

LOUGHBOROUGH
UNIVERSITY OF TECHNOLOGY
LIBRARY

AUTHOR/FILING TITLE	
DEWA, FS	
ACCESSION/COPY NO.	
040013071	
VOL. NO.	CLASS MARK
	LOAN COPY

040013071 8





THE USE OF MICROCOMPUTERS IN MATHEMATICS TEACHING IN FIJI

by

Fereti Seru Dewa B.A., Cert. Ed., M.A., MBCS

A Doctoral Thesis

Submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy of the Loughborough University of Technology, 1988.

Supervisor and Director of Research:

Professor A.C. Bajpai OBE, C Eng., FIEE, FBCS
Director of CAMET and Head of Department of
Engineering Mathematics
Loughborough University of Technology

© by F S Dewa, 1988

Loughborough University of Technology Library	
Date	Oct. 89
Class	
Acc. No.	040013071

ABSTRACT

THE USE OF MICROCOMPUTERS IN THE TEACHING OF MATHEMATICS
IN FIJI

by

FERETI SERU DEWA

C.A.M.E.T.

(Centre for Advancement of Mathematical Education in Technology)

Loughborough University of Technology

At the end of 1983 the Ministry of Education in Fiji informed schools that computers would be introduced in 1984. In February 1984 some selected schools received the first microcomputers.

At a Conference on Computers in the Classroom, held in August 1984 at the University of the South Pacific, the Head of Mathematics at a senior secondary school said, in a paper presented at the conference:

'while there may have been some pre-planning at headquarters level it seems that no arrangement was made with individual schools.....'

Amongst the problems highlighted in the paper by the Head of Mathematics was:

'the difficulty in deciding on a suitable type programme to offer to the students...'

This thesis primarily concerns the application of microcomputers in teaching mathematics in Fiji. The author's experience shows that teachers in Fiji are aware of the need to respond to the microcomputer technology but this response is restricted due to the almost total lack of staff with even a basic knowledge of computers. Before any significant progress can be made in specific areas such as mathematical education the problem of teacher training needs to be addressed. Mathematics can make contributions in all areas and levels of education. Many

areas of the curriculum involve mathematics. A developing country like Fiji needs to consider priorities alongside applications when these concern new technologies such as computers.

The assumption that computers enhance mathematics learning is made and the thesis investigates ways of implementing the technology in mathematics teaching as practised in Fiji. Due to the political situation in Fiji the investigation relies on the author's experience during the pre-military coup of 1987 there, and on consultations with some U.K. professionals particularly at Loughborough University of Technology.

To address the demand for originality in a thesis, the problem of converting computer programs from one brand of hardware to another is discussed in detail. This exercise is important for developing nations like Fiji to avoid re-inventing the wheel in writing programs from scratch and wasting valuable resources. Textbooks written and intended for schools outside Fiji have been used successfully in education in Fiji in the past. There is no obvious reason why computer programs cannot be imported as well. These need to be converted to run on machines that are available locally and the thesis will analyse the conversion of BBC microcomputer software to run on an Atari ST microcomputer. Models of mathematics lessons are discussed and recommendations and strategies for implementation of microcomputers in the teaching of mathematics in Fiji are put forward.

KEY WORDS: Fiji education; Mathematics Teaching; Developing nations; Microcomputers in Mathematics; Computer Program Conversion; Computer Enhanced Learning.

ACKNOWLEDGEMENTS

With deepest sincerity I express my gratitude to Professor A.C. Bajpai OBE for his enthusiasm and inspiration during the writing of this thesis. He has been a source of motivation and an academic mentor to me. His wide experience of developing countries and mathematical education has been of immense help. Without his professionalism and dedication the thesis might never have been completed. I also thank the Department of Engineering Mathematics for the use of their facilities.

I am also indebted to the Fijian Affairs Board, Ministry of Fijian Affairs for their faith in me and their reliable financial support during a very trying time for the Republic. I also wish to thank the University of the South Pacific for allowing me leave to pursue my research in Britain.

I wish to thank Mike Donohue of Applied Business Computers (ABC), Leicester for his help and advice on the printing of the manuscript.

To my dear wife Molly I express my appreciation for her patience and understanding over the years and her assistance during the writing of the thesis and to my children for their tolerance.

CONTENTS

THE USE OF MICROCOMPUTERS IN TEACHING MATHEMATICS IN FIJI

CHAPTER 1 FIJI, A BACKGROUND TO THE INVESTIGATION: An Introduction 1

1.1	Geographical	1
1.2	Historical Background	3
1.3	Population and Labour Force	7
1.4	Expatriates in the Labour Force	13
1.5	Remarks	14
1.6	Author's Background and Summary of Chapters	15

CHAPTER 2 DEVELOPMENT OF EDUCATION IN FIJI SINCE THE 70's

2.1	Aims of Education in Fiji	18
2.2	Educational Agencies	20
2.3	Structure of the Education System in Fiji	23
2.3.1	Teacher Training	24
2.3.2	Pre-School and Special Education	28
2.3.3	Technical and Vocational Education	29
2.3.4	Curriculum Development	30
2.3.5	Other Services	32
2.3.6	Comments on Education in Fiji	
	During the Years Before 1980	34
2.4	Educational Reforms in the 80's	35
2.4.1	The Fiji General Election of 1982	35
2.4.2	Reforms	36
2.4.3	Reactions to the Changes	41
2.4.4	Government's Response to the Opposition	45
2.4.5	Concluding Remarks	47

CHAPTER 3 COMPUTERS IN EDUCATION IN FIJI

3.1	COMPUTING AT THE UNIVERSITY OF THE SOUTH PACIFIC	
3.1.1	The University of the South Pacific (USP): A Historical Background	48
3.1.2	The Beginnings of Computing at USP	49

3.1.3	Courses Offering Computing at USP in 1985	52
3.1.4	A Trial Project on Teaching Mathematics Using Micros at USP	54
3.1.5	Other Computing Facilities at USP	59
3.2	COMPUTING IN EDUCATION IN FIJI OUTSIDE THE USP	
3.2.1	Introduction	61
3.2.2	Official Government Initiative	62
3.2.3	Response to Introduction of Microcomputers in Schools	66
3.3	The Fiji Experience	74
3.3.1	Developing Countries: Features	75
3.3.2	The Lack of Technical Background	79
3.3.3	Compromise and Improvise	80
3.3.4	Public Relations	80
3.3.5	Research	81
3.3.6	Simple Programs	82
3.3.7	Public Awareness of Computers	82
3.3.8	The Remainder of the Thesis	82

CHAPTER 4 COMPUTERS AND EDUCATION

4.1	A Definition of a Computer	84
4.1.1	Computer as a Calculator	85
4.1.2	Current Popular Definitions	89
4.1.3	Historically Derived Definitions	92
4.1.4	A Definition Related to Automation	95
4.2	Computers in Education: An Introduction	103
4.2.1	Programmed Learning	104
4.2.2	A Procedural Approach	108
4.2.3	A Non-Procedural Approach	112
4.2.4	Systems Approach in Instruction	116
4.2.5	Relevance of Early CAI to Fiji	119
4.3	Computer Hardware	

4.3.1	Hardware Contributions to Enhance Mathematics Teaching	126
4.3.2	Computer Mathematics Without Hardware	127

CHAPTER 5 THE ELECTRONIC SPREADSHEET: A SOFTWARE PACKAGE FOR MATHEMATICS

5.1	Software development	132
5.2	Computer Software Styles	147
5.3	The Electronic Spreadsheet and Mathematics	151
5.3.1	A Project on Using the Spreadsheet for Problem Solving	152
5.3.2	Spreadsheet and Numberwork in the Primary School	154
5.3.3	Secondary School Mathematics and the Spreadsheet	168

CHAPTER 6 PROGRAM CONVERSION

6.1	Why is Program Conversion Necessary	193
6.2	Steps in Program Conversion	195
6.2.1	Identifying the Program	195
6.2.2	The Transfer of Programs	198
6.2.3	The Training	208
6.3	Conversion of MIME Project Unit on Vectors	209
6.3.1	Conversion Approach	212
6.3.2	GFA Basic on the Atari ST	216
6.3.3	Features in the Conversion of Screen Output	217
6.3.4	Other Graphics Commands	218
6.3.5	Other Useful GFA Basic Commands	219
6.3.6	Conclusion	221

CHAPTER 7 SUMMARY, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

7.1	Summary	223
7.2	Recommendations	226
7.3	Suggestions for Further Research	228
7.4	Conclusions	230

REFERENCES

APPENDICES

- A A TRIAL PROJECT ON USING THE MICROCOMPUTER AS A
TEACHING AID

- B COMPUTER PROGRAMMING: GRAPHICS FIRST

- B1 AN INTRODUCTORY COURSE IN COMPUTER PROGRAMMING
FOR PRIMARY SCHOOLS IN FIJI: THE GRAPHICS APPROACH

- C COMPUTERS IN SCHOOLS CONFERENCE/WORKSHOP

- D SURVEY ON THE USE OF MICROCOMPUTERS IN SCHOOLS

- E COMPUTER USAGE IN THE SOUTH PACIFIC

- F PROBLEM SOLVING USING SPREADSHEET AND BASIC
LANGUAGE: A COMPARISON

- G DATA REPRESENTATION IN COMPUTERS

- H COMPUTER MATHEMATICS WITHOUT ACCESS TO
COMPUTER HARDWARE

- I A PREPARATORY COURSE OUTLINE IN THE USE OF THE
ELECTRONIC SPREADSHEET FOR MATHEMATICS
LEARNING

- J MICROBASED TEACHING METHODS PROJECT

CHAPTER 1

1 FIJI, A BACKGROUND TO THE INVESTIGATION: An Introduction

For those not familiar with Fiji, this chapter provides some background information on the island group. It discusses the geography and history of the group as well as the political development and manpower needs of Fiji. Of importance is the location of Fiji in relation to other nations of the developing South Pacific region. The physical location is reflected in the contributions that Fiji is making to the development of the South Pacific region as a whole.

In certain tables given in the chapter totals may not tally due to rounding errors.

1.1 Geographical

Fiji comprises several islands; the exact number is not known due to the differing definitions of an island and furthermore it varies between high tide and low tide. The number officially quoted lies between three hundred and eight hundred. The islands themselves are of varying geological structures covering some seven thousand square miles. Approximately one hundred are permanently populated and the rest are used for planting, temporary residence and leisure activities.

The islands lie just west of the 180th meridian of longitude and approximately one thousand miles north of New Zealand. They are centrally placed among the South Pacific Island territories and act as a gateway to the South Pacific region. They also lie on the main sea and air routes between Australia and New Zealand to the west and the United States of America and Canada to the east.

Two main islands dominate the group:

- 1 Viti Levu - the largest island in the group (about 5000 square miles) comprises approximately three fifths of the total land area and supports about three quarters of the total population of Fiji. Suva, the capital of the group, is located in the south east corner of this island and Nadi, with an international airport, is on the Western side.
- 2 Vanua Levu, the second most important island of the group, has an area of just over 2000 square miles, a little less than half the size of Viti Levu.

Compared with the vast surrounding expanse of the Pacific ocean or even with the two main islands the other islands of the Fiji group are very small.

The marine environment has had a strong influence on the development of Fiji and will continue to do so in the future. But like many island communities in the South Pacific, Fiji suffers from the predominant physical disadvantages of distance and relative isolation from major population centres as well as from other similar communities in the South West Pacific region. Even internal communications are very difficult due to the islands' varied geological structures of high peaks and dead volcanoes towering over green valleys.

Climatic Conditions

The friendly climatic conditions prevailing in the Fiji group of islands have had a marked influence on the way of life and the development of the group.

A prevailing south easterly trade wind produces a marked difference in rainfall between the eastern side of the main island of Viti Levu and the western side.

This gives rise to two regions the east/south and the north/west, each with its own distinct characteristics. The north/west has an abundance of sunshine and supports the country's most important export commodity, sugar. The very much wetter east/south is covered in thick vegetation. The rainy season in Fiji is from December to March but, the difference between the wet east/south and the

dry north/west is very marked during the rest of the year. Temperatures vary between 70°F and 80°F (approximately 21°C - 27°C), the hottest time of the year being during November and December.

1.2 Historical Background

It is said that the Polynesians and the Melanesians, two of the three racial groups in the Pacific, came from Western Asia as a result of population movement which spread from Western Asia to Malaya in East Asia and Indonesia. From there it spread to the islands in the Pacific as far north as Hawaii, south to New Zealand, and east to Easter Island.

Another theory, by a Norwegian called Thor Heydhal, supports the Kontiki expedition, which tried to show that the Polynesians came from South America. Recent evidence seems to discredit this theory. The background of the Melanesian people to which the indigenous Fijian race belongs is uncertain. Fijian legends and folklore tell of many different origins.

Abel Tasman, an early Dutch explorer, sighted the islands in 1643 and Captain James Cook of the British Royal Navy landed on one of the islands in 1774. Captain Bligh of Mutiny of the Bounty fame charted thirty nine of the islands when adrift in his little boat after the mutiny. On his return to the islands in 1792 on HMS Providence, Bligh laid claim to the islands which became known as the Bligh Islands. Later as a result of the country being rich in sandalwood (a much sought after wood), came the British beachcombers, traders and missionaries who produced the first written language and were the first white settlers.

Tribal disputes and problems with the settlers eventually forced some of the tribal chiefs to seek protection within the British Empire. This was achieved by handing power over the islands to Great Britain on condition that Great Britain paid compensation demanded by the Americans for damage suffered by some American trading posts. In 1874 a Deed of Cession was signed making Fiji a British Crown

Colony and a member of the then British Empire. It continued so until, in 1970, Fiji became an Independent Dominion member of the Commonwealth and remained so until the Military Coup of May 1987 when Fiji was declared a Republic.

Political Development

British colonialism in Fiji was by the invitation of the indigenous Fijians. Previous to the Deed of Cession of 1874 local conflicts between warring chiefs were seen as an attempt to establish some sort of order to tribal differences and to try and control activities practised by the white settlers.

The introduction of firearms helped the rise of Cakobau, one of many tribal chiefs, as leader of the Fijian people in the early 1870's. Cakobau's dominance of the whole of Fiji has been challenged in modern times, but it was he who established the first 'independent government' of Fiji. It has been claimed that European settlers at the time encouraged the recognition of Cakobau as King of Fiji, without any consultation with other equally important tribal chiefs, to bring about some form of order and government. This lasted two years, but continuous unrest and tribal rivalries and pressures brought about by the American demands for compensation then led to the Deed of Cession of 1874.

The new British colonial government experienced many difficulties. Finances were scarce and an epidemic of measles nearly wiped out the Fijian population. The first one hundred thousand pounds of much subsequent British financial aid provided temporary relief. Attempts were made by the British colonial government in 1883 and 1885 to change the form of government by federation with New Zealand and/or Australia but both failed. Further attempts for formal association with New Zealand, made at the turn of the century, did not succeed but resulted in the granting, in 1904, to Europeans on the islands of an elected representative in the Legislative Council. The same privilege was granted to indentured Indian

labourers in 1929. The Indians were brought in after cession as indentured labourers by Europeans who regarded the operation of a sugar plantation economy as a solution to the need for economic development. Women were allowed to accompany the indentured labourers from India in order to avoid undesirable social effects associated with the grouping together of large numbers of males. To provide security for those who did not want to return to India, the indentured labourers were allowed to settle in Fiji at the end of their contracts. This has led over the years to an unfortunate fragmentation and compartmentalisation of the economic and social life of Fiji's two main races, the native indigenous Fijians and the descendants of Indian indentured labourers. Had indentured labourers not been encouraged to settle in Fiji, some problems prevalent today in the country might have been avoided.

On October 10th 1970, after more than ninety years of British colonial rule, Fiji became an independent nation and a member of the Commonwealth of Nations. This was seen as a natural stage of the normal evolution of constitutional and political progression in Fiji without any pressure on the colonial ruler as characterised by decolonisation in other parts of the world.

For seventeen years since independence in 1970, Fiji's political scene has been dominated by two political parties.

- 1 The Alliance Party, which is seen as a party for ethnic Fijians, has been in office for the seventeen years since independence.
- 2 Providing a capable opposition is the National Federation Party (NFP), backed mainly by the descendants of Indian indentured labourers.

A further political development in Fiji saw the emergence of the Labour Party in the early eighties. The Labour Party was initially a coalition of the two major races in Fiji who were opposed to the two racially biased political parties, the Alliance Party and the National Federation Party. The general election of

1987 voted the new Labour Party, who had by now formed a new coalition with the National Federation Party, into office. The Alliance Party who had not considered the possibility of being out of office had lost the election. In contrast to the peaceful decolonisation process of 1970, which transformed Fiji from a British Crown Colony to an Independent State of the Commonwealth, a bloodless military coup overthrew the newly elected Labour government after the 1987 election and declared Fiji a Republic in May of the same year.

TABLE 1.1

POPULATION & LABOUR FORCE TRENDS, 1956-80
(in thousands)

	1956	1966	1976	1980
Pop	345	477	588	638
14+	186	254.3	346.1	390.8
M	97.9	129.7	174.0	195.4
F	88.9	124.6	172.1	195.4
LF	93.3	125.8	175.8	205.0
LFPR	50.0%	49.5%	50.8%	52.5%
HD	79.7	106.4	118.2	123.5
Tot	173.0	232.2	294.0	328.5
LFPR including HD				
	92.7%	91.3%	86.0%	84.1%

Note: Pop = total population, M = male,
14+ = 14yrs and over, LF = labour force,
F = female, HD = Home Duties,
LFPR = labour force participation rate.

(Source Fiji's DP8, 1981-85)

1.3 Population and Labour Force

Population growth in Fiji is more than sufficient to cater for future manpower needs in most categories of the labour market. It is the higher level of skilled workers that are not always easily available. To successfully meet manpower needs when required, education and training play an important role.

Table 1.1 shows the trend in population and labour force from 1956 to 1980 in thousands except for LFPR which are in percentages.

The number of 14+ represents those available for work, e.g. 186,000 in 1956. This number is made up of 97,900 males and 88,900 females. The numbers under LF (labour force) indicate the number employed, 93,300 in 1956, and this is 50% of 186,000, the total available for work. Those employed in domestic duties are not included in these figures. Home duties, which include domestic duties¹, for 1956 accounted for 79,700, and this raised the total LFPR to 92.7% for the year 1956. Population growth rate has remained relatively static at 2.1% since 1966 but a decline to 1.5% per annum is expected by the end of the century. The labour force (population over 14 years old) growth rate is faster than the population growth rate but is expected to decline when the fertility reductions of the 1960's begin to show an effect.

The growth rate of home duties, normally carried out by women, shows a decline, possibly due to the changing attitude to the role of women in society. The change in attitude has given the women more freedom, and opportunities to pursue further education resulting in a wider scope of job opportunities. The author sees this as a cause for the lack of child control in Fijian society, which accepted the role of women as that of child minding. With further education

¹Home Duties represent women that do housework for their families and domestic duties are those that do housework for others and get paid.

women have moved out of the home to seek employment elsewhere thus depriving young pre-school children of care and attention. The plight of pre-school children is a major problem in Fiji, and results in an ever increasing incidence of juvenile crime. In providing employment opportunities for women the government has failed to cater for the young pre-school population that depend on the women.

The presence of expatriates in the country also contributes to more women being employed in domestic duties, but as the number of expatriates tends to decrease there becomes a shortage of work for women in the homes of the well-to-do expatriates. The decline in total labour force participation rate (LFPR + HD) is due to the reduction in home duties participation by women and also to the rise in the number of 14 year olds and over, staying on at school.

TABLE 1.2
OCCUPATIONAL STRUCTURE OF LABOUR FORCE, 1966-80

	1966	1976	1980	1976-80 increase
PT	8.3	12.6	15.0	2.4
M	NA	1.7	1.9	0.2
CSSW	NA	32.1	36.5	4.4
AGR	66.9	76.4	89.0	12.6
PCO	NA	33.0	41.4	8.4
OU	NA	20.0	21.2	1.2
HD	106.4	118.2	123.5	5.3
Total	232.2	294.0	328.5	34.5

Note:

PT = professional/technical, M = managerial,
 CSSW = clerical/sales/service workers, AGR = agricultural,
 PCO = production/construction/operators,
 OU = others/unskilled, HD = home duties

(Source DP8, 1981-85)

Table 1.2 shows the breakdown of the labour force from 1966 to 1980. Professional and Technical workers show a high growth rate since 1966. The growth rate increase of agricultural workers since 1976 is due to the expansion in the sugar industry.

