problem-oriented languages, so we may expect an upsurge in the development of user-oriented systems. Many of these the "end user" will be able to use himself directly, on-line, as in airline reservations systems and point-of-sale retailing, or by filling in simple instructions and parameters on coding sheets, as happens today with many technical and engineering applications, or indirectly through a low-level coding clerk who understands the system or "package" but is not a programmer. All of these possibilities reduce the need for highly trained and expensive intermediaries. At the same time, some argue, as the ability to write a relatively simple program in a high-level language becomes a common attribute of many, including most professional people, it will not so frequently be necessary for the user with a non-standard requirement to have to seek the services of a computing specialist.

This is certainly a plausible argument, albeit one on which there is not by any means unanimous agreement. If it proves to be true, it could imply a degree of polarisation. If, for many everyday purposes, everybody gains more immediate access to computing power, we shall not need many people whose skills lie mainly in writing fairly simple programs, but we may need more people than at present (but fewer than the current number of applications programmers) who have high level skills that enable them to produce the good quality user-driven software that makes all this possible. We shall also continue to need, possibly in growing numbers, those who are able to undertake systems analysis and to design complex information systems and their individual programs.

Against this view, it is argued that all this has been prophesied for some years, but that the difficulties of achieving parametric and other truly general user-oriented programs have kept these kinds of development well behind the growth in applications needs.

It would, however, be imprudent for educational bodies to assume too blithely that those who complete their courses in the 1970s and 1980s have an assured future well into the 21st century as applications programmers. A few, although by no means most, courses seem to be based on such assumptions. If programming (conceived in narrow terms) does reduce eventually to a fairly straightforward and low-skilled clerical function, those who are trained vocationally for little else could find life rather bleak.

Some employers interviewed expressed the view that it is not necessary for a programmer to have undertaken a university or CAE course; that a couple of months, or even a few weeks, could suffice for someone with sufficient aptitude to become effective in writing programs. If "programmers" are simply people who code programs, maybe they are right, and anticipate the shape of things to come.

Curriculum Questions

It is not appropriate for us to comment in any detail on the curriculum content of individual courses currently offered. However, many of our suggestions about specific needs in computing education converge with what we have identified as important areas of general educational need, leading to some major recommendations.

More particularly, we have pointed out in various parts of this volume that:

* The inherent difficulties of manpower forecasting, especially the long term forecasting needed for educational planning, when there are so many complex variables involved, when change is rapid, and computing itself is undergoing very rapid change, make one look for as flexible and adaptive a planning process as possible.

* The processes of social change, leading for example to more career change and mobility within the work force, again suggest the need for maximum flexibility in courses and versatility in graduates.

* The convergence apparent between the kinds of education needed by those pursuing a "liberal" education and those seeking a more vocational education - with increasing emphasis on the need for sound foundations as well as on the production of employable skills, suggest greater modularity, as well as variety, in course structures.

* Concern with the obsolescence of skills, and retraining, as well as with the broader issues of continuing education, reinforces the desirability of modularity and flexibility.

* Students (and also employers) are increasingly indicating a wish for more personal involvement in the choice and content of courses, for reasons which include the wish to explore areas of individual interest and vocational preferences.

All of these point to the need to reduce rigidity, in many ways.

STRUCTURE - MODULARITY

Much could be achieved through greater modularity in course design, at all levels and in all institutions. In itself, this would lead to greater adaptability and ease of change in response to changing educational needs, student demands, or to technological change. It would also facilitate greater co-ordination and interchange, on a co-operative basis, between institutions - of ideas, course materials, staff and students - as well as increasing the choice available to individual students.

GREATER CHOICE

There could be much greater freedom and choice in the personal construction of educational programs by students. These need to be subject to necessary (but minimal) limitations of a practical and academic nature, and there should be due provision for counselling on the vocational suitability of any particular program proposed.