Calculations of labour force by occupation are based on estimates of the growth of industries since the 1976 census and are generally consistent as shown in Table 1.1 and in the estimated training output shown in Table 1.3.

TABLE 1.3

TRAINING OUTPUT BY LEVEL, 1976-80

Level	1976	1977	1978	1979	Totals
Prof	91	104	115	125	435
S/Prof	415	436	455	480	1786
Tr/Clr	2198	2329	2460	2591	9578
Form 5&6 School Leavers					
	6178	6475	6772	7069	26494

Note: Prof = Professional, S/Prof = Sub Professional,
Tr/Cl = Trade/Clerical.

(Source Fiji's DP8, 1981-85)

The increase in numbers of professional, technical and managerial workers between 1976 and 1980 is 2,600 as indicated in Table 1.2 ($15.0 + 1.9 - 12.6 - 1.7 = 2.6$ thousands).

The increase in the professional, technical and managerial work force must be due to people who completed their training during the period 1976-1979.

The total training output at the professional and sub-professional level during this period (1976-1979) as shown in Table 1.3 is $435 + 1,786 = 2,221$.

The increase in number in employment at the professional and sub-professional level, 2.6, is greater than the training output for the same period, 2.2.

The difference ($2.6 - 2.2 = 0.4$) shows the number of workers at this level who are not trained for the posts they are holding or trained abroad.

TABLE 1.4
EDUCATIONAL QUALIFICATION STRUCTURE OF LABOUR FORCE
(in thousands)

Occupation	Education								
	1976			1980			1976-80 increase.		
	P	S	T	P	S	T	P	S	T
P	1.9	5.1	5.6	2.3	6.1	6.7	0.4	1.0	1.1
M	0.4	0.8	0.4	0.4	0.9	0.4	0.0	0.1	0.0
C	16.5	14.9	0.6	18.8	16.9	0.7	2.3	2.0	0.1
A	68.3	7.7	0.4	79.6	9.0	0.5	11.3	1.3	0.1
O	42.8	13.0	0.5	46.7	15.4	0.6	3.9	2.4	0.1
H	94.9	21.9	1.2	99.0	23.2	1.3	4.1	1.3	0.1
TOTAL	224.8	63.4	8.7	246.8	71.5	10.2	22.0	8.1	1.5

Note: Education

- P = primary education only or no education,
- S = some secondary education,
- T = some tertiary education,

Occupation

- P = professional/technical, M = managerial,
- A = agricultural, H = home duties,
- C = clerical/sales/services
- O = production/construction/operators/unskilled

(Source Fiji's DP8, 1981-85)

Table 1.4 shows the educational structure of the labour force during the period 1976-1980.

Overall there is an increase in the number of workers with some form of education at all levels. Workers with some tertiary education show an increase of 1,500 while those with some secondary education and primary education show an increase of 8,100 and 22,000 respectively. The education development in Fiji today has overtaken demands or it is misdirected. This is shown by the number

of school leavers with high academic qualifications, New Zealand School Certificate and New Zealand University Entrance, who are without employment. Some of them are overqualified for tasks that they are engaged in. A review of the role of education in Fiji is badly needed to ensure that prevalent demands of society in Fiji are catered for.

TABLE 1.5

OCCUPATIONAL BREAKDOWN OF WORK PERMITS, 1980

Code Occupation ISCO	Number	% of Total
01 Physical Scientists	13	0.7
02 Architects & Engineers	126	7.1
03 Surveyors, Draughtsmen, Engineering Technicians	41	2.3
04 Aircraft & Ship's Officers	88	5.0
05 Life Scientists	2	0.1
06 Doctors	27	1.5
07 Nurses	13	0.2
08 Statisticians, Mathematicians	8	0.4
09 Economists	3	0.2
11 Accountants	98	5.5
12 Judges & Lawyers	3	0.2
13 Teachers	295	16.7
14 Religious Workers	158	8.9
15-19 Journalists, Authors, Artists, Other Professionals	55	3.1
2 Administrators, Managers	374	21.1
3 Clerical Workers	15	0.8
4 Sales Workers	16	0.9
5 Service Workers	68	3.8
6 Agricultural Workers	48	2.7
7/8/9 Production, Construction, Operators	150	8.5
Sub-total	1591	90.0
0-9 Not Classified	176	10.0
TOTAL WORK PERMITS		1767.0

Note:

ISCO = International Standard Classification of Occupations
(Source Fiji's DP8, 1981-85)

TABLE 1.6**EXPATRIATES IN SELECTED GOVERNMENT DEPTS, JULY 1980**

Department	Number	% of Total
Education	145	31.7
Public Works	61	13.3
Agrc. & Fisheries	43	9.4
Health	38	8.3
Civil Aviation	19	4.2
Judicial & Crown Law	17	3.7
TOTAL	323	70.6

(Source Fiji's DP8, 1981-85)

1.4 Expatriates in the Labour Force

Expatriates in Fiji are brought in by the government for their expertise and also as part of foreign aid. Those in private enterprise are there to look after their investments. It is difficult for the local labour force to understand and accept that developing countries like Fiji will need the services of expatriates for many years and this has caused disagreements. By the same token there are expatriates who abuse their positions which make working towards a common goal difficult to achieve. Nevertheless expatriates in Fiji have contributed enormously to the country's development.

Available figures show that 1,767 work permits were valid in May 1980 representing 0.8% of the work force.

Table 1.5 shows the occupational breakdown of work permits.

Work permit holders shown in Table 1.5 do not include those brought in by the government who work in the civil service. Table 1.6 shows a departmental breakdown of 323 of the 457 expatriates employed in the Civil Service in June

1978. There is no information available on the other 124 expatriates who are employed in the private sector.

There is still scope for localisation in Fiji but some occupations are, by their very nature, e.g. *temporary demand for a particular skill, too expensive to localise*. It is also desirable to have people with overseas experience work in Fiji for the benefit of the local labour force who can upgrade their skills by working alongside expatriates. Education towards satisfying local requirements, which can be only be achieved by proper identification of local needs, can achieve localisation that will be beneficial. Education in Fiji has for a long time been aimed at the creation of a consumer society which uses foreign and imported ideas and products. It is time now to educate to 'produce' instead of 'consume'.

1.5 Remarks

The chapter is an introduction to Fiji for those not familiar with the island group.

The mild and favourable weather conditions in Fiji give rise to a land of plenty which in turn is reflected in the attitude of the people. This is shown by the generous nature of the Fijians and a sense of non-competitiveness. The geographical location gives the people of Fiji an insular attitude making progress, especially with technical innovations, difficult to accept. This is made more complex by the use of Fiji, with its international airport, as a gateway into the South Pacific region. Fiji is host to many South Pacific regional organisations like the University of the South Pacific (USP) and the South Pacific Economic Commission (SPEC), hence it plays an important part in influencing regional policies.

The introduction of new technologies should initiate new concepts in the aims of education. It provides an opportunity for the nation to review its educational

policies. Computers in education should give teachers and educators in Fiji the chance to ask many questions about what they consider is their profession. The computer without actually being used in education can play an important role by provoking discussions and debates on the role of education in society, the role of the teacher in education, the role of the computer in the class room and many more aspects of education. Such discussions and debates can do nothing but good for education in general.

1.6 Author's Background and Summary of Chapters

The author's involvement with mathematics and education began in Fiji where he received his primary and secondary education in the 50's. A nine year spell in the British Army as a Radio Technician kept his interest in mathematics alive and influenced him to take up teaching on completion of his army service. Having graduated and obtained a teaching certificate, he later taught mathematics in British secondary schools, Papua New Guinea High schools and Fiji secondary schools. Then a one year spell as Computer Systems Analyst/Programmer with NCR (New Zealand) Ltd. installing systems in the South Pacific region was followed by a lecturing post in mathematics at the University of the South Pacific (USP) in 1980.

At the USP the author was able to combine his two interests, mathematics education and computers in surroundings conducive to research. Public awareness of computers in Fiji was just beginning and a study of computers in Fiji education gained him an MA award from the USP in 1986. During this study the author identified the problems inherent in the teaching of mathematics with the use of computers in Fiji. It was recommended to him to approach Professor Bajpai at CAMET with a proposal to investigate the topic and the Professor kindly agreed to supervise and direct the research which is the subject of this thesis.

Chapters 2 and 3 examine the education system in Fiji and the implications of computers. They begin by analysing the education set-up prior to the 1980's. From 1982 onwards education in Fiji went through some drastic changes and the thesis takes a critical look at the events surrounding the introduction of computers in education in 1984.

Chapter 4 offers a definition of computers that is applicable to education. It traces the origin of computers and the various definitions given to it. The misconception of what a computer is, and its effects, are discussed and a logical approach to a definition formulated. The chapter highlights the fact that, in the discussion of computers, benefits in education can be derived without access to computer hardware. The chapter concludes with a practical description of a simple microcomputer system which could be used in the study of computer mathematics.

Chapter 5 presents the various styles of computer software available for teaching and learning. The use of features unique to computers in software for teaching is emphasised. The chapter also investigates the electronic spreadsheet as an alternative mathematics software package. Its availability on almost all brands of hardware and its application in commerce make it an attractive proposition to developing countries. The power of the spreadsheet lies in its mathematical functions which enable it to process numbers and algebraic expressions.

Chapter 6 investigates the conversion of programs which are developed on one particular brand of hardware to run on another. This exercise is considered as an alternative to developing programs from scratch for countries like Fiji which cannot afford software development from scratch. The conversion of a MIME Unit program on Vectors from the BBC to the Atari ST microcomputer running under GFA

Basic is given as an illustration and its possible adoption as a teaching strategy in Fijian context is discussed.

Finally Chapter 7 summarises, makes recommendations and suggests areas for further research.

CHAPTER 2

2 DEVELOPMENT OF EDUCATION IN FIJI SINCE THE 70's

Originally education in Fiji was the responsibility of the elders who passed on their own skills and knowledge to the younger generation by word of mouth and demonstration. Formal education as we know it today was introduced by the Europeans who needed new skills to service their needs. The first Europeans to settle in Fiji, the missionaries, set up the first schools to teach native Fijians to read and write and do arithmetic. These were skills needed to service the requirements of the early European settlers. Demands have changed over the years and educational policies have been reformulated to cope with the new demands. The author feels that it is now time for a review of educational objectives, which should reflect the present needs of the local population instead of allowing foreign pressures to be the only influence over the direction that education takes.

This chapter discusses the development of the education system which exists today in Fiji, and comments on its value to the nation as a whole.

2.1 Aims of Education in Fiji

The broad aims of the educational system as outlined in Fiji's Development Plans are:

- (i) to provide a balanced programme of education for the full development of children as individuals in a changing society, taking into account their abilities, interests and aptitudes
- (ii) to develop Fiji's human resources in such a way as to guide all citizens towards satisfying, productive employment in accordance with natural needs thereby accelerating economic development
- (iii) to encourage a greater sense of national awareness, self-reliance and a

pride in being a citizen of Fiji

- (iv) to promote the cultural identity and social advancement of Fiji and its people amidst increasing contact with the outside world.

These aims though aimed at realising the potential of the Fijian people have also deprived the new generation of some of their cultural values in exchange of new imported ones.

Seven Long Term Aims of Education in Fiji

Since independence in 1970 several Development Plans for Fiji have been designed to cover five year periods. The Development Plan for 1970-1975 was the sixth development plan for Fiji and is referred to here as DP6, 1970-75. Other Development Plans are similarly referred to in this chapter. The objectives of DP6 were identified and adopted when Fiji gained her independence from Great Britain in 1970.

Seven long term aims in education, originally set out in DP6, were retained in DP7, 1976-80 and DP8, 1981-85. These were:

- (i) to provide ten years of education for every child who wants it, ref. Class 1 to Form 4, Fig. 2.1
A further two years to be made available to those whose Form 4 performance indicates that they can cope with Form 5 and Form 6 work
- (ii) to continue to improve the quality of the teacher training programme
- (iii) to staff primary schools wholly by trained teachers and to achieve an acceptable pupil/teacher ratio in schools
- (iv) to improve the quality of education through improved provision of books and equipment as well as through curriculum revision
- (v) to continue to expand the provision of fee free education in classes 1 - 6
- (vi) to continue to find ways and means of improving areas of education of Fijians

- (vii) to align technical and vocational education with manpower requirements of the economy.

In the author's view these broad aims are imprecise. There is a need to identify and define more clearly the areas that are to be addressed, and to suggest how the problems might be solved. This will involve the need for better and more careful planning, with people from many backgrounds and with knowledge of the Fijian way of life making an input. The value of considering comments and views from a wide selection of the population cannot be overemphasised, and is something not previously encountered in Fiji.

2.2 Educational Agencies

The early educational needs were satisfied by the village community. Native Fijians were trained in the art of fishing and hunting and leisure activities. These traditional demands were totally different from those required by the early European settlers who needed bookkeepers and clerical staff to man their businesses. The European settlers realised that it was cheaper to teach the native Fijians to read, write and do arithmetic than to bring in a trained person from abroad. In addition the missionaries taught native Fijians to read so they could read the Bible. Thus the first formal school to be opened in Fiji was intended to help the early settlers to operate their businesses. It was mainly funded by the traders with a government subsidy.

Over the years many agencies, such as the church, recognising the need for the local population to equip themselves with skills required to meet new demands, have set up educational institutions to aid government educational programmes.

TABLE 2.1 is a list of educational agencies operating in Fiji in 1970.

In addition to those listed in this table there were 59 kindergartens, mostly privately run.

TABLE 2.1
EDUCATIONAL AGENCIES, 1970

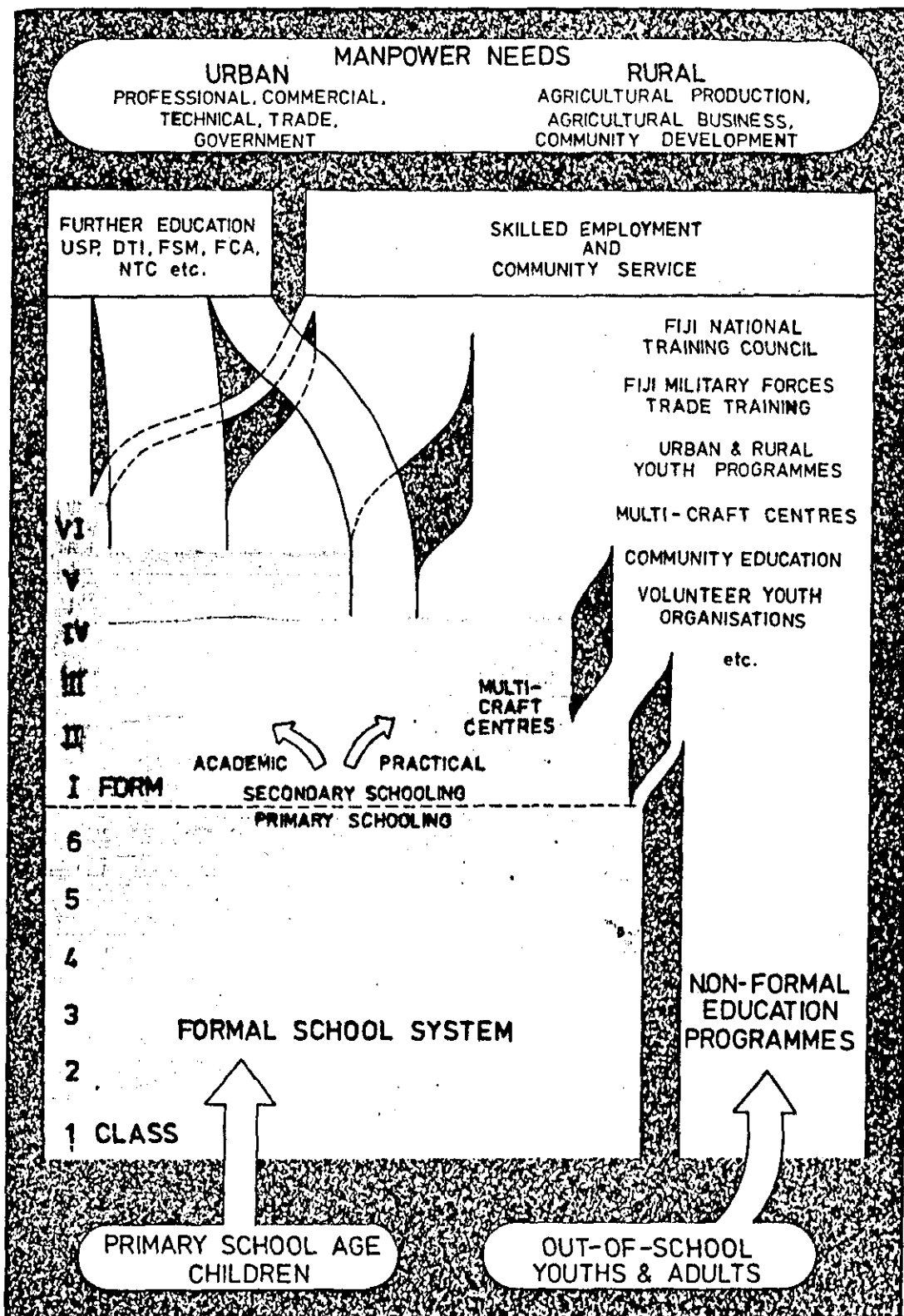
	A	B	C	D
Government	26	6	4	1
Committee	500	37	2	-
Catholic Church	32	5	1	1
Methodist Church	19	7	3	-
7th Day Adventist Mission	11	2	-	1
Diocese of Polynesia	6	-	-	-
Marist Brothers	2	1	-	-
Assemblies of God Mission	2	1	-	-
Sisters of St Joseph De Cluny	-	1	-	-
Brethren Assemblies	2	1	-	-
Latter Day Saints	1	-	-	-
Civil Aviation Administration	1	-	1	-
South Pacific Sugar Mills	2	-	-	-
Emperor Gold Mining Co Ltd	1	-	-	-
Fijian Affairs Board	1	1	-	-
Medical Department	2	-	-	-
Social Welfare Dept	1	-	-	-
Land Development Authority	1	-	-	-
Crippled Children's Society	2	-	-	-
Private	4	-	9	-
Young Women's Christian Assoc	-	-	2	-
TOTAL	616	62	22	3

Note: A = primary school B = secondary school
 C = vocational training D = teacher training
 (Source Fiji Annual Report 1970)

STRUCTURE OF EDUCATION IN FIJI

FIGURE 2.1 (next page)

FUTURE STRUCTURE OF THE EDUCATIONAL SYSTEM



.FIG 2.1

2.3 Structure of the Education System in Fiji

FIGURE 2.1 shows the structure of the education system in Fiji.

Formal schooling starts at the age of six at Primary level, though there are voluntary organisations running kindergartens for the under sixes. Primary schooling ends at Class 8 (Form 2) when some primary schools insist on students taking an examination before being allowed to continue into Form 3 of a secondary school. There is a move towards ending primary schooling at Class 6 and beginning Secondary Education at Form 1(Class 7). This is effectively a change from an Eight Year Primary/Four Year Secondary education programme to a Six Year Primary/Six Year Secondary education programme.

At the end of Form 4 in the secondary school pupils sit the Fiji Junior Certificate examination as an entry qualification for Form 5. To continue into Form 6, a pass in the New Zealand School Certificate at the end of Form 5 is a pre-requisite. Students may sit the New Zealand University Entrance examination at the end of Form 6.

It is government policy to provide fee free primary education. This in effect makes attendance at primary school compulsory, while that at secondary school is voluntary and dependent on the ability to pay.

Post Secondary Education

Further education in Fiji is available at:

- The University of the South Pacific (USP)
- The Fiji Institute of Technology (FIT)
- The Fiji School of Medicine (FSM)
- The Fiji College of Agriculture (FCA)
- The Lautoka Teachers College (LTC)
- The Corpus Christi Teachers College (CCTC)
- The Pacific Theological College (PTC).

Non-formal Education Programmes are offered by:

The Fiji National Training Council (FNTC)

Urban and Rural Youth Training Programmes

Multicraft Centres

Community Education Volunteer Youth Organisations.

Primary School Education

Great progress has been made in making education accessible to all, especially at the primary level. Table 2.2 shows the enrolment figures of various age groups within the 6-16 age band, and gives these as a percentage of the total population in the respective groups.

For primary education, Classes 1-6 /Ages 6-11, this shows an attendance level of 98% .

The post primary figures, Class 7(or Form 1) to Form 5/Ages 12-16, indicate that approximately 28% of the population in each year are not receiving schooling.

2.3.1 Teacher Training

Primary School Teacher Training

Nasinu Training College used to offer pre-service training for primary school teachers. Lautoka Teacher Training College (LTTC), which opened in 1977, boosted pre-service training, and at the same time offered intensive in-service training for primary teachers. Pre-service training is also available at the Catholic Church maintained Corpus Christi Teacher Training College (CCTTC), and at the Seventh Day Adventist College at Fulton Mission (SDATTC).

TABLE 2.2
PRIMARY SCHOOL ENROLMENT AS A PROPORTION OF POPULATION

	(1000)				
AGE	1975	1976	1977	1978	1979
6-11					
Enrolment	94.6	93.9	92.9	91.7	91.9
Population	96.4	95.0	94.3	94.1	93.8
% Enrolled	98.1%	98.8%	98.5%	97.4%	98.0%
12-13					
Enrolment	29.0	29.3	29.9	29.5	29.5
Population	32.7	33.7	33.6	32.6	32.4
% Enrolled	88.7%	87.0%	89.0%	90.5%	91.0%
14-16					
Enrolment	26.9	28.4	29.1	29.0	29.4
Population	45.9	47.4	48.1	50.0	49.9
% Enrolled	58.6%	59.9%	60.5%	58.0%	58.9%
TOTAL					
6-16					
Enrolment	150.5	151.6	151.9	150.2	150.8
Population	175.0	176.1	176.0	176.7	176.1
% Enrolled	86.0%	86.1%	86.3%	85.0%	85.6%

(Source FIJI's DP8)

TABLE 2.3

PROGRESS IN PRIMARY TEACHER TRAINING 1969-1979

YEAR	TT	UT	TOT	%T	PT	PTR
1969	2251	620	2871	78.4%	34.5	44.0
1970	2828	889	3717	76.1%	32.7	42.9
1974	3345	884	4229	79.1%	31.9	40.4
1975	3544	730	4274	82.9%	31.6	38.1
1976	3583	524	4107	87.2%	32.5	37.3
1977	3685	524	4209	87.6%	31.5	35.9
1978	4196	239	4435	94.6%	29.6	31.3
1979	4260	140	4400	96.8%	29.4	30.4

Note: TT = trained teachers, UT = untrained teachers
 TOT = total teachers, %T = % trained
 PT = pupil to teacher (trained+untrained) ratio
 PTR = pupil to teacher (trained) ratio
 (Source Fiji's DP7 & DP8)

TABLE 2.3 shows the progress of primary teacher training for the period 1969-79.

The last column shows the ratio of pupil to trained teachers.

The last but one column shows the ratio of pupil to the total (trained and untrained) number of teachers. There is clearly an improvement over the years in the pupil to trained teacher ratio. Progress was slow in the early 70's because of the growth in the number of primary schools at that time. Also any effect of increased teacher training takes time to show.

As enrolment at teacher training institutions increases and primary school expansion slows down, improvements in the ratio of pupil to trained teachers will result.

Available figures show an increase in primary school teacher training enrolment from 335 in 1969 to 506 in 1974. This represented an annual average increase of

8.6% in primary school teacher training enrolment as against an increase of 3.1% in primary school pupil enrolment for the same period. This improvement in the pupil to teacher ratio in the primary sector may have been the reason why the government decided to close Nasinu Teachers College in 1984.

The reduced number of untrained teachers in the primary sector has led to an improvement in the quality of education in primary schools. The raising of the entry qualification into primary teacher training to the School Certificate Level has also contributed to the improvement in quality of primary school education.

Secondary School Teacher Training

The University of the South Pacific provided two pre-service courses for teachers before the education reforms of the 80's:

- (i) a 3-year Diploma in Education for teachers of lower secondary forms (1-4). In 1970 there were 46 first year students and 23 second year students
- (ii) a 4-year B.A. or B.Sc. degree course with a concurrent graduate Certificate in Education. There were 37 undergraduates in 1970.

A major development in this direction was the introduction of a Bachelor of Education Course in 1975 by the University of the South Pacific as a measure towards improving the quality of secondary school teachers. However in the early 1980's government support for secondary school teacher trainees at this University was withdrawn, and this effectively put a halt to pre-service teacher training at the secondary school level. The withdrawal of government support for trainee teachers is discussed later in section 2.4.2 on reforms.

In-service certificate courses continue to be offered by the University of the South Pacific in:

Post Graduate Certificate in Education
In-Service Certificate in Education
In-Service Diploma in Education Certificate in Teaching English as a
Second Language
Diploma in Guidance and Counselling
Vocational Teacher's Certificate
Certificate in Curriculum Studies
The Diploma in Educational Administration.

Because of the withdrawal of government support for teacher trainees at the University, the University stopped offering the Diploma in Education course after 1984.

2.3.2 Pre-School and Special Education

Kindergartens

The government encourages privately run kindergartens by supplying advisors and running courses for kindergarten teachers. In addition the government regulates the setting up of kindergartens to ensure proper facilities are provided and trained people are employed.

Women's interests groups like the Young Women's Christian Association (YWCA) are involved in providing kindergartens, reflecting the attitude existing in Fiji that child minding is women's work. It is also an indication that the women in Fiji have attained a certain level of education and are capable of other employment, and the kindergarten provides somewhere for young children to go, while mothers go to work.

Special Education

Due to improvement in the medical services more handicapped children are surviving to maturity. At the same time there is an awareness among parents that handicapped children can and should be treated, instead of being isolated at

home and becoming social outcasts. The task of providing for the handicapped is mainly left to private organisations. The government contributes:

- (i) to the supply and pay of trained teachers
- (ii) in the provision of supervisory staff
- (iii) assistance in the payment of fees
- (iv) assistance in the provision of specialist facilities.

2.3.3 Technical and Vocational Education

Secondary school leavers with at least a Fiji Junior School Certificate, taken at the end of Form 4, are eligible for these technical and vocational courses.

Fiji Institute of Technology (FIT)

Trade and technician level courses are offered at the Institute. The Institute also plays a part in training teachers of practical subjects for the Multi-craft Centres which are located in some secondary schools.

Ba Technical Centre

This was designed to meet the technical training needs of the Western Division of Fiji. Another centre is planned to meet the demands of the Northern Division.

School of Maritime Studies

Fiji's geographical location and attributes give her a special interest in marine technology. The school is an attempt to meet the demands for the expertise required to fully utilise the marine resources available in Fiji's environment.

Multi-craft Centres

To enable more secondary students to experience various craft disciplines and to make craft facilities available to out-of-school youths and adults during out-of-school hours, craft centres were set up. These centres were established in:

- (i) existing secondary schools by expanding the industrial arts and home economics facilities, thus enabling instruction in a wider selection of subjects and activities
- (ii) areas where they can serve groups of villages or groups of neighbouring secondary schools.

Agro-Technical Education

The importance of agriculture to Fiji has long been recognised by the government. Land utilisation for maximum benefit is encouraged in all sectors of the community.

Various schools offer agricultural programmes such as:

- (i) gardening programme for schools
- (ii) gardening programme for Forms 1 and 2
- (iii) agriculture (crop and animal husbandry) for Forms 3 & 4.

The Fiji School of Agriculture, situated at Koronivia outside the capital Suva, trains agricultural officers who are employed by government, and also by the Fiji Development Bank, which finances most agricultural ventures in the country. The University of the South Pacific also provides training in agriculture at its School of Agriculture located at the Apia Campus on Western Samoa.

2.3.4 Curriculum Development

The old system of education in Fiji, as experienced by the author, selected and moulded a small group of academically inclined students, using a programme of increasingly difficult examinations. A large proportion of pupils fell by the wayside and were not catered for. The new objectives in curriculum development aim at providing an appropriate and relevant form of education and training, whether formal or non-formal, for every individual. Every individual has potential, and education should bring this potential to the fore, enabling him

to contribute towards the betterment of society.

Specifically, curriculum revision and development in Fiji aim to:

- (i) complete the change from eight years primary/four years secondary school programme to the six years primary/six years secondary programme
- (ii) match an integrated primary curriculum to an appropriate secondary curriculum to cater for the large proportion of non-academic pupils
- (iii) update existing courses and introduce new ones in primary and secondary schools with appropriate teaching materials
- (iv) broaden and enrich the curriculum at secondary level with emphasis on:
 - the acquisition of practical skills
 - careers information and guidance
 - simple accounting and banking procedures
 - the preservation of social and physical environment
 - vernacular language and cultural heritage
 - multi-cultural activities
 - education for family life
 - road safety
 - swimming and life saving
 - consumer awareness
 - the need to grow more food
 - community service.

Objections to the implementation of the above enrichments of the curriculum stem mainly from the fact that they are non-examinable topics. This same objection created problems during the introduction of computers in schools (see Chapter 3). Some of the items, like swimming, are viewed by the Fijians as an unnecessary waste of resources. They feel that swimming is learnt outside school

and is as natural as learning to speak. The majority of Fijians live in rural areas where road safety is not as important as in the towns. Rural dwellers feel that resources could be better spent on examinable subjects, which they see as a 'step up' for their children to a better standard of living.

An attempt to overcome the objections is being made by:

- (i) a prolonged publicity campaign to stress the importance and advantages of a broader curriculum to include non-examinable topics
- (ii) lengthening the school year to cater for the extra activities
- (iii) encouraging the growth of voluntary national youth organizations to be responsible for instruction in some of the 'enrichment' subjects.

Examinations

With the emphasis on enriching the curriculum with the activities discussed above there is a need to revise examinations. The move is towards prescribing examinations to suit local needs. At the moment examinations at Forms 5 and 6 are still partially New Zealand-based, but have a local bias in some subject areas. Steps are being explored in collaboration with other South Pacific countries, and in consultation with the University of the South Pacific, to set up a South Pacific Board of Examination Assessment. This Board is to develop examinations and other means of assessment and help in training personnel in the development and use of assessment procedures and techniques.

2.3.5 Other Services

Grants provided to non-government schools include:

- (i) fee-free grant to primary classes 1-6
- (ii) remission of fees to classes 7-8
- (iii) remission of fees based on incomes of parents in Forms 1-4 and on both performance and parental income in Forms 5-6
- (iv) a per-capita grant in respect of every child in Forms 1-4 in secondary

schools

- (v) a per-capita grant in respect of aided students in Forms 5-6
- (vi) a licensed teacher or reserved teacher grant in primary schools
- (vii) salary grant in respect of non-government teachers and clerical assistants in secondary schools.

Some teachers in Fiji are not registered by the government and as such their wages are the responsibility of the school committee. These teachers are known as Licensed Teachers and some of them are not formally trained to teach and are hired by the school committee.

Discretionary building grants are also available to schools on application.

Support Services

Support services available to the education system include:

- (i) Careers Services: Forms 3,4,5 and 6 are given advice on employment opportunity and selection.
- (ii) The Fiji Museum: the museum offers a good opportunity for pupils to study earlier cultural activities and values of the Fijian way of life
- (iii) The Fiji Arts Council: an institution aimed at developing traditional as well as contemporary expressive and visual arts particularly in connection with young people.

Teachers' Unions

Two teachers' unions to cater for the two main racial groups exist in Fiji. The Fijian Teachers' Union (FTU) is mainly patronised by indigenous Fijian teachers, while the members of the National Union of Teachers are mainly non-indigenous Fijians. Teacher Unions have been very active in negotiating better teaching conditions. Public relations between Unions, parents and government have been good for many years. This cordial relationship was shattered in the early eighties when educational reforms brought about by the government caused nation wide unrest and demonstrations. This is dealt in more detail in the next

chapter.

2.3.6 Comments on Education in Fiji During The Years Before 1980

During the period before the 70's education in Fiji was limited to a privileged few, either those that were academically inclined or those that could afford it. Progress through the education system was determined, in most cases, by success at the examinations. There was only a handful of secondary schools and post secondary education was provided by neighbouring countries New Zealand and Australia. The curriculum was geared to satisfy some criteria that were totally foreign to the native Fijian and did not include skills or knowledge that identified with his needs. This was acceptable as long as there was enough employment to absorb the educated population. The curriculum and educational objectives of the pre-70's have been carried forward to the 80's, and today there are many young people in Fiji with New Zealand University entrance passes who are without jobs and without the skills and knowledge to improve the Fijian way of life. They have been trained in skills that are, as far as Fiji's development is concerned, irrelevant.

What Fiji needs is an education system that takes account of the demands of Fijian society, instead of presuming that imported ideas and values are the only ones worth cultivating in school. At present Fijian culture and values are not taught in school. It was the tribal duty of the elders to pass their skills and knowledge on to the young, and the elders no longer do this so the children are missing out on this part of their education.

Young people continue to flood into the towns in Fiji because they are looking for the jobs that they believe they are trained for. In reality the jobs are not there. In the author's opinion there is a living to be made in the rural areas, but the young do not possess either the inclination or the skills to respond. As a result the towns in Fiji are breeding places for all the usual social

problems. The next section deals with the changes in the education system in Fiji during the early 1980's. This period has been seen as a turbulent period for Fiji. It started off with some very controversial changes in the education system and culminated in two military coups.

2.4 Educational Reforms in the 80's

Educational reforms in Fiji in the early eighties were brought about by the newly elected Minister for Education, Dr Ahmed Ali. The reforms were controversial in that there were national demonstrations demanding a return to the pre-Ali state of affairs in the education system. Some of the changes were reasonable but it was the way they were implemented that infuriated the people.

2.4.1 The Fiji General Election of 1982

Political affiliations in Fiji have always been to one of two parties. One is either an Alliance Party supporter or a National Federation Party supporter. From time to time a neutral party of sorts emerges only to fade away because of lack of support. The Alliance Party which has been in office since independence from Great Britain in 1970 again won the 1982 General Election. Dr. Ahmed Ali, who stood for election for the first time, was elected to Parliament on an Alliance ticket and was appointed to the Cabinet as Minister for Education. In the previous Cabinet Mr Semesa Sikivou, an experienced educator as well as a politician since the 1950's, was Minister for Education. Compared to Mr Sikivou, Dr Ali is young and inexperienced and this showed through time and again in his dealings with members of the public. Dr Ali resigned his post as Director of the Institute of Social and Administrative Studies at the University of the South Pacific to take up the Cabinet post of Minister for Education in his first year in Parliament.

Dr Ali introduced many changes into the education system which were the cause of many public grievances. On reflection Dr Ali's handling of the education reforms

may have contributed a lot to the Alliance Party losing the general election of 1987 which triggered the military coup of May 1987.

The changes in the education system discussed here are not in chronological order. It is important to point out that they all occurred within three years of the 1982 General Election.

2.4.2 Reforms

Closure of Nasinu Training College (NTC)

A primary school teachers' training college since the early days, funded by government, Nasinu Training College (NTC) was closed, and then converted to a residential college and computer centre.

NTC provided three separate courses:

- (i) a one year, post-School Certificate (post Form Five) pre-service course for teachers of Classes 6,7 & 8
- (ii) a two year post Fiji Junior Certificate (post Form Four) pre-service course for teachers of Classes 1-8, with special emphasis on classes 1-5
- (iii) a third-year Craft teachers course for trained teachers who wish to become specialist handcraft or homecraft teachers in Classes 7 & 8.

Students attending Foundation courses at the University of the South Pacific were billeted at the Nasinu campus.

These primary school teacher training facilities were discontinued and the campus at Nasinu, some four miles out of Suva, was converted to a residential college, while part of the premises housed a computer centre for schools. The residential part of the campus continued to be used to accommodate foundation students of the University of the South Pacific (USP) on Fiji government scholarships. Foundation students are those fresh out of secondary schools and experiencing university life or post-secondary education for the first time.

Nasinu campus is some six or seven miles from the main campus of the University.

Considering Fiji's standards of communication and transportation this distance is long. Foundation students felt they were not part of the university community, as they were not able to participate fully in university activities due to the difficulties of transportation between campuses during off-peak hours. Access to university facilities like the library is limited. The University serves eleven nations of the South Pacific region, and the Foundation students from Fiji living at Nasinu feel themselves to be at a disadvantage compared to those who live at the university main campus which is located at Laucala Bay. Free transport between the two campuses was only available at certain times of the day, and not at all after six o'clock in the evening. This the students complained was very restrictive. The fact that they lived away from the main campus and came under additional regulations, some of which made them feel as if they were still at secondary school, gave the students a feeling of isolation and frustration.

Foundation students were not the only ones who objected to the arrangement; teachers were also unhappy with the closure of NTC. The teachers' Trade Unions felt that the closure of Nasinu was not in the best interests of education, as more teachers were needed. The Unions also felt, as a professional body involved in education, they should have been consulted about the closure of NTC. Lack of consultation seemed to be a hall mark of Dr Ali's administration as his term of office continued.

The closure of Nasinu Training College left the country with two primary school teacher training institutions at:

- (i) Lautoka Teacher's college - a government run college on the western side of Viti Levu, the principal island of Fiji
- (ii) Corpus Christi College run by the Roman Catholic Mission, providing a post-school certificate course for primary teachers.

Discontinuation of Diploma of Education Course at USP

The University of the South Pacific provided secondary school teachers' training for the countries of the South Pacific region with two courses before the 1980's;

- (i) a 3-year Diploma in Education for teachers of lower secondary forms 1-4
- (ii) a 4-year B.A. or B.Sc. degree course with a concurrent graduate Certificate in Education.

Students from Fiji attending the two teachers courses were mostly sponsored by government and automatically gained a teaching post on graduating as a fully qualified teacher.

The new government reforms:

- (i) stopped financing all teacher training at USP
- (ii) allowed those already in training to finish the course but did not guarantee them employment.

This was a bitter blow for intending teachers as government sponsorship was the only means of obtaining training. The decision effectively stopped the supply of newly trained teachers. Even worse off were those already in training, Diploma students and Graduate teacher trainees, knowing there was no job at the end of the course. Some of the students held a demonstration on graduation day and burnt their certificates while still in their graduation dress.

Introduction of Teachers' Volunteer Service

Since the only source of trained secondary school teachers, the USP, was being discontinued, the government had to look elsewhere for new teachers. The government introduced the Teachers' Volunteer Service as an entry point into the teaching service.

Volunteers are either trained teachers or graduates interested in taking up teaching as a career, and are to be paid much less than a new teacher recruited

during the pre-volunteer days. Volunteers work in schools for one or two years until such time that a teaching vacancy occurs, when their position is reviewed. Graduating teachers from the USP were offered volunteer posts.

The author observed at the time the lack of any guidelines on the duties of volunteer teachers. There is no guarantee that a volunteer will be taken on as a registered teacher on a realistic salary after a certain period of satisfactory service.

Reorganisation of Some Schools

Queen Victoria School (QVS)

Traditionally QVS is one of three secondary schools seen by ethnic Fijians as an embodiment of something Fijian. The other two schools are Ratu Kadavulevu School (RKS) and Adi Cakobau School (ACS). QVS and RKS are both boys' secondary schools and ACS is a girls' secondary school. All have boarding facilities. The three schools are actually government schools, which means they receive more in the way of grants from government than do committee schools, which are funded mainly by the committee and the community. The three schools are regarded by many as a few of the last strongholds of 'Fijian-ness', to coin a phrase. While village community set-ups and extended family units, two concepts considered vital by many ethnic Fijians, are slowly disintegrating, ethnic Fijians look to the three schools as a source of inspiration to promote their identity.