Some of the constraints to which educational institutions refer, in the need for adequate staff and other resources to support a broader program with more options, could be overcome substantially through a more modular approach to courses, even if this brought a cost through some increase in administrative complexity. Although the situation has changed even during the research project, there are many undergraduate and postgraduate programs in computing which offer very restricted choices indeed, or no choice at all.

Especially since the majority of computing practititioners would benefit from the "mixed major" type of educational background, and as there will be needs for a wide variety of combinations of computing skill with knowledge of other disciplines, restrictions on choice should be carefully examined with a view to their relaxation or removal.

NEW ROUTES TO CREDENTIALS

All too frequently institutional barriers limit the ways in which a student can gain credit or certification for his knowledge and skills. We support the moves (such as those suggested by the Open University Enquiry) for greater access to education. Of particular relevance in computing is the frequent failure to take into account the work experience and informally gained knowledge of the student. This is true at many levels. For example, the graduate with several years experience in EDP but no formal qualifications or training in computing must frequently submit to a long and frustrating program of subjects that fail to extend his abilities, if he wishes either to gain some form of accreditation for the knowledge he has already, or to further his studies in computing beyond his present level of knowledge. Similarly, there are many barriers that impede the path of the person with (say) a diploma who wishes later to undertake further studies and gain higher qualifications.

As one of the instruments of social change, one might expect computing to offer a lead in moves towards recurrent education. However, even sandwich courses on the conventional pattern seem to have failed to arouse the enthusiasm of educators and employers, in the EDP field.

TRANSFERABILITY

Related to the question of new routes to credentials, we have been made aware of many problems which arise for those who wish to transfer between institutions, whether of the same or of a different type, or even who wish to transfer between courses within the same institution. Especially as the computing work force is presently quite mobile, and many EDP staff shift geographically, this presents real problems.

EMPHASES

The most striking conclusion from the statistical data presented in Volume 2 of the full report was that the bulk of new EDP staff needed in the next few years will be for the small user. In fact nearly half will be needed by those who at present do not use EDP at all. The needs of the small user must therefore dominate the thinking of those who offer specialist courses designed to produce EDP systems staff, and those who offer a "major" in computing within multidisciplinary courses producing general purpose practitioners.

This does not of course imply that colleges should concentrate on small machines (many users will be service bureau or utility customers, anyway). It does imply that thought should be given to the environment in which most students will eventually work.

Some of the staff needed by small users will undoubtedly be obtained by recruitment from larger and more experienced users (increasing the anguished cries of "poaching"!), and some of the output from vocational courses in EDP will initially fill the vacancies so caused. However, whether as their first or second job after completing their initial course in computing, a very large proportion of students of computing will eventually be employed in small organisations.

As the needs of large organisations have been most evident during the past decade, courses have tended (explicitly or implicitly) to meet these needs. This is no longer appropriate, except in a few cases (such as the Canberra CAE, which mainly serves the needs of the Australian Government for trained staff).

Instead of assuming that the student upon graduation will go to a large and bureaucratic organisation, with an established EDP department, headed by an experienced manager and surrounded by many senior staff to supervise him in his apprenticeship in real world computing and guide him in his contact with management, we need a new paradigm.

Before long we must assume that most EDP or computing systems staff will work in organisations with at most 100 or so employees. The EDP group will comprise a manager or supervisor, possibly an assistant to help in programming and administration, and at most a handful of ancillary staff for data entry, operations, production control and secretarial duties. The manager is likely to be in almost daily contact with the chief executive, who may have little detailed understanding of computing, but expects results from computing that help achieve his organisation's objectives. The manager will be expected to turn his or her hand to many things. He will undertake his own analysis and design, advise on the selection of computing facilities, control staff, and deal directly with people at all levels within the organisation. Above all, especially in private enterprise, he must see himself not just as a specialist but as an essential contributor to the organisation in meeting its objectives, which in small business may be quite volatile.