QVS is an institution created by the government, and seen by the Fijians as fostering the old tribal system. The school, with very old traditions, was built to educate the children of tribal chiefs only. As a sign of high regard for the school the name of the British sovereign, who ruled at the time Fiji was ceded to Great Britain, was bestowed on the school. In Fijian society each member is aware of his position in the hierarchical system and many traditional rituals are designed to remind members of their place, thus reinforcing the

importance of the structure. From the beginning QVS was intended for the education of the families of the chiefs only and for many years no commoner was admitted to the school. To be given a place in the school was indeed an honour amongst ethnic Fijians. This of course has changed in recent times and native Fijian commoners are admitted after careful testing. Competition for places at the school is strong. The old way of life was slowly being eroded and the Fijian Administration, a local government set-up to administer the affairs of rural Fijians, has been abolished by the government. The people looked, almost in desperation, on Queen Victoria School as something they could identify with. Many people in high public office and held in great esteem by the ethnic Fijians are products of QVS.

The new reform by the government has allowed non-ethnic Fijians to teach and study at the school. The majority of ethnic Fijians are traditionalists and they were infuriated by this move by the government. Teachers were shuffled about and a new non-ethnic Fijian Head Teacher was installed at Queen Victoria School. The people reacted very strongly to the changes with letters in the newspapers, and public meetings were held calling on the government to abandon the reforms.

Changes at other schools

Ratu Kadavulevu School (RKS) is another predominantly ethnic Fijian school bearing the name of a paramount Fijian chief, descendant of Cakobau who instigated the cession of Fiji to Great Britain. The word 'Ratu' is a title which is inherited. The school, RKS, was built on a site given freely by the owners for the education of ethnic Fijians. The school was initially used as a preparation school for entry into QVS and it was the ambition of every ethnic Fijian to attend RKS and then go on to QVS.

Integration was also introduced in RKS as a result of reforms by the government. This added to the anger of ethnic Fijians who felt another of their symbols of identity was being removed.

Some primary schools in the rural areas are, due to their locations and accessibility to rural ethnic Fijians, populated entirely by ethnic Fijians. Non-ethnic Fijians live mainly in urban areas where employment is available. The rural areas are mainly populated by ethnic Fijians who own approximately 80% of all land in Fiji. These rural primary schools, attended only by ethnic Fijians, have always had ethnic Fijian teachers. The government changes in the early eighties included the placing of non-ethnic teachers in these primary schools. The parents of children at the affected schools opposed the changes and some schools had problems operating due to the non-arrival of new teachers who feared for their safety.

2.4.3 Reactions to the Changes

The effect of the changes in general was total chaos and unrest. The changes were brought about so fast, without any consultation or discussion with interested parties, that the whole education system almost ground to a halt.

Opposition to Integration in Schools

Ethnic Fijians did not want non-ethnic teachers and pupils at Queen Victoria and Ratu Kadavulevu Schools, nor in rural primary schools with an all-ethnic Fijian pupil population. Because of their rejection by some school committees, and fear of violence, non-native teachers were reluctant to teach in these schools.

The author was present at one of the public meetings called to discuss integration in schools. The meeting was attended by prominent members of the ethnic community, educationists, trade unionists and politicians. The tone of the meeting was such that one could see the ethnic Fijians' fear that integration in schools was another step towards the total erasure of their identity.

Ethnic Fijians argued that:

- (i) integration in the two boarding schools, Queen Victoria School and Ratu Kadavulevu School, was a violation of Native Fijian inheritance
- (ii) many schools in the country are integrated and they wanted the option for their children to attend a non-integrated school to be available
- (iii) many non-integrated rural primary schools enjoy goodwill by the local population who are ethnic Fijians and who will not continue to contribute if the primary schools are integrated
- (iv) the use of Fijian as the language of instruction in some primary schools will create problems for non-ethnics who do not speak Fijian
- (v) integration will de-emphasise Fijian culture which is taught in non-integrated schools.

The author observes that the idea of integration in the schools is a good one but the people who would gain the most from it were not yet ready for it.

The Ministry of Education put forward two main points:

- (i) The level of examination achievement of ethnic Fijians will improve as a result of integration.

The view that ethnic Fijians are not as bright academically as non-ethnic Fijians is widely held in Fiji. The author believes that, because of this widely held view, most ethnic Fijian students tend to adopt an attitude of mediocrity towards their academic studies when they are part of an integrated group, where they feel they are second rate students. In an all ethnic Fijian group, students tend to work harder. More research is needed in the area of underachievement by ethnic Fijian students.

- (ii) The government was committed to the policy of multi-racialism and it was only proper that it practised what it preached. To educate the

country in what multi-racialism is, the government felt that it should be practised in schools as well as in public. Schools that were seen to be run on racial lines were instructed to take positive action towards integration.

A point worth noting is that schools were in no way pressurised by members of the public or teachers to integrate. There were no instances where a student was turned away because of ethnic origin. Non-ethnics were not in any way agitating for integration, and the confrontation on the integration issue was between the government and the ethnic Fijians.

The author remarks that the community was happy with the way things were. The development of multi-racialism and integration in schools and other areas of life are expanding at a rate which is acceptable to the people. Some schools were viewed by the community as belonging to a particular racial group, and some were viewed as integrated, and there was no attempt to interfere with this set up. The two major races were aware of the possible conflict in any compulsion for integration and were prepared to let events take their course without any interference.

Teachers' Protests

Teachers protested at being placed in schools that did not welcome them for two main reasons:

- (i) those who were placed in rural schools feared for their personal safety, because of the opposition to integration by the local population
- (ii) many teachers did not speak or have any knowledge of the ethnic Fijian language or culture and did not feel confident to take up positions in schools populated entirely by ethnic Fijians

Teachers protested at the withdrawal of government support for teacher trainees at the University of the South Pacific. Teachers saw this as discouraging new

recruits coming into the profession, making worse the situation in the already overcrowded classes.

Teachers totally rejected the Volunteer Service created by the government to accommodate newly qualified teachers and those hoping to take up teaching. They felt this was cheap labour and was belittling the teaching profession. The government statement said Volunteer Service was to be a new feature of the Civil Service and it was being tested with teachers as there was no immediate need for more teachers in the schools. The teachers and Unions denied the allegation that there were enough teachers.

Student teachers staged a hunger strike and graduating teachers held a bonfire ritual in which they burnt their teaching certificates in protest against the government decision to abolish automatic registration as a teacher after graduation. Teachers went on strike and schools closed for weeks in protest against the government's decision to run down teacher training.

The Protest March

Opposition to changes in the education system as described above were declared by different sectors of the public. Teachers, parents, students, Unions, and the public all had their own reasons for opposing some aspects of the changes in education.

They all agreed that schools could not function within the new framework introduced by the government.

The various sectors drew up petitions to present to government and realised they all had the same ideas in principle.

- (i) They wanted a return to pre-reform arrangements:
teachers to return to positions they held before the reforms,
trained teachers to be registered as fully trained teachers,
the Teacher Volunteer Service and government imposed integration in

schools to be abolished.

- (ii) Should the government want to bring about any changes they should be discussed fully with all the interested parties, i.e. teachers, parents and Unions.
- (iii) All demanded the removal of the new Minister for Education, Dr Ahmed Ali, who they all agreed was inexperienced in dealing with sensitive issues and was unapproachable.

Armed with their petitions the various organisations marched through the streets of Suva, the capital city on the island of Viti Levu, to present the petitions to Parliament. At the same time people demonstrated in Lautoka, the major centre on the western side of the island of Viti Levu and in Labasa the major centre on the island of Vanua Levu. The protest march in Suva will go down in history as the largest demonstration ever seen in Fiji. During the demonstration a hunger strike by student teachers took place, schools were closed due to teacher strikes and negotiations between teachers and the Ministry of Education were deadlocked.

2.4.4 Government's Responses to the Opposition

The government, in trying to respond to needs in education, brought in as the new Minister Dr Ahmed Ali, who was in his first term as a parliamentarian.

In his attempts to reform some educational aspects in Fiji the new Minister met with a lot of opposition from all sections of the community as described above.

Chaos and unrest continued as negotiations between teachers, government officials and politicians were deadlocked.

To try and break the deadlock in negotiations several changes in the Department of Education were made. These were:

- (i) the Permanent Secretary for Education, Mr Epeli Kacimawai, a seasoned

senior civil servant and diplomat, who was negotiating for the Minister of Education, was removed from office due to differences of opinion with the Minister.

- (ii) Mr Narsi Raniga, another senior and experienced civil servant, who, like Mr Kacimawai had also served abroad as government representative, was brought in as the new Permanent Secretary.
- (iii) Differences of views still prevailed with the new combination of Ali/Raniga and this time Dr Ali was replaced by Mr Filipe Bole, an ex civil-servant and diplomat turned politician.
- (iv) The Minister/Permanent Secretary combination of Bole/Raniga was no more permanent than the others and Raniga was replaced by Mr George Guivalu.

Mr Guivalu had served as Headmaster of Ratu Kadavulevu School and District Commissioner before his appointment as Permanent Secretary for Education. His experiences served him well in his negotiations to break the deadlock in the disputes between the government and the various groups.

It is interesting to note that the government in its attempt to settle the dispute did not succumb to any of the demands made by the various groups of protesters, except that dealing with the removal of Dr Ali as Minister for Education.

The timing of the removal of Dr Ali as Minister for Education was an attempt by government to disguise the fact that it was in response to public demands. The removal of Dr Ali took place at a late stage as if it was an after-thought. In retrospect the dispute between teachers, parents, Unions and ethnic Fijians on the one hand, and the education department on the other, was one of the major causes, if not the main cause, of the Alliance Party losing the General Election of 1987. The loss of the Alliance Party in the election, as mentioned earlier, led to the military coup and the declaration of the Republic of Fiji in the same

year.

2.4.5 Concluding remarks

This chapter has given the background to the development of education in Fiji. In justifying the discontinuation of teacher training in Fiji the Minister for Education referred to the introduction of computers in schools, as if to imply that computers will make up for the lack of teachers. It was during the early eighties that government funded the first computers in the schools in Fiji. This introduction of computers in schools in Fiji, and the problems associated with it, are discussed in the next chapter.

CHAPTER 3

3 COMPUTERS IN EDUCATION IN FIJI

The development of computing in education in Fiji is still in its infancy and as such it is difficult to identify areas where computer applications are most useful. The review in this chapter will discuss the development of computers in Fiji education along two routes: development in the schools and development at USP. The reason for this two-pronged approach is that the Fiji government administers the schools but the University of the South Pacific (USP) is the responsibility of the governments of several countries in the South Pacific region including Fiji.

3.1 COMPUTING AT THE UNIVERSITY OF THE SOUTH PACIFIC

3.1.1 The University of the South Pacific(USP):A Historical Background

The University of the South Pacific was established on the recommendation of the Morris Report in 1966 [2], the machinery for which was set up by the governments of the United Kingdom and New Zealand with the co-operation of the government of Australia. The Alexander Report [3] further recommended the implementation of the recommendations. As a result of these two reports the University of the South Pacific was established at Laucala Bay, an old wartime site of a New Zealand Air Force flying base, near Suva. Legislation [4] was enacted in June 1967 and an interim council set up. The initial planning period was consolidated by the granting of a Royal Charter and Statutes formally establishing the University of the South Pacific on February 10, 1970.

The University was established in accordance with the wishes, and to serve, the Governments of:

The Solomon Islands (formerly the British Solomon Islands)

The Cook Islands

Fiji

Kiribati (formerly known with Tuvalu as The Gilbert and Ellice Islands)

Tuvalu

Vanuatu (formerly The British Resident Commissioner of New Hebrides)

Tokelau (formerly The Tokelau Islands)

The Kingdom of Tonga

The Independent State of Western Samoa.

The University of the South Pacific is based at Laucala Bay, where the School of Humanities, School of Social and Economic Development and the School of Pure and Applied Science are located. The School of Agriculture is located at Apia in the Independent State of Western Samoa. Due to the geography of the region great emphasis is put on distance learning and each member nation of the University hosts an Extension Centre to coordinate University affairs in the host nation.

3.1.2 The Beginnings of Computing at USP

The starting point in time for any significant use of computers in the classroom at USP was 1980 when credit must be given to Dr. Donald Joyce, then Reader and Head of Mathematics at USP, who instigated the purchase of one unit of an Apple II microcomputer for use in the maths department.

Dr John Lovell, a Fullbright Fellow at the University Extension Services, brought with him in 1980 from the United States an Apple microcomputer. As a result the extension services purchased eleven units of Apple II microcomputers and the mathematics department purchased one unit. The extension services were to place one Apple II microcomputer in each of the USP regional centres in the islands.

The mathematics department started their usage of computers in the classroom with the one Apple II unit.

The First Course Using Computers at USP

The first use of computers in the classroom at USP was as a subject of study. It was a non-credit course in computer awareness held during the two week semester break in 1980. It was offered to the public and no entry qualification or previous knowledge was required. Because of the overwhelming public response to this first awareness course further courses were organised.

Topics taught at this first course included very basic concepts of computer hardware and software. The students were interested to know how one can display, erase and manipulate displays on the screen. Basic programming was taught and students were impressed by the fact that they were able to display texts and numerical results of calculation. The course highlighted the lack of technological experience in the background of the students. This is still a consideration in Fiji even today. To make significant headway in technological innovation the lack of technological background must be remedied first.

Further Courses Using Computers at USP

Due to the encouraging response to the first course, which was held during the day, it was decided to hold further courses in the evenings. This change of timing had a number of advantages:

- (i) It enabled those in employment to attend without taking time off work and losing pay.
- (ii) Facilities, classrooms and hardware were available in the evenings.
- (iii) Tutors to run courses were also readily available in the evenings.

The courses were run by the author but it was very difficult to get help for mounting non-credit courses. This difficulty arose because evening non-credit courses did not count towards normal workload. Consequently the course was relegated in importance and survived only through the goodwill of the author.

Evening Computing Classes At USP

Attendants

The numbers for the evening courses had to be limited to ninety and two courses were run concurrently. They were attended mainly by people who were interested to find out what computing was all about. Attendants ranged from high school students, to retired people, business people, teachers, doctors and the unemployed. There was no formal pre-requisite for the courses.

Course duration

The courses lasted for 10 weeks with a one and a half hour lecture per week.

Topics covered

Topics covered in the evening courses were very elementary, catering mostly for people who had never seen a computer before. There were no pre-written packages that could be shown and the programs demonstrated were very simple ones with very few lines.

Students attended the courses because of their curiosity rather than to improve their job opportunities. Job opportunities in computers were scarce in Fiji in those days and in the author's view are still limited today.

The following topics were covered:

- (i) Identification and functions of various components of a simple microcomputer system, both tape and disk based.
- (ii) Connecting up and switching on of system.
- (iii) Simple trouble shooting without opening any of the units.
- (iv) Introduction to Basic programming.

Practical Sessions

Hands-on experience was an important component for the course. Due to limited hardware facilities, practical sessions were difficult to carry out satisfactorily. A booking system enabled each student to have one hour per week

on the keyboard.

Hardware

The evening courses were so popular that the maths department was able to purchase six Commodore Pet microcomputers and tape recorders with money raised from the course fees. These were increased to nine with two disk drives and a printer twelve months later.

This departure from Apples in hardware choice was due to the non-availability locally of Apple microcomputers at the time. The choice of Commodore Pets was ill-conceived since there were other, cheaper and, in the author's view, better microcomputers available locally by that time. The department realized this mistake time and again in later years, both in financial terms and in hardware suitability.

Further Development of Computer Usage at USP

Up to the end of the 1985 academic year USP was using Commodore Pet microcomputers for teaching awareness and for programming. The awareness course was still being offered in the evenings as a non credit course.

3.1.3 Courses offering computing at USP in 1985

Foundation Mathematics

Foundation mathematics offered an introduction to programming in Basic during the second semester of the two semester foundation mathematics programme.

First Year Degree Courses

ED 111 , Calculus, Linear Algebra and Computing and ED 113 , Basic Mathematics
A first year degree mathematics course ED111 includes an Introductory Computer Programming component to complement Calculus and Linear Algebra. Introductory computer programming is also offered with ED 113: Basic Mathematics-another first year mathematics course. The first of the two above courses ED 111 is

intended for students who wish to study mathematics as a major subject. The second course, ED 113, is intended to service those disciplines in the social sciences and education where a working knowledge of basic mathematics is required. They can not both be credited for the same degree award.

Second Year Mathematics Course: ED 214 , Data Processing

ED 214 is a second year degree course requiring ED 111 or ED 113 or equivalent computing experience as a pre-requisite. The course aims to develop an understanding of the concepts and impact of computer systems and to develop skills in the techniques of data processing as relevant to the South Pacific.

By 1985 the USP had also acquired an ICL mainframe computer which had been in use at the Native Land Trust Board, a statutory body administering Native Fijians' lands, who were upgrading their system. ICL had offered the outdated machine to USP as a gift. The machine was being used for administrative purposes and for students taking ED 214.

IBM Network Installation

In 1985, with finance provided by foreign aid, an extensive IBM network was installed. The author's departure in early 1986 and the political situation created by the military coup of 1987 have not made it possible for him to give here a detailed account of the new system at USP.

The 1988 course offerings of the mathematics department at USP include:

- MA 111 Calculus, Linear Algebra and Computing
- MA 151 Introduction to Computing
- MA 251 Data Processing
- MA 351 Computer Science.

Further the USP Technology department offerings include:

- Computer Aided Technology.

Computers and Teaching Mathematics at USP

It can be said that no mathematics teaching using the microcomputer actually took place at USP up to the end of 1985, except for the odd student doing computing projects in numerical analysis.

The author in 1984 carried out a trial project using microcomputers to teach mathematics to a group of foundation students (see Appendix A).

3.1.4 Trial Project on Teaching Mathematics Using Micros At USP

A description of the project appears in Appendix A. The project investigated the use of microcomputers in the teaching of mathematics. It was a first attempt at USP in using the new technology to teach mathematics and the initial objective was not clearly defined at first. It was more or less a case of, let's find out what obstacles there are, and if some popular beliefs about the new technology are true. The project was initiated and carried out by the author without any support from the department. The author wants to make it clear that this was not due to any misgivings in the department about the usefulness of the exercise, but because the lack of resources and time within the department made it impossible for any constructive support to be given. Hence the project experienced many problems.

Problems encountered with trial project

Numerous problems were encountered when carrying out the trial project on using microcomputers in teaching mathematics. In general problems are to be expected when applying new innovations in a country like Fiji and a lot has been learned from the exercise. Three areas that the author feels are important are given here.

1 Availability of Suitable Hardware

At the time the project was mounted the only available hardware in the department was the Commodore Pet microcomputer. This was unfortunate as a

major area the project wanted to look at was graphics and the Pet did not have suitable graphics capabilities. However, the Atari 800XL was available in Fiji at the time and the Atari dealer in Suva lent the project two units of Atari 800XL and one unit was purchased for the project. The Atari 800XL presented a far superior alternative to the Commodore Pet microcomputer.

2 Availability of Suitable Software

Software suitable for the project was not available for the Atari 800XL which at the time was regarded as a games machine. Consequently, the author wrote the programs for the project. Two programs were produced:

- (i) Program 'POLY' which investigated polynomials and
- (ii) Program 'RATIONALS' which investigated rational functions.

3 Administering the project

The problem of administration included:

- (i) where to hold computer sessions ?

For any new innovation there is always the problem of where to accommodate it physically. In this instance, the question of where to use the microcomputer and where to store the hardware when not in use created problems.

In addition to the scarcity of space there is the added problem of security. Fiji at that time was, and still is, undergoing a lot of social changes resulting in unsociable behaviour giving rise to security risks both to persons and properties.

- (ii) how to timetable computer sessions ?

This in a way depends on the type of program and the students. If students are not familiar with computers they need to spend time on hardware familiarisation exercises before any meaningful work

can be attempted. Some programs are intended to be free standing, when no previous lessons in the topic being studied are necessary while some programs are for reinforcing materials previously studied. The cooperation of other members of staff is essential. Some students like to use the computer during class time and others want to use it after normal class hours. This creates the problem of supervision and locking up.

(iii) is the computer to be used by the teacher only ?

This depends partly on the type of computer program and also on the level of computer experience of students.

Demonstration programs will not hold the students' interests for long. Once demonstrated by the teacher the programs tend to drift into obscurity and be forgotten.

When using interactive programs students will want to respond to the programs in their own time without, what the student thinks as, the critical and sometimes patronising comments of teachers. Students will want to input data that they think the teacher avoided.

The age of students also has to be considered. Are they mature enough to be left completely alone with the machine or do they need some degree of supervision ?

Solutions to some of the problems depend on the type of program, while some of the problems may be solved only by trial and observation. As students get more familiar with the computer, problems will be different. Discussion and exchange of ideas between users of computers in education should help solve most of the problems.

Computer Facilities Investigated by Trial Project

The project was in a way a demonstration of the facilities available on the computer. It tried to show the students some mathematical concepts with the help of computers. In addition to enhancing some mathematical concepts the project also tried to demonstrate some facilities available with the computer.

Facilities demonstrated include:

(i) Graphics

The use of graphics to enhance mathematical ideas is generally accepted. The project investigated if graphics provided by the computer are acceptable and clear enough to be of benefit to students. Graphics can be too sophisticated and complex, blurring the mathematical concepts being demonstrated. Clarity of display of computer graphics depends on hardware and software. The build-up of computer graphics on the screen can be slowed down for observation and this is useful for reinforcing ideas and sustaining attention.

(ii) Interactivity

How much interaction is possible between student/teacher and machine ?
How is this interaction beneficial to the understanding of mathematical concepts ?

The immediacy of responses to inputs, and the speed of display of data and diagrams are great motivators for students. They encourage students to be more adventurous in their inputs.

(iii) Speed of Calculation

There are some situations where speed of calculation is useful and other situations where fast calculation is not necessary and in fact the calculation needs to be slowed down. For example, in numerical integration the calculation of the integral in the interval (a,b) with n sub-intervals needs to be slowed down with n small. Once the method

is clear, then n can be made very large and the integral calculated quickly to show how the integral approaches a limit.

The speed of the microcomputer, the interactive facility and the accuracy provide a motivating environment for the learner.

Summary of Project Findings

The project confirmed most of what is already generally accepted about computers and learning mathematics in developed countries. However, the important thing that it achieved is that students were able to experience learning mathematics using the computer, which was a totally new experience for them. The topics investigated took on a new meaning by the fact that they could dictate and accurately predict the graphic output on the screen.

The students all agreed that:

- (i) Clear and accurate graphics provided by the microcomputer helped in the understanding of mathematical concepts.
- (ii) Not all mathematical topics are suitable for microcomputer applications.
- (iii) The speed, accuracy and the ease of use of the microcomputer coupled with the clarity of graphics representation encouraged students to go that little bit further and sometimes outside the scope of the current topic.

Time was made available for a lot of mathematical discussion when the tedious task of displaying the graphics was readily achieved with the computer.

- (iv) The choice of hardware was very important because of the need for hardware friendliness and graphics abilities.
- (v) Programs need to be short and lend themselves to alteration by the user. Interactive programs were definitely very useful in many ways,

but could be very confusing to novices who did not know what input was expected.

To enable the user to alter programs the author would recommend later an *interpreted language*.

3.1.5 Other Computing Facilities At USP

Other early computer uses at USP were by the Extension Services who purchased Apples and more recently Commodore 64's.

The Extension Services of the USP administer all courses offered through correspondence and those offered after hours. This effectively took the responsibility of computer evening courses away from the mathematics department. The Extension Services operate from the USP centres located in all the member nations of the USP with the headquarters located in Suva at the main USP campus on Laucala Bay. The Fiji centre of the Extension Services took over the teaching of computer evening courses, but did not have the staff. The author, though working in the mathematics department, was instrumental in setting up the evening courses for the Extension Services.

The initial purchase of some Apple II's and computer hardware in the Extension Services of the USP was boosted by the purchase of a further six Commodore 64's. By the end of 1985 the Extension Services of the USP had one Apple II each at the USP Extension Services centres in the islands and six Commodore 64's at the Fiji centre.

The Extension Services encountered many problems during the early days of computing and most of the problems have been solved through enthusiasm and determination of the Extension Services staff. A major concern at the time was the lack of trained personnel who could take responsibility and oversee its proper use. This concern was justified some months later when a tour of the USP centres around the Pacific region revealed that a number of microcomputers were

unserviceable.

It was realised at the time that a contributing factor was the lack of use resulting in the lack of basic maintenance of the microcomputers. This state of affairs has since been rectified by USP engaging a qualified technical manager and the training of personnel at each extension centre.

The lack of a core group of people expert in certain aspects of computing has been a stumbling block in the development of all applications of computers in the country.

Current Hardware At USP

By the end of 1985 USP had available for teaching purposes:

- (i) an extensive network of IBM PC's
- (ii) eight Commodore Pets
- (iii) four Atari 800XL
- (iv) twelve Apple II
- (v) five Commodore 64's

3.2 COMPUTING IN EDUCATION IN FIJI OUTSIDE THE USP

The introduction of computers in the schools in Fiji came at a time when education was going through some very controversial reforms. Because of the way it was implemented, the author saw it as an attempt at the time to distract public attention from the real issues that were facing Fiji education. Due to the mishandling of the introduction of computers it was fraught with problems which could have been avoided.

Innovations such as computers can only be implemented by government and funded by government. Teachers and schools in Fiji do not have the facility or resources to initiate developments like using computers in the classroom. Teachers in Fiji are good at carrying out instructions to the letter and the

lack of detailed instructions on what to do with computers caused many problems.

3.2.1 Introduction

The arrival of the first microcomputers in Fiji in the early eighties was preceded by the introduction of video systems in the country. Fiji has no television broadcasting service and the video system took the country by storm. The market was flooded with cheap Japanese video systems and libraries of legitimate original and illegal pirated tapes sprang up. By the time the first Sinclair and Atari followed by Commodore, Apple, Microstar and Amstrad microcomputers arrived in the shops a proportion of the population was already familiar with the television screen and the video recorder. This experience with the video system before the arrival of the microcomputer is important from the point of view of introducing microcomputers to a non technical audience like the Fiji public. Any technical experience and knowledge picked up during the use of a video system can only be beneficial during the early stages of computer experiences. The lack of technological background on the part of students creates severe learning problems when the students have to deal with high technology in later years.

School Visits

During the computer evening classes held at USP some school teachers attended and showed an interest in the use of computers in the class room for teaching. The author arranged to visit the teachers at their schools and talk to other teachers and students about computers.

These visits were made during the 1983 academic year and activities carried during the visits included:

- (i) showing students and teachers a microcomputer system
- (ii) demonstrating a short basic program involving graphics
- (iii) talking to the group about computers and the uses of computers.

These visits were unofficial in the sense that they were not initiated by the Ministry of Education and they took no more than one and a half hours.

They highlighted the lack of a basic knowledge of computers that existed amongst the school population at the time.

Those schools visited, eleven in all, were the only schools which had seen a microcomputer before the official announcement by the Ministry of Education, in late 1983, that microcomputers were to be placed in schools.

3.2.2 Official Government Initiative

The announcement to place computers in some secondary schools was made by the Minister of Education during the last session of Parliament in 1983. It is noteworthy that the announcement was made during a period of upheaval in the education system in Fiji. This was one of the innovations introduced by the government to try and soothe the unrest caused by other reforms being introduced at the time.

The Minister of Education used the introduction of computing in schools to justify several cutbacks in other areas of education notably:

- (i) the closure of a teachers' training college, which would provide premises for a computer centre and accommodation for foundation students at USP
- (ii) the removal of financial support for teacher training. Computers now could help to fill the gap created by the shortage of teachers
- (iii) the introduction of the Teacher Volunteer Scheme which would provide volunteer teachers. Those teachers to be complemented by microcomputers in the classroom.

The announcement in Parliament indicated that a few selected secondary schools would be issued with four units of microcomputers in the following school year

(1984) to start with. The government undertook to equip all secondary schools with microcomputers at a future date. This was again seen as an attempt to gain political mileage for the ruling party. The early eighties were a turbulent period in the political affairs in Fiji.

Microcomputer Introductory Courses for Teachers

The first awareness course organised by the Ministry of Education was mounted in January 1984. Any programme organised by a government agency is given the label 'official' and this is regarded as the sole requirement for authenticity.

The course was run at the now defunct Nasinu Teachers' College campus, part of which is now known as the Nasinu Residential College Computer Centre (NRCCC). The course lasted two weeks and was attended by teachers from schools which were selected to receive the first batch of four microcomputers supplied by the Ministry of Education. This became the first of a biannual programme of awareness courses for teachers run by the Ministry of Education.

Selection of Hardware for Schools

The government announcement in Parliament to place computers in schools was the first indication of the government's intentions. It was immediately followed by the announcement of the choice of hardware.

The selection of hardware for schools was made solely by the Minister of Education with no consultation with interested parties. Even though there was by this time more than one supplier of microcomputers operating in Suva, the capital city of Fiji, the supply of hardware was not put out to tender. This unethical procedure of spending public money infuriated members of the Fiji Computer Society when at the inaugural meeting of the Society the Minister of Education urged the private sector to support computer education in Fiji.

The choice of the Commodore 64 microcomputer for use in Fiji schools by the Minister of Education was puzzling to say the least in view of the availability

of other microcomputers in Fiji.

Commodore 64 Microcomputers versus Others

The others in this instance are those microcomputers which were available in the shops in Fiji at the time the choice of hardware for Fiji schools was made.

These others included the Atari 800XL and the Apple II which presented a better alternative to the Commodore 64 in several ways.

A comparison of the Commodore 64 and the Atari 800XL is given here.

(i) Cost

The Atari 800XL was selling cheaper in Fiji at the time than the Commodore 64. This is an important consideration in developing countries like Fiji.

(ii) Graphics Facilities

The use of graphics is a major attraction with computers in education. To create graphics on the Atari 800XL is a much easier operation than on the Commodore 64. Whereas the Atari 800XL provides graphics command in Basic the Commodore 64 requires some Pokes and Peeks commands which *require a knowledge of the more complex machine language variety.* On entering the correct combination of Peeks and Pokes the Commodore 64 blanks out for some time before it reappears in graphics mode, and this thoroughly confuses the novice. The Atari 800 XL instantly changes mode when the correct Basic command is entered.

(iii) Screen Resolution

The Atari 800XL has a higher screen resolution than the Commodore 64. High resolution allows better diagram definition.

(iv) Text Manipulation

Text manipulation on the Commodore 64 is easier to achieve than on the Atari 800XL which requires all non-numeric variables to be dimensioned.

The representation of large texts, two other sizes beside the normal size, is easily achieved on the Atari 800XL.

(v) **Software Availability**

A point raised in support of the Commodore 64 at the time was the availability of software. It was considered that the Commodore 64 had more software available than the Atari 800XL which was pointed out to be a games machine.

This may be so, but the ease of operation of the Atari 800XL and the adequacy of very simple programs at the time would still favour the Atari 800XL.

The operations explained in the comparisons above are all discussed with reference to Atari Basic and Commodore Basic. It is assumed that they are all possible in machine language, which school users in Fiji are not expected to wrestle with at this stage.

Graphics First

The comparisons between the Atari 800XL and Commodore 64 are centered around the graphics facilities of the microcomputers. It is important that the first experience of students with microcomputers should expose the students to the kind of graphics, colour and sound possible with the hardware. This will help infuse enthusiasm as shown by the popularity of computer games. Most courses on programming begin with topics other than graphics. This is probably due to the difficulty of switching the computer system to graphics mode but with appropriate hardware, graphics can be demonstrated with little programming skill. This is demonstrated in Appendix B.

The graphics advantage of the Atari 800XL over the Commodore 64 make the Atari 800XL the ideal choice for schools in Fiji.

3.2.3 Responses To Introduction of Microcomputers in Schools

After a two week awareness course for teachers held in January/February of 1984, selected secondary schools were given four Commodore 64 microcomputers each by the Ministry of Education.

Reactions to the introduction of computers came from both teachers and pupils, and were mixed. Some disappointment was evidenced but on the whole computers had an encouraging start.

The reactions were reflected in the:

- (i) teachers' comments at the First Computers in the Classroom Conference/Workshop(CCCW) at the end of the 1984 school year (see Appendix C).
- (ii) Students responses were reflected in a survey carried out at the end of the 1984 academic year (see Appendix D).

Teachers' Comments On Micros In Schools

During the 1984 school year, the first year of computers in Fiji schools, the author was inundated with enquiries on computers from school teachers. The author arranged the conference/workshop at the University of the South Pacific (see Appendix C) to identify and find solutions to problems experienced with computers in schools.

Two aspects of the conference of 1984 gave it significance.

- (i) It was the first conference of this nature to be held in the country
- (ii) It was held one academic year after the first microcomputers appeared in the classroom in Fiji.

Secondary school headmasters were invited to send representatives to the conference and the response was overwhelming.

Several factors indicated the enthusiasm that existed amongst teachers at the time. Some of these factors are:

- (i) A limit had to be put on the numbers and some teachers had to be turned away.
- (ii) The conference fee of ten Fijian dollars (then worth 6 pounds sterling) did not deter anyone from attending. This was not a small sum to pay but there was no application to waive the fee.
- (iii) The conference was held during the long Christmas school holidays when most teachers in Fiji travel long distances to get to their homes for the Christmas festivities. A large number of teachers were prepared to give up three days of their holidays to attend the conference without any compensation.

Comments

Teachers' comments at the conference, and discussions that followed, referred to the following areas of computing in schools in Fiji:

- (i) The teachers agreed there was a lot to be gained from the use of computers in the classroom and commended the Ministry of Education for the innovation. This was surprising considering the lack of computer expertise amongst teachers.
- (ii) There was a desperate need for teacher training in computing. Most teachers in schools did not have the basic skills to operate the machine. There was a fear of students and staff losing interest if this was not rectified.
- (iii) There were no physical amenities provided in schools to accommodate microcomputers. These were sited in libraries, staff rooms etc, which locations were found unsuitable for various reasons.
- (iv) The role of microcomputers were not properly defined by the Ministry of Education. This lack of Ministerial policy on the role of microcomputers in the classroom coupled with the lack of skills of teachers made life very difficult for the first twelve months of

microcomputers in the classroom in Fiji.

Students' Responses To Micros In Schools

The responses are deduced from a questionnaire administered to three secondary schools at the end of the academic year in 1984. The numbers given in the responses in the questionnaire (see Appendix D) are percentages.

Factors Influencing Students' Responses

The following points need to be borne in mind when analysing the responses to the questionnaire:

- (i) A large majority of students first used microcomputers in 1984 (see Appendix D, QUESTION 1). This means their first exposure to computers was in the classroom as none of them owned a microcomputer (see Appendix D, QUESTION 6). This factor would undoubtedly have influenced their attitude towards computers.
They would not have seen or experienced microcomputers in situations other than in the classroom.
- (ii) A large majority (see Appendix D, QUESTION 2) had only used the Commodore 64 microcomputer. Consequently the responses in the questionnaire must be seen as referring mainly to the Commodore 64 microcomputer.
- (iii) The lack of skills on the part of teachers, resulting in a lack of use of microcomputers (see Appendix D, QUESTIONS 16, 17, 18 & 19), means that students would not have been exposed to a comprehensive display of the facilities available on microcomputers.
- (iv) Most teachers involved with microcomputers were either mathematics teachers or science teachers (see Appendix D, QUESTION 21). Students therefore would not have seen the use of microcomputers in subjects other than maths and science.

Students' Responses To Questionnaire

Bearing in mind points (i) to (iv) above, the following responses to the questionnaire showed an acceptance of computers by students.

(i) Usefulness of computers

Students found microcomputers most useful in mathematics (see Appendix D, QUESTIONS 4 & 15). This is a reflection of (iv) above. It could also be due to the misconception that computers are only for solving mathematical problems. This is a misguided view generally held by those new to the technology.

Educational software imported or locally written in Fiji at the time was mostly mathematical with very little, if any, on other subjects.

(ii) Students' Enthusiasm

Students' enthusiasm for the new technology is revealed in the response to QUESTION 7 in Appendix D. Several factors may have contributed to this enthusiasm:

(a) The novelty of the technology and restricted access to hardware.

88% of students are first time users (see Appendix D, QUESTION 1) and none owned a microcomputer (see Appendix D, QUESTION 6).

(b) Students' recognition of the power of microcomputers in education. Over 90% of students thought that computer learning is useful (see Appendix D, QUESTION 8).

75% of students preferred microcomputers to charts, slides, films and models as teaching aids (see Appendix D, QUESTION 11).

(c) Inadequate time for hands-on experience. The majority of students were timetabled one hour or less per week on computers (see Appendix D, QUESTION 5).

(iii) Microcomputer Facilities

The ACCURACY and SPEED of the microcomputer are rated very highly by students (see Appendix D, QUESTION 9). Arranged in order of usefulness the five facilities in QUESTION 9 read:

ACCURACY, SPEED, COLOUR, GRAPHICS, SOUND

Some students thought SOUND and COLOUR had no use at all. This may be due to the kind of programs that were available to students.

For the most basic mathematics tutorial programs SOUND and COLOUR are not essential for the program to work satisfactorily.

The ACCURACY and SPEED of calculation of microcomputers were emphasised when using microcomputers for exercising basic mathematical skills. Some students who experienced computer ANIMATION found it useful (see Appendix D, QUESTION 10).

The SCREEN as a display facility is rated as good as the blackboard (see Appendix D, QUESTION 12). Use of more sophisticated programs with controlled animation may tip the balance in favour of the screen.

(iv) The Microcomputer and Mathematics Learning

Given the fact that a large majority of students, 97%, (see Appendix E, QUESTION 16) study mathematics and 87% (see Appendix D, QUESTION 17) preferred mathematics, the benefit of using microcomputers in teaching mathematics was confirmed by their responses to QUESTION 22/APPENDIX D.

This is particularly noteworthy considering the poor quality of programs that were available in Fiji at the time.

(v) Computer versus Teacher

Students agreed that computers can not replace teachers (see Appendix E, QUESTION 14).

Students recognized the importance of having the teacher available

when working on computers.

This is in opposition to the Minister of Education's implication, when justifying cuts in education expenditure, that computers will make up for the lack of teachers.

The need for the teacher's inputs during computer sessions may only be temporary due to:

- (a) the type of programs being used may have required frequent inputs which students wanted to check with the teacher before entering data
- (b) students may not have been confident on how to operate the computer thus requiring a lot of assistance from the teacher
- (c) students may not have had enough background on the subject matter and required verbal reinforcement from the teacher.

Whatever the reason or reasons for this need of teacher input, the response confirmed the philosophy that computer programs need to be demonstrated and the subject matter be taught before students are allowed to use computer programs. Computer programs should be used to 'enhance' (ref. Bajpai and Carruthers [1]) the understanding of concepts being taught and not as a free standing method of instruction. Free standing here means programs that do not need any teacher contribution whatsoever, before the program is run or after the program is run. The program introduces the topic and provides all the teaching.

In describing a Computer Enhanced Learning Unit Bajpai and Carruthers[1] said:

For example, a group of first year Mathematical Engineers were given a computer based tutorial on Numerical Integration, having previously been taught the subject in a conventional lecture. The

tutorial was meant to 'enhance' the student's knowledge - to take the hard facts and information already taught and turn it into an intuitive feeling

Free standing programs will need very complex programming systems. Improvements in programs can also be better achieved if teachers are present during the use of programs by learners. Teachers can then see and observe how the interaction between learner and program can be improved.

(vi) Interactive Programs

Students' responses to QUESTION 21/Appendix D confirmed the power of interactive programs.

The interactive facility makes the microcomputer one of the very powerful teaching aids of today. Interactive systems provide motivation and encourage a sense of adventure to delve further than the current level of the topic (see Appendix A).

(vii) Group Work on Computers

Students at this stage preferred to work alone or in twos on microcomputers (see Appendix D, QUESTION 13). This is in contrast to the conclusion of a Trial project on Teaching Mathematics Using Microcomputers at the University of the South Pacific(USP) (see Appendix A) which recommended group work. This opposing attitude to working in groups is due to:

(a) the number in the group at USP, no more than ten at any one time, was much less than the numbers in the groups in the schools.

This tends to make the student in the school group feel left out especially when he/she does not get a chance to make an active contribution. This feeling of passive participation on the part of students in the schools will lead to boredom and, if not

checked in time, cause disruptive behaviour.