What does this imply for the education of EDP staff? Above all, a sound grasp of fundamental computing principles and adaptability will be more important than detailed knowledge of advanced computing topics, provided that the graduate is aware of the limitations of his knowledge and knows where to gain additional knowledge as he needs it. A strong orientation in the subject matter or disciplines relevant to the business will be a great asset, whatever these may be. Therefore for many a general or multidisciplinary education, in which computing modules comprise one "major" and subject matter modules another, will be appropriate.

Further, most full-time EDP staff will work in small groups, and will need to be competent in many aspects of EDP work, including systems analysis, system design, program design, and program implementation. Assumptions that there are two distinct and rigidly separated categories of EDP staff - analysts and programmers - will therefore not fit most cases (if they ever did).

BALANCE

In all post-secondary courses in computing, and especially in those taken by potential full-time computing practitioners, sound and solid foundations must be laid. The emphasis must be on concepts and principles, and the imparting of a critical awareness and understanding of informatics, rather than on particular techniques, especially those which are modish, ephemeral and obsolescent. For many who are exposed to computing as an essential tool which will be used in another profession or discipline, the emphasis should be on basic informatics and the application of computing to problems in their own subject domain.

Continuing Education in Computing

What *kinds* of continuing education are needed in computing?

In June 1972 the ACAE expressed the view in its "General Guidelines" that first degree and higher degree level courses in computing studies should provide sufficient flexibility to be used in continuing education for those already employed. In its document the ACAE identified three needs:

(a) the accelerated study by a graduate of an ADP specialist course, leading to the award after only one year full-time of a qualification normally obtained after a full undergraduate course;

(b) the availability of individual units from degree courses; and

(c) postgraduate courses.

Since the needs for continuing education have been found to be more urgent, and much larger, than those for "first entry" qualifications, such an approach must now seem to be far too limited.

While all of the suggestions above have merit individually, there is a need for a major emphasis on continuing education of much vaster scale than this. If the relative needs are to be considered, our tertiary educational bodies could well regard their primary role as to provide continuing education in computing, and the running of undergraduate courses of various kinds as an incidental function. It might then seem appropriate to ask which of the continuing education provisions in computing could be used in undergraduate courses!

At the least, there is a need for a great expansion in the provision of continuing education in computing, as well as for much greater variety in the forms this takes. There are at least five different needs for continuing education, each requiring different forms of provision:

(a) refresher courses;
(b) diversification courses;
(c) "capping" courses;
(d) "synthesising" courses; and
(e) postgraduate courses.

Refresher courses normally seek to help those already basically qualified in their own field to renew their understanding of it, and to catch up on recent developments.

Normally a good basic foundation must be assumed, and especially if the aim is to update knowledge of current techniques, relatively rapid assimilation of material is possible, in intensive courses, of from a day to (more typically) a week or so's duration.

Both the students and the teaching method of such courses are likely to be quite different from those at most university or college courses. Such courses can be, and to a limited extent are being, run by educational bodies (summer schools, etc.), private educational institutes (specialised seminars of a day to a week or more), professional societies (such as the ACS Professional Development Programme).

Diversification courses aim to supplement the training of those already with basic qualifications, through the study of a new but related subject or discipline. On a limited scale, these could include, for example, the study of digital communications by those with a basic computing training concentrated in EDP and its applications. More broadly, the growing introduction of graduate diploma courses in computing is a valuable response to the need for many with a basic first degree in any of countless fields to obtain a sound grasp of computing, usually with the aim of applying computing to their original field. Such graduate diploma courses can assume that students are mature, and have a basic education and well formed study habits, and can accelerate and compress somewhat the treatment more appropriate to an undergraduate course.