At the disruptive behaviour stage the inexperienced teacher will be unlikely to diagnose the problem and lay the blame for the disruptive behaviour on some short term symptoms.

- (b) Students who are not fully conversant with the basic operation of microcomputers, and there are many of them in schools at this stage, are not keen to advertise their ignorance by making mistakes in front of their peers.

Students involved in the Trial Project at USP (see Appendix A) had more basic knowledge of microcomputer operations than those in secondary schools and had no hesitation when it came to operating the machines while their peers looked on.

The students in the schools will prefer to work alone until such time that they are more confident with computers.

- (c) There is also a strong sense of communal feeling among students at USP, especially those in the Foundation Year.

These students have left secondary schools together, from different island nations, to come to USP.

In their Foundation Year they tend to identify themselves with their particular island group and this forms a basis for group work in which they feel secure. This communal sense of belonging manifests itself in many ways and could be used to great advantage. The communal feeling is seen to wear off as students progress through university.

(viii) General Comments

There was a general acceptance of computers amongst the students, so much so that they agreed microcomputers should have a place in

the school (see Appendix D, QUESTIONS 19&24). They even go as far as to say that the government should spend more money on microcomputers (see Appendix D, QUESTION 23).

Summary of Reactions To Micros In Schools

A summary of the reactions is given here in the way of recommendations.

On the whole schools have given the green light to microcomputers in spite of problems which could be minimised by implementing the following:

- (i) The Ministry of Education should liaise with other interested parties to expand on the foundation already laid before teachers' enthusiasm and interest in computers wears off.
- (ii) The Ministry of Education should put forward its intention for the role of microcomputers in schools. On this basis the question of hardware should be re-examined and software policy formulated.
- (iii) A scheme for in-service training for teachers should be set up.
- (iv) An information service is required for updating hardware, software and other information relevant to computers in the classroom.

The committee proposed by the conference in Appendix C could include the above suggestions in its functions.

3.3 The Fiji Experience

Innovations in education need the support and goodwill of the community and the public at large because the benefits of a good education system are not as immediately felt as those from the products of manufacturing industries. The public need to be far sighted to appreciate the need for education and give willingly the time and resources to new innovations in education. Conditions prevailing in developing countries like Fiji make it essential that public support is available for the successful applications of new developments in

education.

The Fiji experience in computerisation in education and the background as described in the previous chapters highlighted some areas that need careful planning. Those emerge as a result of conditions prevalent there.

Some of the features of developing countries are now discussed, with reference to the Fiji experience in computerisation in education.

3.3.1 Developing Countries: Features

Economy

The state of the economy which is a consequence of resources, expertise etc. will determine the purchasing power and the quality of hardware, software and expertise available.

Several questions on technological applications like computerisation need to be considered when dealing with countries like Fiji with an economy well below that of an industrialised developed country.

(a) The question of 'old hardware' versus the latest technology arises.

Eight bit machines like the Commodore 64 microcomputer and the Atari 800XL microcomputer are matched against more sophisticated machinery like the IBM, BBC Master Series and Acorn microcomputers, all much more powerful and more expensive than the Commodore 64 and the Atari 800XL. Some schools in Britain now possess advanced microcomputers and the old eight bit BBC microcomputer retired or relegated to some secondary tasks.

Does Fiji need to upgrade hardware choice to more sophisticated and costly products ?

This is a question that Fiji should seriously consider, especially when industry and commerce are utilising the latest in technology.

The manufacturers and dealers do put up a good argument for upgrading

equipment. In developing nations like Fiji, where there is a lack of knowledge about new technology, there is a tendency to acquire equipment with a sophistication well in excess of requirements. At the same time there is a danger that developing nations could become dumping grounds for outmoded, outdated and, sometimes, technology with questionable values to improve the standard of living. Fiji has experienced these with agricultural technology in the importation of pesticides that are banned in other developed countries. Carlos J. Lucina and Luiz C. Martins [5], raise the same problem:

'Computer technology has become an integral part of the economy of some developing countries. It is extremely important to those countries not to be only a marketplace for this new technology in which it is used for just a sparse set of applications (sometimes with questionable results).'

The initial decision to introduce computers into Fiji schools did raise some comments on priorities. It was pointed out at the time that some Fiji schools were in desperate need of the basics of education like books and desks.

In the author's view, 'old' technology, eight bit and non-expensive microcomputers have enough facilities to enhance mathematics learning. To teach computer studies the use of a sophisticated machine as used in industry is beneficial.

To upgrade educational hardware or not is a question that can be satisfactorily addressed by identifying the role of computers in education. Strictly speaking, before the purchase of initial hardware, a definition of the role of computers should be spelled out. This was not the case in Fiji when the first computers were purchased.

Without purchasing hardware, computers can benefit education through an evaluation of what role computers can play in education. The evaluation exercise presents an opportunity for those in education to review their profession.

- (b) Can Fiji afford to produce educational software packages from scratch, or should it purchase software written overseas ? Bajpai et al [6] highlight the scarcity of good educational software especially in mathematics teaching. A reason for this is cost. Bajpai [7] pages 423-424, says,

' Government, industry and other funding bodies have still not awakened to the importance of investing large sums of money for the production of suitable, good and well-tested educational software Production of educational software is a long laborious process requiring the expertise of experienced teachers and the knowledge and skills of good programmers capable of producing animated programs with provisions for suitable interaction..... '

Is Fiji in a position to embark on a project requiring the expertise and resources described here by Professor Bajpai ?

Program conversion provides an alternative to the costly exercise of developing software from scratch. Chapter 6 of the thesis investigates the conversion of pre-written and tested software intended for the BBC microcomputer to run on an Atari ST microcomputer.

- (c) The training of computer programmers for educational software is time consuming and expensive. The alternative is to import personnel with the required skills. Sceptics will surmise that the new technology is creating employment not for the local population but for more expatriates to enter the country.

Foreign influence

Foreign influence, sometimes termed by some as foreign interference, is always prevalent in developing countries. Some developing countries enjoy the influence to their advantage, or mutual advantage, with the foreign power. In some instances foreign influence in the form of financial aids and resources are abused by the developing countries.

The location of Fiji makes it attractive to foreign powers for various reasons. How attractive it is manifests itself in the willingness of foreign powers to fund projects.

Two foreign agencies were willing to fund the computer installation at the University of the South Pacific. One of the agencies was prepared to share the funding with the other, while the other wanted to fund it alone or not at all. The latter did not want to share the privileges derived from such generousities.

A feasibility study of the project was carried out by a consultant from one of the prospective donor countries. No local representative was invited to work with the consultant. Any input by local personnel was through a committee which had a majority of expatriate members, many of whom have now left the service of the USP. New replacements from abroad will come in and stay, for say three years, implement their ideas and leave. An unsatisfactory state of affairs exists as a result of the chopping and changing of people and not being able to remedy the problem.

A better investment for the USP would be if local personnel worked with the consultant from the beginning as the local personnel will still be around when most expatriates have left.

What seemed a generous offer at the time might turn out to be an expensive exercise in the long run in terms of obligatory gestures by the recipient towards the donor countries.

Technology requirements

Most developing countries are developing in the sense that they are behind in technological advancements. The question which arises is, 'do we need technology?'. Fiji relies mainly on agriculture and the tourist industry. A return to living off the land and sea as in the olden days would eliminate the need for technology. Values and demands in Fiji today however can not be met by conditions of old, therefore technology is essential to satisfy today's demands in Fiji.

Computers will serve society in several directions. Labour saving devices, entertainment, administration, education, medical, the list is endless. The application of computers in any field will have some drawbacks which need to be weighed against the advantages. For example, will the computer find a place in a society with high unemployment figures, a lack of technically trained manpower and a dependence mainly on agriculture and tourist revenue?

The advantages of computers in education are made overwhelmingly clear by the work of many researchers world wide. With this assumption Fiji can safely explore ways of utilising the computer in education. Computers in education can be used as the basis of an administrative system, as a problem solving tool, as the basis of an integrated learning system and as a subject of study.

Fiji needs a clear definition of the role for computers to address her needs and demands. Care is to be exercised not to confuse the needs and demands not applicable to Fiji to those relevant to Fiji.

3.3.2 The Lack of Technical Background

There is a vast difference between the technical background of pupils and teachers in a developed country and that of pupils and teachers in a developing country like Fiji. This is not to say that the difference does not exist among other users of technology. With this in mind a user manual for equipment

intended for British schools needs to be revised before being released in a developing country. Assumptions applicable to a British user are not as obvious to a Fijian user. This applies mainly to the very basic literature which is not as detailed as more advanced handbooks which are not intended for the end user.

3.3.3 Compromise and Improvise

The author's experience with computers in education in Fiji so far has shown that there is a need to improvise in many instances. This is more so when resources are scarce, especially in new technologies. Improvisation in technology needs a technical background in addition to acquired technical knowledge. Local people in Fiji do not have a technical background, and they look to expatriates to provide the insight gained from a technical background. The uncooperative attitude in some quarters towards technical innovation needs a readiness on the part of the innovator to compromise. This uncooperative attitude is due mainly to the fact that people do not understand the new technology, and are afraid of the change.

Some headteachers were not sure of the advantages of computers and were not prepared to give up time to accommodate the new technology.

Compromise in this case was the author giving up free time to accommodate teachers at the school who were prepared to attend computer classes during lunch times and after school. It needs total dedication, from at least one member of staff, for a computer programme in a school to succeed.

3.3.4 Public Relations

Before any new innovation is implemented an exercise in public relations is necessary. In the education system in Fiji it is important to convince various groups of people if an educational innovation is to be successful. This is necessary due to the limited support by government and the dependence of schools

on private sources of support which include parents/teachers/friends associations and old students associations. When convinced these organisations could be very resourceful especially at an early stage of new innovations. It is difficult to attract financial assistance to a new innovation that has no visible track record to show, especially in developing countries like Fiji. Computers in education in Fiji will need time, insight and dedication before any benefits are realised.

3.3.5 Research

Developing countries like Fiji cannot afford to mount research projects on the scale of the National Development Programme on Computer Assisted Learning (NDPCAL) in the United Kingdom. The question Fiji should be addressing is how to implement the findings of projects like the NDPCAL.

Electrification in Fiji is far from complete and most rural schools do not have electricity. Yoong-Ming and Peng-Yee [8] suggest how to teach computational mathematics without access to computer facilities at primary, secondary and university levels.

A primary school headteacher in Fiji wrote to the author enquiring about battery powered or solar powered computers. Failing this the headteacher suggested he was in a position to persuade the village elders to allow the use of the village electric generator on some afternoons. The village electric generator was intended for lighting at night only. The author intends to look into the possibility of this at a later date.

There is scope for research into the use of computers in distance learning programmes at the University of the South Pacific. Communication and transportation systems serving the University region of the South Pacific are very different from that which the Open University of the United Kingdom has to cope with.

3.3.6 Simple Programs

Due to the lack of technical background of computer users in education in Fiji, the use of sophisticated packages like data bases is to be avoided at this stage, especially in primary schools. The concept of a network or a link up like teletext will be too complicated to assimilate without seeing it in everyday use. Fiji does not have a television broadcasting service and is not likely to in the near future.

Simple and easy to operate programs should be encouraged at an early stage in primary schools. The use of the immediate mode of computers provides a good exercise in keyboard skills and familiarisation, without any software.

Upper secondary schools and post-secondary students will benefit from using commercial packages which can be used for learning mathematics.

3.3.7 Public Awareness of Computers

There is still a lack of computer awareness and Fiji needs to tackle the problem at the national level. The University of the South Pacific and the Ministry of Education are addressing the problem in some way, but there is still a wide section of the population not catered for. Computer use is on the increase in developing countries in the South Pacific (see Appendix E), and there is a danger of some developing countries becoming a marketplace only for sophisticated computer technology.

3.4 The Remainder of the Thesis

The rest of the thesis will attempt to answer these questions and put forward a case for the use of computers in education in the teaching of mathematics in Fiji. The type of software to be used and the administration of computers in mathematics teaching in Fiji will be highlighted.

First the implication of computers in education is reviewed. A definition of

computers as used in education is formulated and the relationship of computers to mathematics learning discussed.

CHAPTER 4

4 COMPUTERS AND EDUCATION

4.1 A Definition of a Computer

Many different definitions of computers, derived in various contexts, exist which result in confusion and, sometimes, misuse of computers. Due partly to manufacturers who are interested mainly in selling their products and to misinformed sources, there is a common belief that computers are indispensable in industry, commerce, entertainment and education. The public at large are led to believe that the computer holds great promise for education. The search for the realisation of this belief is a continuous process. Due to the complexity of computers the great promise in education has remained vague, and often disguised and misleading, causing a literal misinterpretation of what computers offer. Literal misinterpretation of computers by educators leads to complacency in attempts to understand the technology giving rise to ignorance of what a computer is.

In a recent survey carried out by the author on secondary school students eighty per cent of those asked to give a description of a computer said 'it's a machine'. Dr John Lovell, a Fullbright Fellow at the University of the South Pacific (USP), Fiji, who brought the first microcomputer to Fiji in the early eighties and contributed in some way to the introduction of microcomputers at USP, defined the computer in one of his seminars at USP as a 'doer'. A point missed by many is that a computer, unlike a washing machine or sewing machine, is not designed to do things. The educator who misses this distinction between a computer and ordinary machines tends to look for a definition of computers in ordinary places. This leads to a common, misleading, literal definition which tends to give rise to erroneous implications and applications.

This chapter will attempt to provide a definition of the computer that is

useful for its use in education. It also describes the components and workings of a computer which could be used in the study of mathematics.

4.1.1 Computer as a Calculator

Common definitions of a computer are related to characteristics which set it apart from other types of calculators. The speed, accuracy and enormous storage capacity are three such characteristics normally referred to in definitions.

These three characteristics are highlighted by manufacturers as inducements to users to buy a particular product. The incomplete statements in advertisements create popular beliefs which, due to lack of knowledge, become accepted. The hasty use of words and lack of clear language is a source of philosophical problems and results in faulty conclusions. In attempts to define computers with unclear and imprecise language the discussions are littered with half-truths and incomplete conjectures. The definition described here will attempt to avoid ambiguity and confusion by using clearly defined and precise words. The description given is aimed at making the educator more appreciative of what computers can offer education. The three characteristics, speed, accuracy and storage capacity, are investigated here to give a clearer understanding.

Speed of Computers

Speed is often used in describing computers, but is rarely fully explained.

Advertising brochures give descriptions that only mean something to the professional, but what is attempted is a definition of speed that the user should be aware of. The speed of computers includes a multitude of activities which contribute to the time computers take to carry out a particular task.

Speed needs to be more fully defined so as not to mislead or confuse.

As an example of the half-truths and incomplete words, take the claim by Paul Siegel [9], that a computer can multiply two ten digit numbers in the time it takes a jet plane to fly an inch. The time referred to by Siegel is unclear and

this leads to different interpretations. Does the time referred to include the time taken to write the program, input the data, output the data etc? This is seldom clearly defined when the speed of processing with a computer is discussed. Failure to identify the difference between the time to prepare the computer to do a job and the time it takes the computer to do the job can be disastrous when computerising jobs previously carried out by hand. The distinction between the two times is important to the potential user who will be faced with the problem of purchasing software to run the computer. The novice user, especially in places like Fiji, unaware of this distinction, genuinely feels robbed when confronted with the price of software that has taken a long time to develop.

The students, comparing the solution of simultaneous equations by writing a computer program in Basic to solve the equations with using an electronic spread sheet (see Appendix F), highlighted how fast the computer Basic program displayed the solution of:

$$a_1x + b_1y = c_1$$

$$a_2x + b_2y = c_2$$

after the values of $a_1, b_1, c_1, a_2, b_2,$ and c_2 were entered. None of the students considered the time it took to write the Basic program. They considered the Basic program solution faster than the solution derived from using the spreadsheet simply because the entry of data in the Basic program is easier than with the spreadsheet. The Basic program displayed the prompt to enter data, and on pressing return the solution immediately appeared. With the spreadsheet the cursor had to be moved to the appropriate cell for the entry, and this was repeated six times for a pair of simultaneous equations. The students wrote the computer Basic program, but the spreadsheet was pre-written. In deciding which was faster they considered the time it took to write the program in Basic, and the time it took them to enter data on the spreadsheet. These were considered in

isolation not as part of the time it takes to solve the problem. 'Speed' was not clearly defined.

Time Involved in Software Development

The time taken to produce the software depends mainly on the size of the task to be computerised and the expertise of the personnel available. Large systems will entail long hours of planning during the system analysis stage to produce an acceptable flowchart. Decisions on storage and display media will depend on hardware availability and system requirements. The speed of analysis and actual programming is also greatly affected by the capability of the analyst and programmer.

A poorly defined problem takes longer to complete than a well defined problem. The poorly defined problem for computers in the South Pacific may arise due to the lack of knowledge about what the computer is capable of. The author's experience in the South Pacific shows a tendency to define the problem to suit the program instead of designing the program to suit the problem. This practice appears to flourish where there is a general lack of computer expertise.

Time Involved in Computer Processing

The speed of processing includes the time taken to:

(i) Prepare Data

Whatever form the input data takes they have to be, in most instances, initially input manually. There is a validation check involved when the raw data is checked for inconsistencies due to human error.

Preparation is complete when data is verified.

(ii) Input Data

Method of data entry can be 'batch' or 'realtime', and they each have their advantages and disadvantages which involve speed. Data may be

manually input from a keyboard or electronically read as in optical character recognition systems, both contributing to how fast the job can be done.

(iii) Processing

Once data is in memory ready to be operated on, the electronics need to move the data around and this involves access time, which depends on the storage media used and the method of access; for disk systems positioning time, head load time, latency time and transfer rate time are all relevant when considering speed.

The actual processing time is very fast and is measured in milliseconds, but it becomes noticeable and tedious when vast amount of data are to be processed.

Accuracy of Computers

The accuracy of the computer is taken for granted with the assumption it will never output an incorrect response. It is rarely recognized that accuracy of the computer also depends on the accuracy of the inputs and the accuracy of the instructions contained in the program. Errors in inputs and procedures in computing can be expensive. The accuracy often referred to in computers is the ability to perform calculations to a greater precision than is manually practised. Furthermore, computers will not mistake addition for subtraction and will not suffer from stress and strain which affect human accuracy. Given the right instructions the computer will predictably perform and output the correct result.

Computer Storage Capacity

It is common knowledge that a computer has a larger capacity for storing information for recall than humans. Including storage devices like magnetic tapes and disks this capacity for storing information is theoretically without

limit. When storing large amounts of information the question of retrieval becomes important. Storing is only meaningful when whatever is stored is retrievable.

When considering the question of storage capacity of computers, the questions regarding which information is to be retrieved, how it is to be retrieved, how is it to be displayed and how quickly it can be retrieved are all relevant. To store data on magnetic tapes for an enquiry system will not serve the purpose of using computers for fast retrieval of information. The vast storage capacity of computers is only meaningful when used in the proper situation.

A little extra care with words and language used to discuss what a computer is will present a different view from that which is commonly accepted. The common belief that a computer is fast, accurate and able to store a large quantity of information may be correct but does not go far enough to provide a complete description of a computer.

Careful use of words and language is only a preparation to a definition of a computer which will be useful in education. The next step is to look at current definitions and the history of computers which have supported each other giving them credibility.

4.1.2 Current Popular Definitions

Among the accepted methods of defining an object are, naming the object and describing the object. The two modes are used extensively in attempts at defining computers.

Literal Interpretation of Computer

The name 'computer' is regularly used to refer to an 'electronic digital computer'.

Electronic

The word 'electronic' creates the false impression that a computer is an electronic gadget. Computers can also be mechanical. The electrification of the computer gives it speed, which is very useful when using the computer, but speed and the use of electricity are not essential properties for a device to be classed as a computer.

Digital

The word 'digital' creates the impression that computers represent quantities by numbers only, and it only deals with numbers. Analogue computers represent quantities by analogy, like a thermometer which outputs a distance proportional to temperature. An electronic thermometer produces a voltage proportional to temperature. Most computers are digital, but this does not imply that to be a computer a device has to display quantities as numbers.