What have sometimes been referred to as "capping courses" provide the graduate who has a basic qualification with further specialist training appropriate at the graduate level, often after a period of practical experience. A particular case of especial importance would seem to be the training in systems analysis and system design strategy for those who already have a basic qualification and some experience in applications programming and a general grounding in information systems principles. One of the issues as yet incompletely resolved is how far one can teach systems analysis at the undergraduate level, especially to the full-time student with no practical experience of business or government or of applications programming in a real life environment. It would seem that a graduate diploma might prove appropriate. This would be a natural use of the idea of a graduate diploma course, which is defined as one which is postgraduate in level but not in content, a definition perhaps more apt for what we have described as a "diversification" course. The provision of graduate diploma courses is at present the major contribution of the CAEs to continuing education opportunities in computing, but there would seem to substantial scope for far greater diversity and innovation in the use of graduate diplomas. It would appear that some at least of the graduate diploma courses presently offered are unnecessarily rigid, and fail to provide a preparation that is truly relevant to the needs of all who take them.

"Synthesising" courses seem to be needed by many who are already employed in computing, but have their original qualifications in other fields. This is a special need to which little attention has yet been given in Australia. There are many with years of experience and considerable knowledge of EDP, but with a basic qualification in another discipline, and without a comprehensive grounding in computing to which to relate their substantial but inevitably patchy knowledge. There are many in this category, and there will continue to be for a decade or more, and there seems to a considerable demand for courses that suit their needs. To undertake a normal undergraduate course in computing, even with exemptions from non-specialist units, can be wasteful of time, frustrating and burdensome, especially for the mature student with a demanding full-time job and domestic responsibilities. A specially designed course, that covers the same ground as a full major in computing but at a rapid pace, and that fills in the gaps in the students' formal background, while placing the knowledge they already have as well as new concepts and knowledge into an overall theoretical framework, is needed.

Some students attempt to find the educational opportunities they need through enrolling in Master's degree programmes. However, this is possible for only a few, especially as many Master's degrees have restrictive admission requirements, and in particular as there are very few Master's degrees in computing, or similar awards, available basically through coursework and projects, rather than through the traditional method of a thesis representing a year's full-time research work or its equivalent. It would seem that true postgraduate courses represent a largely unfilled need in computing education, as distinct from the fairly plentiful opportunities to obtain Master's or Ph.D. degrees through research.

A Model - and a Plan

On page 51 we presented, as Figure 2, a diagrammatic model developed by several participants at the search conference, showing the major categories of educational demand for computing education, the main factors influencing them, and their principal relationships. That model would seem still to serve as a valuable basis for discussion of the issues dealt with here, and as a possible framework for an educational "plan".

Such a "plan" (which we would see as a co-operative, participative, interactive and adaptive exercise, not as a centralist, bureaucratic imposition) must take into account the aspirations of individual students, the needs of the computing industry, and of employers at large, and overall national interests with respect to computing and to education.

Further in Volume 3 of the full report, dealing with the search conference (especially in Figure 3 of that volume), an attempt was made to distinguish the various dimensions of need, which are appropriate for any more detailed consideration and planning.

It would seem that such a model, and framework, could provide the basis for a determined effort by all those jointly involved to come to grips with the problems of computing education, and develop an adaptable and modular approach to their solutions.

In this volume, which we hope has been suggestive and positive as well as provocative, there should be some indicators as to the directions in which computing education should move, as well as sufficient exposure of points of controversy to spark constructive dialogue on those issues deserving further debate.

However, if this is to be effective as a policy-directed research project and is to achieve positive change, it is crucial that <u>all</u> who are concerned with computing education are involved. We are therefore speaking not merely to the CAEs or to the ACAE which commissioned the study, but to the whole body of educators, students, industry and government who are concerned, but all too rarely see themselves as <u>jointly</u> concerned.

Implications of a Plan

In this volume we have suggested many ways in which we see changes as being desirable, even essential. In the previous section we have, sketchily, suggested a possible basis for planning under a changed, and changing, understanding of computing education needs.

It would, however, be naive to suggest that changes are needed, without any thought about the desirable mechanisms for achieving them. In our recommendations in Part 1, and elsewhere in the full report, we make several specific pleas for particular initiatives, including greater interaction between computer users and educational bodies, the establishment of centres of excellence, assistance for the smaller colleges, provision for policy co-ordination, and needs for further work.

If the changes we urge, after wide consultation with interested groups, and prolonged study, are to be realised, then these initiatives are of the utmost importance.

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POSTSCRIPT

Our report, of which this publication comprises about one-third, was presented to the Commission on Advanced Education in 1975. At the same time its completion was announced to the public, and widespread interest was aroused.

Prompt publication of this report, or any government publication of it, were prevented by restrictions on government spending, so that this publication through the CCE of the ANU comes twelve months after the report was completed, and more than eighteen months since the draft of our summary of findings and recommendations had been made available to the Commission. A brief word is therefore in order, by way of a postscript, to look at changes since then.

In its Fourth Report [Australia 1975e], the Commission made several comments, based largely on our findings and recommendations, for example:

"5.54 The field of electronic computing is barely thirty years old and represents one of the significant growth areas within the college system. It is both an expensive and specialised field and the Commission has continued to study the needs of the community for computer education and of the colleges for computing facilities."

"5.58 The computing industry is rapidly becoming one of the largest secondary industry groupings in developed countries, and the social and educational implications of this growth are most significant. Evidence available to the Commission indicates a continuing demand not only for computer specialists but also for a variety of persons with an understanding of computing as part of an education embracing other disciplines. Rapid changes in the field of computing also point to the need for flexibility in course design and for the provision of continuing education and refresher programs.

"5.59 The Commission supports the provision of associate diploma and short courses in addition to full professional courses. These shorter courses should cover computing and elective subjects with the aim of producing practitioners whose professional preparation is, however, not yet fully comprehensive. The qualifications gained, as well as appropriate practical experience, should be recognised for admission to later courses, including 'conversion' courses for those who desire it.

"5.60 The growing impact upon society of the computer and computing technology has implications for almost all levels of education. Many secondary schools are already offering some computing studies to their pupils. We therefore urge colleges concerned with the preparation of teachers to take due account of these trends and to provide increasing opportunities for students and practising teachers to undertake studies in computing."

However, in the Budget brought down only two months after the commissions had presented their reports for 1976-78, it was announced that normal triennial funding would be suspended for a year. The rate of growth of educational spending was greatly reduced and almost all capital expenditure in higher education not already committed was halted. Since then, the change of government at the end of 1975 has brought a commitment to "small government" and acceptance of the fight against inflation as the primary economic objective. Both of these have sharply curtailed the flow of government funds, especially for new initiatives.

We thus have a climate in which educational administrators, whether at a national, State or institutional level, are hard pressed. Since salaries for existing staff represent a large proportion of recurrent educational expenditure, competition for any uncommitted educational dollars to support any new initiatives is intense. It can be dangerous to think of education in terms only of the provision of resources, without at the same time considering how to make most effective use of them, or the need for other changes within the educational system. Yet it remains true that without adequate resources, many changes are difficult or impossible to achieve.

The first conclusion we must therefore draw is that when money is tight, it is more important than ever to use what human and material resources are available where they are most needed. This may require the redeployment of some resources from areas of need to areas of even greater need.

Thus it is quite urgent that priorities should be agreed and established, both within computing education and between computing education and other educational claims. In our report we place strong emphasis on continuing education, computer awareness for all, and on multidisciplinary courses that include computing and other fields. If others agree, they should argue against present patterns of priorities and work for constructive change.

For this to happen, there should be open and vigorous debate between all concerned - teachers, administrators, employers and others in the community. We are grateful that the CCE has now made it is possible for this part of our report to be published as a contribution to such a public debate. We do not expect everyone to agree with us on all points, but we believe that what we have said deserves discussion.

To what extent have the quantitative estimates in our report been affected by the events of the last eighteen months? We found that over the next few years the demand for full-time systems and programming staff was likely to be about three times as great as the number completing appropriate university or CAE courses.