The conclusion that a computer deals in numbers only, derived from the word 'digital', is reasonable but is a serious drawback when an understanding of computers is sought. The word digital refers to the way information is represented and not to the nature of the information. Computers deal only with digital information. The ASCII code, shows the representation of characters as used in modern microcomputers (see Appendix G).

Computer

The name computer itself suggests the commonly held view that computers are used only for arithmetical calculation. This is a fallacy as computers can execute any well defined procedures that involve the processing of symbols or characters whether they are numeric or otherwise. For example the computer procedure below will add an 's' to any string of characters, alphabetic or non alphabetic, entered:

```
input" word ";w$
plural$=w$+"s"
print plural$
```

The procedure above is not restricted to numeric characters.

The fact that adding machines, calculators, and arithmetic machines are part of the computer's lineage does not restrict computers to numerical operations solely. This lineage is laboured by historians who subscribe to the origin of the definition that a computer is a fast adding machine.

The Simplified Descriptive Definition

The descriptive definition of the computer again reinforces the limited definition associated with number processing.

Adding Machines

The familiar adding machine provided a convenient reference at a time when a fuller understanding of computers was being investigated. Computers process symbols and do calculations. The processing of numbers is only part of the wide spectrum of symbol processing. Symbols, whether numbers or otherwise, represent information and computer processing is the processing of information. When considering the effect of computers on revolutionizing data processing, the definition of '*a large and fast adding machine*', does sound insufficient. With little on offer as an alternative, the concept that a computer is a mere machine doing menial tasks when required, is passively accepted.

Larger Brain

An alternative to the above descriptive definitions is that of 'a large brain which can make decisions about what and when to do something'. This alternative takes account of the ability of the computer to deal with concepts rather than physical phenomena like motion. The ability to deal in abstractions is a distinguishing feature of humans from other living creatures. The computer is closer to humans than most living creatures in this respect. The computer can be directed to keep track of many conceptual entities like names, addresses, colour and so forth. The computer can deal with concepts because it can make decisions

based on class membership, size or other defined criteria. The two popular forms of definitions of computers, the literal interpretation of the name and a simplified description of the computer, create confusion and opposing views if taken together or separately.

4.1.3 Historically Derived Definition

To add to the confusion the definition derived from the history of computers is also misleading. The word 'computer' and 'count' are derived from the same word in Latin, 'puto' which means reckon. This encourages the concept that counting devices are the same as computing devices. This is not false but is only part of the whole story. With this common link in their origins, historians begin their discussions on calculating devices like the abacus and continue with devices like the slide rule, Napier's bones, the flyball governor, Pascal's calculator and Leibnitz's stepped wheel. This eventually leads to the calculating machine, thus reinforcing the misconception about computers as calculating machines. The historian has looked to the past for something to back up what is already a popular belief. Calculating devices are computing devices, but computing devices encompass more than just calculating devices.

History has also indicated that computers have existed for several thousand years. Cavemen's scribbling on walls, markings on sand, fingers for counting, hourglasses and Babylonian maps are cited as some sort of primitive computers.

With appropriate technology the Greeks might have invented the first computer. Gerald Hawkins [10] in his book, *Stonehenge Decoded*, describes how he used a computer to prove that Stonehenge, the ancient Druid temple, was built to be a computer. Harold Borko [11] in his book describes how divers discovered an old Greek computer off the shore of the Isle of Antiythera. B.V.Bowden [12], refers to Gebert, who later became Pope Sylvester II in the tenth century and was said to have made a bronze head which would answer 'yes' or 'no' to any question put

to it. Reference is also made to Blaise Pascal who, in 1642 at the age of nineteen, built the first digital calculating machine as a present to his father. All these references may be legitimate to the discussion of computers but is not enough to justify defining a computer as a calculating machine.

Charles Babbage

The case of Charles Babbage is further evidence that historical events cannot be linked to the current developments in computers. Babbage was born in Devonshire, England, in 1792 and spent his fortune and lifetime developing calculating machines. A model of a calculating machine called the Difference Machine completed in 1822 was designed to do certain calculations using a procedure called 'the method of differences'.

To demonstrate the method consider the equation:

$$y = x^2 - 3x + 2$$

To evaluate the values of y using the 'method of differences' first calculate by hand a few values and the Differences D1 and D2 (see Table 4.1)

TABLE 4.1

x	y	D1	D2
0	2	-	-
1	0	-2	-
2	0	0	2
3	2	2	2
4	6	4	2
5	12	6	2

The difference column D1 is derived from the difference of the current value and the previous value of y , and column D2 is derived from the difference of the current value of D1 and the previous value. Note that the values in column D2

are constant. Should the value of column D2 not be a constant, another column, D3, has to be evaluated, and so on until a difference column value is constant.

The next value of y is evaluated by first calculating the value for column D1 given that D2 will be 2.

$$D1 \text{ will be } 2 + 6 = 8$$

$$Y \text{ will be } 8 + 12 = 20; \text{ when } X = 6$$

Successive values of Y may be calculated in this way.

The method of differences works for other equations as well and this was a major contribution by Babbage in designing a machine to carry out the procedure.

While the construction of the Difference Engine is not an easy task, the 'skill' provided by the procedure gives the machine its sophistication. When a procedure is expressed in terms that are clear and unambiguous it is not incredible that a machine can be constructed to execute the procedure. To feed numbers into his machine Babbage adopted the method of Joseph Marie Jacquard, a French weaver who invented the method of using punched cards. Jacquard used punched cards in his loom to allow needles to pass if there is a hole and restrict the passage of needles by the absence of holes. Dr Herman Hollerith, a United States official, adopted the method in 1880 and used it to process the 1890 United States census figures.

Babbage went further than inputting numbers with punched cards. He proposed building a more complex machine to process any algebraic procedure that could be described to it. He argued that if Jacquard's loom can weave any pattern described by a stack of punched cards, on any fabric in any colours by changing the colour of the yarn, then in the same way his complex engine, which he called the Analytical Engine, could be stacked with punched cards describing algebraic procedures. These cards, called operation cards, could then be provided with another set of cards called variable cards, describing the numbers to be

operated on. The variable cards are likened to the different coloured yarns used in Jacquard's loom.

The pattern of operations on the operation cards remains the same, only the description as provided by the variable cards is allowed to vary. An Analytical Engine can have a library of operation cards describing different patterns of calculations. Babbage died in 1871 without building his Analytical Engine due to the lack of the technology level required for its construction, but his work during the first half of the nineteenth century contained all the ideas underlying present day computers. Historians find it convenient to link Babbage to the development of computers. Borko [11], says that due to the demands of business and government and the advanced technology in the twentieth century, the time is right to 'renew the vision of Babbage'. The fact is Howard Aitken (see [13]), who constructed the first digital computer while at Harvard University in 1939, never heard of Babbage until after his construction was completed. Aitken was amazed to learn that both he and Babbage were concerned with the same problem. With due respect to Babbage the computer belongs to this century and any reference to history in the definition of the computer will remain inadequate.

4.1.4 A Definition Related To Automaton

The study of machine behaviour, the theory of automata, provides an interesting area to look to for a definition of computers. Basically an automaton is a device that has an input and an output such that the output in some way influences the input. As most machines come under this generality the automata theorist restricts the investigation to:

- (i) machines that process or deal with information
- (ii) machines that process information which is complex
- (iii) the way machines behave and is not concerned with the physical construction or characteristics of the machine.

The computer comes under the category described above and can be classed as an automaton.

Turing Machines

An insight into automaton can be gained from a discussion of the Turing Machine which was described by Alan Turing [14] in a paper in 1937.

Imagine a machine with a tape running through it like a ticker tape. The tape is divided into squares with a symbol written in each square. The Turing machine can perform three actions:

- (i) read a symbol on a square
- (ii) write a symbol on a square
- (iii) move to the right or left.

The three operations together constitute a cycle.

The operation of a cycle can be described as

1 0 R

which may be interpreted as

'if a 1 is read, then write a 0 and move to the right'.

The cycle

1 1 R

may be interpreted as

'if a 1 is read, print a 1 and move to the right'

A string of 1's can all be changed to zeros by applying 1 0 R to it.

$1\ 0\ R(111111) = 000000$

To change every other 1 to zero and leave the others as they are will need a different Turing machine.

$?(11111111) = 10101010$

To achieve the above, the machine will need to be able to use both 10R and 11R cycles, and furthermore some extra instructions are needed to indicate which of

the two cycles is to be carried out at a particular instant.

First label 1 1 R as A, and 1 0 R as B, and then the instruction to indicate which of the two cycles to follow is tacked on the end.

$$A = 1 1 R B$$

which says:

'if 1 is read, print 1, move right, execute cycle B next'.

$$B = 1 0 R A$$

which says

'if 1 is read, print 0, move right, execute cycle A next.'

Applying A will achieve the required conversion

$$A(11111111) = 10101010$$

Applying B results in

$$B(11111111) = 01010101$$

The point about a Turing machine is the simplicity of its basic operations which when strung together can make up a complicated set of procedures. It has been shown that for any precisely defined computational procedure a Turing machine can be constructed to execute the procedure. Because a Turing machine is completely defined by its procedure each procedure will require one Turing machine.

To avoid constructing machines for every procedure, a Universal machine is constructed to imitate the necessary machine to execute whichever procedure is input. The Universal machine is no longer dedicated to one procedure and the computer is such a Universal machine.

Part of the input into the computer describes

- (i) which machine is required to execute the procedure
- (ii) the procedure to be executed.

Without a description of the machine to be imitated and the procedure to be

executed, the computer is not capable of executing any action, and it is likened to an incomplete machine. With a program the computer can imitate a calculator, a typewriter etc.

This is a major difference between the computer and other machines. While other machines are designed to perform a particular procedure, the computer is not a machine until provided with a procedure, when it will imitate the machine required to execute the procedure. A discussion of the a definition of computers should be a discussion about procedures. It will be shown in the next section that procedures related to computers are special types of procedures.

Procedures

The type of procedure required for computers has two roles to play:

- (i) it provides a description of the type of machine required, and
- (ii) it defines the process to be executed.

Procedures that satisfy the above are 'computational procedures' and they solve computable problems. A *computable problem* is one that has a suitable set of rules for going from the inputs to the outputs. Information processing problems are computable if they satisfy the criteria of a well-defined set of rules for going from inputs to outputs. A large proportion of computable problems are those dealing with information processing.

Not all rules are computable due to vagueness and ambiguity, and some need some form of decision to determine the outcome.

PROGRAM 4.1

```
input x
input er
y=x/2
start:
```

```

z=(1/2)*(y+x/y)
error=abs(x-y*y)
k=k+1
y=z
if error<err then finis
goto start
finis:
print y;er;k
end

```

Computational Procedures

Not all computable procedures will yield an exact answer or guarantee an answer. The procedure in Program 4.1 is computable and will compute the square root of a number 'x', using the iteration $z = 1/2(y + x/y)$ where y is the previous estimation. Iteration methods seldom yield an exact solution. Program 4.1 works according to the following procedure:

- 1 read a value for 'x', the number whose square root is to be calculated
- 2 read a value 'er' indicating the accuracy of the solution sought
- 3 calculate $y=x/2$, the first approximation
- 4 calculate the value of $z=1/2(y+x/y)$
- 5 evaluate $error=abs(x-y*y)$
- 6 increase the number of iteration $k=k+1$
- 7 replace the value of y by z
- 8 if er is less then error goto step 10
- 9 goto step 4
- 10 print values of y, er, and k
- 11 stop.

An input of $x=144$, and $error=0.1$ yields

$y = 12.000505968$ after 6 iterations.

With the same value of $x = 144$, and an error value of $.05$ the solution is the same as above.

$$y = 12.000505968$$

An error value of 0 for the same x value, yields the exact value

$$y = 12 \text{ after 7 iterations.}$$

The accuracy of the result depends on the procedure and the information contained within the procedure and not on the computer.

An input of $x = -144$ does not give a solution. This is due to the inadequacy of the procedure described in Program 4.1.

An amendment to the procedure as shown in Program 4.2 will cater for negative values of 'x'.

PROGRAM 4.2

```
input x
initialx=x
x=abs(x)
input er
y=x/2
start:
z=(1/2)*(y+x/y)
error=abs(initialx*initialx-y*y)
k=k+1
y=z
if er < error
goto finis
else
goto start
endif
finis:
```



```

if initialx < 0
    print str$(y) + "i"; er; k
else
    print y; er; k
endif
end

```

Without the amendments, the computer will execute the instructions continuously without stopping, as if the problem did not have a solution. The best that can be achieved is to report there is no solution and come to a stop.

Computational procedures are algorithms which terminate when a solution is reached or when the non-existence of a solution is ascertained.

Heuristics

With the speed of computers today there is a tendency to solve all problems which possess a computational procedure without any regard as to how long and complicated the procedure is.

Take the case of Simon Claude who first suggested the idea of a chess playing machine. Claude calculated that there is something of the order of 10^{20} possibilities for moves in a chess game. Let us assume that Claude overestimated the number of possible moves and that there are only 10^{10} possibilities, and further assume that the computer can explore one million possibilities in a second. There are 31,536,000 seconds in a year. Therefore in one year the computer can explore 31,536,000,000,000 possibilities, and it will take the computer more than one million years to go through 10^{20} possibilities. With a complex set of procedures as in chess the alternative action is to decide on the best option from a few selected possibilities thus reducing the length and complexity of the procedure.

This approach, known as heuristics, is a rule of thumb method and does not offer the same guarantee as the algorithmic approach. Computers may be instructed to execute heuristic procedures by considering priorities among them. Whereas the sequences of heuristic procedures may be probabilistic and without guarantee of an optimal solution rather than certain as in algorithmic procedures, heuristic procedures can be structured so that no understanding of the procedures is required to execute them.

The clarity of a procedure depends to a large extent on the ability of the user to comprehend the procedure. In describing the procedure to be executed by a Turing machine, the procedure also defined the machine to execute it.

Consequently part of the qualification for a computational procedure is the ability of the reader to understand the procedure, otherwise the expected accurate output will not materialise. The description of the Universal machine included the ability to read the description and imitate the machine required to execute procedures. The theoretical Universal machine, and its real life counterpart the computer, is able to read computational procedures as a blueprint for a particular machine and also as a set of rules to be executed.

Concluding Remarks

This section has put forward the view that a computer is an incomplete machine, waiting to be completed by a procedure which will convert it into any machine the procedure can describe. The machine is a consequence of the procedure and not the determinant, therefore procedures come before the machine logically and chronologically. The obvious language to discuss computers in is the language of procedures. As a consequence of this description the obvious language of discussion of computers is in terms of procedures. This provides an opportunity to study computers without actually possessing a computer. The implications of this for developing countries like Fiji is attractive considering the difficulty of purchasing and maintaining hardware. Rural schools without electricity can

study computational procedures without access to computing facilities. When pupils from the rural primary schools in Fiji come to secondary schools, where hardware is more likely to be available, they will be better prepared if they have had one or two years of studying computational procedures.

The author has experienced students skipping the task of writing their procedures down first. Instead they try to sort out the procedure at the keyboard. This practice might work for simple programs, but is uneconomical in terms of time when there is a shortage of machines. The study of computers in terms of procedures provides a role for computers in education where hardware is not necessary.

The next section looks at the development of computers in education.

4.2 Computers in Education: An introduction

In view of the definition of computers discussed in the last section, a process intended for computerisation needs to be

- (i) expressed in procedural terms
- (ii) the procedures used must be computational.

This offers the educator an opportunity to analyse educational processes when considering computerisation. Put in another way computers in education is an exercise in educational analysis. The process to be computerised needs to be looked at carefully and a fully comprehensive understanding of the process is required. To those involved in education computerisation should present an opportunity to review their knowledge of the profession.

There were areas in education that were sufficiently procedural to be ready made for computerisation. Office procedures in administration are well-defined processes involving inputs and outputs. The production of school reports have carefully defined and well used procedures. Record keeping which supports report production is another area that is ready made for computerisation due to its

procedural nature. Due to the many variables involved in classroom activities, computerisation in the classroom is a complex exercise. Work already done in this area of computers in education should provide initiatives for countries like Fiji which are still in the initial stage of using computers in education. The importance of selecting the right process for computerisation is discussed in detail as wrong selection can defeat its very purpose which is to enhance learning.

4.2.1 Programmed Learning

Developments in programmed learning encouraged the use of computers. Programmed instruction is a mode of instruction whereby information combined with questions are presented to the learner. The questions are often implicit in form with blank spaces in the written material to be filled in by the learner. The answers to the questions are conveniently available depending on the method of presenting information and questions. Two methods of presenting programmed instructions evolved, the printed text and teaching machines. Programmed learning employed two techniques of programming: linear programming and branching programming.

Linear Programming

Three characteristics of linear programming are

- (i) its derivation from behaviourism, in the principles of operant conditioning. Skinner [15] identifies three procedures involved in linear programming
 - 1 Programme output - some material is presented to the pupil
 - 2 Student input - student responds to the programme output
 - 3 Programme reaction - the programme presents the next lot of material which is pre-determined by the author of the programme

and is in no way influenced by the student's response.

- (ii) linear programming is systematic in its presentation. The programme consists of a series of presentations of information, followed by searching questions on the information previously presented, followed in turn by an analysis of the possible answers the student may have given to the previous questions and so on.
- (iii) linear programming reinforces correct responses and is self pacing. The programme reaction in (3) above is only relevant if the student's response in (2) is correct. The pre-determined programme reaction has no corrective element in case the student's previous response is incorrect. Students can work through the programme at their own pace giving the linear programmes some degree of individualisation.

The systematic presentation of information in linear programming is not flexible enough to allow the individual requirements of students to be addressed. The order of presenting information is pre-determined by the author and succeeding presentations are only relevant if the student's previous response is correct. Any individualisation in the programme is only in the way a student can work through the programme at his own pace. There is no individuality in the material received by students nor the way the material is presented. All students will receive the same information in the same order.

Branching Programming

Crowder [16], modified Linear programming by letting the student's response in (2) above influence the programme reaction in (3). Crowder wrote;

' the essential problem is that of controlling a communication process by the use of feedback. The student's response serves primarily as a means of determining whether the communication process has been effective and at the same time allows appropriate corrective action to be taken. '

In a branching programme after an incorrect student response the student is

directed to an alternative presentation of the same information and then retested. A correct response is followed by new information and so on.

The teaching actions are directed by the student's responses; two students do not necessarily follow the same pattern of information presentation.

The less able student will experience more varieties of presentation styles of the same information.

The new procedure resulting from branching programming, labelled 'adaptive teaching programme', is defined by Atkinson [17], as a programme where the sequences of instructional actions taken by the programme varies as a function of a given student's performance history.

Compared to linear programming, branching programming

- (i) can display more information as the correct response is not as important as in linear programmes
- (ii) accept^s a student's response that does not fit perfectly with stored alternatives
- (iii) comments on a student's response and allows a step to be repeated if necessary.

There is more work involved in branching programming than in linear programming due to its more complex nature. An extension of branching programming is Generative Programming which generates material, problems, solutions and relevant diagnostics as and when it is needed while the programme is in use.

Generative programming was developed for two main reasons

- (i) to ease the author's task of preparing teaching materials. These included information, problems, solutions and diagnostics
- (ii) the belief that in some situations students learn better from attempting problems of an appropriate difficulty than from attending to some pre-conceived systematic exposition.

Programmed Learning vs Computers

Early teaching machines lack the technology to adequately meet the demands of current teaching theories. For instance, testing the student's response in linear programming is not possible. This would involve the comparison of a student's response with the stored correct response which would be available at the appropriate time in the programme. An unsatisfactory alternative was to allow the students to do a self-evaluation of their responses. The requirements of linear programming and the demands identified in the development of branching programmes and generative programmes were adequately met by the computer. The ability to store information in the computer enabled the storing of

- (i) a greater variety of possible responses
- (ii) more than one method of presenting information
- (iii) a record of the students' performance which is useful in determining which route to proceed in a branching programme.