As argued at length in Chapter 3, many factors could affect the reliability of such estimates, not least a recession and general business uncertainty. However, the effect of the economic downturn seems to have been to defer and depress demand, not change it fundamentally. It is significant that during the worst unemployment Australia has seen since the war, EDP staff have remained in short supply.

It would therefore seem that the main thrust of our findings is not affected: If the current needs for computing education are far greater than could be met by any foreseeable resources, the most important task is to determine the areas of highest priority.

October 1976

APPENDIX

TERMS OF REFERENCE

(Project Specification)

In order to provide advice to the Australian Commission on Advanced Education, on the role of the Colleges of Advanced Education in providing qualifications in automatic data processing, the research project will consist of the following:-

A. Basic Qualifications

1. Undertake a community survey to:

   (a) assess the demand levels within Australia over the next decade for the following individuals

      (i) Management Information Systems Specialists

      (ii) Software Systems Specialists

      (iii) Applications Programmers

      (iv) Physical Control Systems Designers

      (v) Data Communication Specialists

      (vi) Professionals and Sub-professionals in other disciplines being taught in CAE's and requiring more than a common introductory course in ADP training.

   (b) Consider likely computer (architecture, software and systems) trends over the next decade, including the development of computer utilities and other resource sharing networks, and assess the broad nature of the ADP training required by the individuals in (a) above in order to determine whether it could be appropriately provided by the tertiary institutions.

(c) In relation to ADP training thought to be appropriately provided by the tertiary institutions, assess the likely demand in terms of numbers over the next decade and also the nature of that demand in terms of length of course, length of ADP subjects, level* of course, natureø of course, etc.

2. Undertake a survey of tertiary institutions to identify courses aimed at satisfying the need in (1) above and the projected outputs, over the next decade, for those courses.

3. Compare the results of survey (1) and (2) and advise the Commission whether the comparison suggests that there should be any change in orientation in colleges of advanced education in relation to:

(a) the nature of ADP courses provided;

(b) the projected number of graduating students in any existing or proposed ADP course.

B. Continuing Education

Advise the Commission as to what demands are likely to be made, over the next decade, on the colleges of advanced education for continuing education by persons who have previously obtained their basic qualifications in the areas identified in A1(a) above. Also advise the Commission as to what additional action might be needed to meet that demand.

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* e.g. higher degree, degree, diploma, associate diploma, graduate diploma, etc. - see booklet produced by Australian Council on Awards in Advanced Education.

ø e.g. broad type of ADP and associated subjects, or broad orientation of course.

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AUSTRALIAN NATIONAL UNIVERSITY
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OCCASIONAL PAPERS IN CONTINUING EDUCATION

No. 1 'The employment of sociologists' – Chris Duke (1972).

No. 2 'Teacher education in an aboriginal context' – Chris Duke and Elizabeth Sommerlad (1974).

No. 3 'The National Fisheries Seminar: 1971 – an evaluation of an evaluation' – Merrelyn Emery (1974)

No. 4 'Participative design' – Fred and Merrelyn Emery (1974).

No. 5 'New Zealand's educational development conference' – Nicolas Haines (1974).

No. 6 'A training course in community development for field workers in a tribal aboriginal context' – Elizabeth Sommerlad (1975).

No. 7 'The assembly line – its logic and our future' – Fred Emery (1975).

No. 8 'Democracy in Learning' – Trevor Williams (1975).

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No. 11 'In pursuit of ideals' – Fred Emery (1976).

No. 12 'Searching – for new directions, in new ways, for new times' – Edited by Merrelyn Emery (1976).

No. 13 'Life-long Education: an Australian Prognosis' – Chris Duke (1976).

No. 14 'Task in India – a learning partnership' – Nicolas Haines (1976).

No. 15 'Computers and the future of Education' – Barry Smith and Barry Z. de Ferranti (1976)