The decision-making ability of the computer is ideal for branching procedures. The speed of computers is needed when comparing students' responses with several options. When early teaching machines were unable to accommodate long and complex branching procedures, printed texts were used. Printed texts did not stand up very well to constant page turning which was a feature of branching procedures. Page turning became a tedious exercise for the learner as well. Computers could handle more information than printed texts without the inconvenience of page turning. When using programmed texts, students are able to look up the correct response without previously having answered the questions. With computers the user has to input a response to the question before the correct response is made available. There is a preference among students for keyboard working rather than reading texts. Input and output media in a computer environment do not wear out and look unsightly like dog-eared texts, so might be said to be much cheaper to produce and maintain. The random number generator of

computers enables programmes to provide a variety of different problems and present information and problems in a random order.

4.2.2 A Procedural Approach

Looking to the classroom for a procedural process the early CAL practitioners found a ready-made candidate in the elementary standard classroom exercise of drill and practice. Drill and practice is a universal and popular teaching technique, especially so in mathematics. The practice involves the presenting of facts to the student who is expected to retain them. The student is then tested to ascertain that the facts have been retained. It invariably turns into a memorising exercise. The procedure of drill and practice requires the teacher to present the facts. The presentation can be oral, read from a book, or written notes on the blackboard. The testing can be oral or written. The questions are phrased such that the correct response can only be provided by remembering the previously given facts. For example, the well-worn multiplication table says, 'two threes are six' When prompted with 'two threes' the student is expected to respond with 'six' from memory. If the student has forgotten the phrase 'two threes are six' it is doubtful that the student will arrive at six by adding three and three or adding two and two and two. A correct response from the student is rewarded in some way and an incorrect response is also indicated in some way. In mathematics drill and practice is commonly held orally where pupils are on public display to the rest of the class. A teacher would call out the question and nominate a pupil to give the answer. The pupil has to stand and call out the answer. An alternative is for the teacher to nominate a pupil to ask a question. The pupil asking the question then nominates who is to answer. The popularity of the oral drill and practice from the teacher's point of view is that it does not take up time to mark written responses and there is less preparation needed, especially if the pupils are nominated to ask questions. It is relatively easy to execute and can be treated as fun games by pupils.

for computerisation. Many early applications of CAL were in the area of drill and practice where the computer is used in place of teachers and text books, to present facts and test retention. The pupil sits at a keyboard and under the computer's control practises some procedures or memorises some facts mainly in the areas of basic skills like arithmetic, spelling drill and foreign language vocabulary memorising.

Stanford Drill and Practice

The Stanford arithmetic drill programme is one of the most well-known of the early CAL in drill and practice. Directed by Patrick Suppes and based at Stanford University in the United States, the Stanford programme was an extensive pioneer in the field of drill and practice using computers. The popularity of the Stanford programme was indicated by the rise in the numbers using it from 1500 in 1966 to more than 6000 in 1969, see Suppes [18]. Suppes intended the programme to drill and review students on concepts previously covered by teachers in the classroom. This was an attempt to give the teacher some control over the progress of drill and practice by the computer.

Though popular (the Stanford Drills are taken by more than 150,000 students a year Suppes, [19]) , Licklider [20], made the following comments in 1962:

'Although the teaching procedures called "drill" have unpleasant connotations, there is little doubt that accumulation of facts and elementary behavioural capabilities are prerequisite to advances at conceptual and integrative levels. Drill has a fundamental, propaedeutic function. Moreover the following facts should be considered:

- 1 In present educational systems a large fraction of the total time and effort is devoted to drill.*
- 2 It is inefficient to have $n-1$ children sit idly by while the n th*

- 2 *It is inefficient to have n-1 children sit idly by while the n th reports that $3 \times 4 = 12$.*
- 3 *Neither teachers nor pupils enjoy present kind of drills enough to oppose its automation.*
- 4 *Automation of drill can be accomplished with relatively small investment in instructional programming and computer programming.*

Young [21], raised some psychological advantages, saying that emotions experienced by those that practise drill and practice in class are not apparent in automated versions. The public display in the non-automated version is replaced by the privacy of one pupil/one machine situation. The non automated drill and practice classroom version. is sometimes looked forward to as a time for ridicule by some pupils at the expense of others. The automated version is tailored to the individual pupil without the risk of public scrutiny.

While automated drill and practice may not be a creative or imaginative exercise it can serve a useful purpose in protecting pupils from public scrutiny which could be psychologically disastrous. The fact that drill and practice is unobjectionable, with its psychological advantages as pointed out by Young [21], and the advent of cheap microcomputers has enabled this form of CAL to survive. Drill and practice were identified as procedural when selected for automation. It has its merits but is fundamentally limited. It does not make more than a marginal contribution to education. The approach identified a process that is limited in its educational value. The fact that a process is practised, and fits the computer should not be used as criteria for candidacy for computerisation. Seymour Papert [22], says:

'How strange it is, that computers in education should so often reduce to using bright new gadgets to teach the same old stuff in thinly disguised versions of the same old way.'

Fubini [23] voiced his concern over the uncritical automation of educational practice when he said:

'I am opposed to using the new technologies mainly as direct substitutes for old methods.'

Fubini implied this is the first stage, when the new technology is used to do something already being done, but in a better way. He further says:

'The second stage is when we employ the discovery to do something new in a new way'. [23]

The computerising of drill and practice without a critical assessment of the educational value is to confirm its usefulness, missing out an opportunity to reassess and perhaps construct a new practice.

Because of the procedural nature of drill and practice, the replacement of the teacher by the computer, for psychological reasons, was welcome.

The individualisation achieved in automated drill and practice removed any emotional traumas experienced by some students.

The computer is seen as compensating for

- (i) the lack of knowledge about the subject by the teacher
- (ii) the inability of the teacher to produce individualized instruction
- (iii) the teacher's insensitivity to the ways pupils are emotionally upset in the class.

If the above faults in teachers are to be removed by using computers, then it may be assumed that teachers in schools must have possessed them. These problems may be removed during automated drill and practice but teachers are also employed in other activities besides drill and practice.

The reasons for identifying drill and practice as a candidate for automation are liable to encourage the very faults they presume to cure. Whether educationally sound or not, old teaching habits, if they fit automation, will be given a new lease of life when scarce resources like computers are spent on them.

Unsuitable teachers will be allowed to carry out tasks they are not properly trained for, since the computers will be expected to compensate for some of their inadequacies. By not using the opportunity to thoroughly examine the process to be automated, there is a danger that computerisation will not benefit education but cover up some areas that need rectifying. Computers in education are to be treated as a mechanism as well as an opportunity for proper formulation of educational processes. When processes are being considered for computerisation the foremost concern should be the problems the processes are expected to solve.

4.2.3 A Non-Procedural Approach

The previous approach of identifying ready-made procedural processes has resulted in encouraging a process that has many faults and shortcomings. It has shown up some of the problems inherent in drill and practice. A second approach to computerisation is to look for processes that are not procedural enough but can be reshaped to fit automation. The problem in this approach is the tendency to overlook educational values in an effort for fitting the process to the computer.

Author-Controlled Tutorial

The author-controlled tutorial, commonly known as tutorial CAI, is a popular use of computers in education. Atkinson [24] says of tutorial systems:

'The point about tutorial systems is that one really expects to carry on all the instructions in a given area within the framework of the computer.'

Referring to the role of teachers in the system, Atkinson [25], further says:

'The teachers need to be familiar with the material that is being presented over the tutorial system, and they must understand the sorts of supplementary activities that they can engage in. But, when I talk

about the tutorial system, for example in the area of initial reading, I assume that a student could learn to read by exposure only to the computer-based curriculum.'

An important feature of a tutorial system is the interaction between learner and teacher. The inability of the computer to hold natural language conversation with the student, unlike teachers, does create a problem.

Richards [26], makes the suggestion:

'Those subjects that are most free from attitudinal complexities-those in which the bare typewritten, factual sentence is wholly adequate to what is relevant in the utterance-are best suited to present day computer technique. The mathematics, the factual sciences, and languages (if confined strictly to the handling of plain sense, factual propositions and to conventional formulae) are the subjects through which the development of computer instruction can best be forwarded.'

Early uses of computers in education dealt with the subjects suggested by Richards, i.e. trigonometry, statistics, geometry, physics, Russian, beginning reading and logic. In tutorial CAI the student sits at a terminal and interacts with the computer. The student progresses through the programme at his own pace and thus is provided with personalised tuition. In tutorial CAI interaction between the computer and the learner is paramount. In an attempt to achieve the interaction required in tutorial CAI, early developers adopted the styles of programmed instruction and employed the three-part approach to system programming: stimulus, response and reinforcement. While most adopted the programmed instruction approach, some ignored the theory and Zinn [27] highlights two examples as:

'Much of the work done at Penn State and Florida State can be characterised as individualized versions of lecture, text or

Philosophy of Tutorial CAI

Whatever mode of presentation is adopted, a feature of tutorial CAI is the adoption of programmed instruction philosophy i.e. the instructional material must be systematically developed in terms of clearly stated educational aims. Various models have been proposed describing how tutorial CAI is to be designed. Bunderson's model [28] consists of six stages of systematic and complex tasks for instructional materials development. Bunderson and other tutorial CAI practitioners have shown that to employ computers properly in education a thorough knowledge of education is essential. The approach defined by Bunderson and practised by others can also be employed in other educational practices and not confined to computerisation. While the computer, properly conceived, can become a means of solving certain educational problems, the actual solution of the problem need not involve the use of computers. For some, tutorial CAI has become the starting point for rethinking and perhaps reshaping some educational practices. As a result tutorial CAI then offers two options; the possibility of computerising certain practices, or continuing with classroom teaching of what is now a systematic and orderly instructional process.

Comments on Early Tutorial CAI

As mentioned earlier there is a danger, in reshaping educational processes to fit the computer, that the educational value of the process will be lost. Computers will be looked on as a tool for solving educational problems that previously seemed impossible to solve. The tendency will be to forfeit educational values knowingly for the sake of computerisation. As a result the computer, because of its strengths and/or weaknesses, dictates practice. This tends to create the myth that technology existed before the fact of its relevance to education and is therefore external to the system of education. As

a result the problem is reversed to that of altering educational thinking to accommodate the new technology and the associated changes. This approach is evident in the adoption of programmed instruction for tutorial CAI.

As a result of programmed instruction theory, tutorial CAI heavily emphasizes the learning of facts, the control and the conditioning of students. Learning in terms of observable and specifiable behaviour has been sacrificed for efficiency and enhanced achievement. The fact that some tutorial CAI derived from programmed instruction can be satisfactorily achieved with pencil and paper is also overlooked. Tutorial CAI addresses efficiency and achievement in education and leaves out some essentials as summarized by Methene [29]:

'Education also has the functions of socializing individuals, of shaping their values, of preparing for citizenship, of conserving traditions, and of imparting some sense of awe before the wonders of the universe.'

Addressing the emphasis on achievement aspects of education by educational technologists, Methene adds:

'The application of technology to the improvement only of the instrumental function of education may thus become an obstacle to a society that is trying to redress the balance between the goals characteristic of the heyday of achievement and economic productivity and the greater pluralism in our values and our culture that we are now beginning to seek.'

The approach which distorts the social values of education for the sake of automation efficiency and achievement will result in technical richness at the cost of moral poverty. The replacement of teachers by computers and the systematizing of educational processes are two features of tutorial CAI, which if oversimplified will tend to alter the underlying character of the educational process. The replacement of teachers is also evident in programmes that attempt

to imitate and mimic the teacher to make students feel they are interacting with a human being. This is evident in attempts at conversation like 'GOOD MORNING JOHN' or 'VERY GOOD MARY'. The fact that conversation is considered suitable for the application is a misuse of the technology and at the same time degrading the process being imitated.

Richards [26] states:

'...early attempts will seek to do by computers just what has been done traditionally by select individual teachers.... such underestimates and misuses.... occur when even technical resources become available.'

When, in the misuse of technology, emphasis is put on efforts to imitate, the educational value of the process is overlooked and what Scheffler [30], calls the '*intentional nature of teaching*' is forgotten.

Scheffler describes teaching as:

'Teaching is a distinctive goal-oriented activity, rather than a distinctively patterned sequence of behavioural steps executed by the teacher.'

The emphasis on behaviour and procedural processes seem to imply that these two areas encompass the whole of teaching. There is no evidence that this is true, and thinking about computers in education presents an opportunity to analyse matters of this nature.

4.2.4 Systems Approach in Instruction

Due to early popularity of systemizing instruction (Bunderson's model includes a systems approach) it was envisaged that instruction can be engineered.

Stake [31] contributed to the idea of educational engineering with a view of educational technology that goes well beyond the use of machines which he called the 'science of education'. Stake defines the goal of the science of education as:

'the discovery of the principles and rules is the goal of the science of education.....the practical organization and application of those rules is the goal of the technology of instruction.'

The conclusion derived from Stake is that teaching is totally procedural, a skill which can be practised without insight into the process.

Stake concludes:

'It is clear that teacher insight is not a necessary precaution for effective teaching.'

'As I see it, in the instructional-system schools, all concepts and skills - intellectual, affective, and psychomotor - will be programmed.'

Stake's idea of science does not reflect the scientist's sense of enquiry and exploration, but presents a self-satisfied educational engineer.

Some Early CAI Projects

The conclusion from Stake's philosophy was not universally accepted by CAI practitioners. Early CAI was also aimed at research into structural strategies, materials development, learning styles and similar investigations. CAI was used as a tool for research as well as for instruction as shown by the projects:

(i) CLASS Project

Based at Systems Development Corporation in the United States, CLASS was established

'to provide an opportunity to explore the important interactions among instructional method, student, and subject matter variables.'

(ii) PLATO-II (Programmed Logic for Automatic Teaching Operation)

Based at the Coordinated Science Laboratory at the University of Illinois, listed as its main goal:

' development of an automatic teaching system sufficiently flexible to permit experimental evaluation of large variety of ideas on automatic instruction.' Bitzer [32].

The PLATO system has a long history, from 1960 with one terminal PLATO I, up to the National Science Foundation funded PLATO IV of 1971 with 950 terminals located at about 140 sites and about 8000 hours of instructional material contributed by over 3000 authors.

Alpert [33] listed the aims of PLATO IV as:

*' to demonstrate the technical feasibility of a truly novel computer-based education network
to prove that the system is manageable, economically viable, and capable of serving a variety of institutions at any educational level
to develop curricular materials for the new medium
to develop acceptance by instructors-users and students of a new medium designed for increasing the effectiveness and productivity of the instructional process.'*

(iii) TICCIT (Time-shared Interactive Computer Controlled Information Television) Project

Funded by the National Science Foundation of America (NSFA) in 1971 and managed by the Mitre Corporation, the purpose of TICCIT was to design and develop hardware and software for a computer-assisted learning delivery system.

The aim of the project was to demonstrate that computer assisted learning:

' can provide today better instruction at less cost than traditional instruction in community colleges', [33].

TICCIT was not designed as an addition to regular classroom teaching but as the main source of the delivery of instruction.

(iv) Bolt, Beranek and Newman Inc.

A dual purpose project described by Licklider [34], as:

'our serious purposes, of course, are research and development: research on learning and teaching; development of a practical and economical system.'

4.2.5 Relevance of Early CAI To Fiji

The early projects discussed in the last section represent the trends of CAI. An important aspect of early CAI is the application of computers in research and development. Fiji could have used the opportunity provided by the introduction of computers to examine and bring about changes in the education system. Instead it did not take advantage of the opportunity. Bunderson's model [28] for development of instructional materials for CAI includes the task of:

'specifying the social and institutional needs to be addressed by CAI'

This was lacking in the application of computers in Fiji education, (see Appendix C). The government initiated the move to bring computers into schools and funded the exercise but did not specify the 'social' or 'institutional needs' to be addressed by computers. The lack of any thinking or planning before the event was the main source of problems during the formative period of computers in Fiji education. The early aim of CAI, that of replacing teachers with computers, was implied when the government in Fiji reduced teacher training, introduced volunteer untrained teachers and introduced computers into schools. Had the government spent time to analyse the situation properly, educational benefits would not have suffered for the price of computerisation. In fact computerisation did not take place, the computers in education in Fiji

in the early 80's served a political purpose. It was an attempt to gain some political mileage by politicians at the expense of educational benefits. Problems experienced in education in the early years of computers have already been discussed in the previous chapter.

4.3 Computer Hardware

There are opportunities for mathematical experiences in discussions of computer hardware without real or practical access to the hardware. This could be employed in situations where hardware is not available and an introduction to computer technology is considered beneficial. Developing countries like Fiji should explore the opportunity of studying about computers, if unable to provide the resources for purchasing hardware. In this instance the benefit of studying mathematics of computers will be twofold: learning mathematics and gaining some knowledge of computer technology. Like most technologies, the technology of computers is full of mathematics (see Appendix H). A description of the hardware is considered necessary and is given here.

Hardware Description

A description of the hardware system that is to be available for teaching mathematics is considered necessary in this instance for two main reasons:

- (i) it is useful to know something of the physical features of the system referred to in the succeeding discussion
- (ii) a computer hardware discussion can provide opportunities for mathematical exercises.

Computers are classified into three main categories: mainframes, minicomputers, and microcomputers. Classification criteria used vary but in general:

mainframes are large and costly

minicomputers are middle of the range

microcomputers are portable, inexpensive, and can be found in homes

and schools.

The profound effect of computers in everyday life is due to the advent of microtechnology making microcomputers very powerful and affordable by many people. It is the arrival of microcomputers on the scene that has enabled developing countries in the third world to benefit in some way from computer technology. From here on any references to computers, unless specified otherwise, will be taken to mean microcomputers.

Figure 4.1 is a schematic diagram of a simple computer system. Simple in the sense that the four boxes shown include all the hardware that is required to carry out mathematics teaching in the classroom.

There are facilities for extending the system, which could be useful to

Extension Courses offered at the University of the South Pacific in Fiji (USP).

The concepts of local area network and computer communication can be of use to the Extension Services of the USP. This is an area needing research at USP and is beyond the scope of this thesis.

The Central Processing Unit (CPU)

The CPU is the heart of the system and it consists of three sub-units, see

Figure 4.2

(i) Memory

This holds the Program which runs the computer and part of the Data being processed.

Memory comes in two versions:

- (1) Read Only Memory (ROM) which holds data and program that can only be read.

Data and programs cannot be written to ROM without any hardware modifications.

When power to the system is switched off, data and programs held in

ROM will remain.

(2) Random Access Memory (RAM) is operational only when power to the system is switched on.

Data and programs can be written to RAM by software and will be erased when power is switched off.

Because of the speed of processing, programs and data need to be in memory, (RAM), immediately before execution.

To fetch data and commands from external storage immediately before execution will have a considerable effect on the speed of processing. Data is fetched from external storage and put in RAM from where it is fetched to be processed. Any data or programs in RAM that will be required at some later date is transferred to external storage before the system is switched off. Sizes of computers are quoted in the number of binary digits the memory can store. Confusion arises when the user/purchaser is not aware of the difference between ROM and RAM. The non user should really be concerned with the size of RAM which effectively, is the available memory. The processing power of the computer is related to the size of its memory. Microcomputers have storage capacities ranging from one kilobyte(1K), which is capable of storing one thousand bytes in memory at any one time, to some with a memory capacity of 1 megabyte capable of holding one million bytes.

(ii) Control Unit

The Control Unit sequences through the program and delegates instructions to the other units of the system. In the control unit are three types of registers which hold data:

- (1) instruction register - this holds one instruction of the program while it is being analysed. The analysis will delegate the instruction to another unit.
- (2) instruction counter - this holds the address, in memory (RAM), of the

instruction being analysed.

(3) status register - contains the current state of the computer and the result of one or more of the previous instructions.

(iii) Arithmetic and Logic Unit (ALU)

The arithmetic and logic unit processes data with arithmetic or edits operations when requested by the program.

A command is either to:

move data about

do arithmetic

or make a decision.

How Computers Operate

Two phases of operation describe how the computer operates, Fetch and Execute.

The computer alternates between two phases.

(1) Fetch

The computer enters this phase when control recognises completion of a command. The instruction counter register provides the address of the command just completed.

The address of the next command is obtained by adding one to the address of the command just completed.

The new command is sent to the instruction register and the computer has a new instruction to execute.

(2) Execute

The control sub-system analyses the new instruction and determines where to send it. The control also determines where to get the datum to be processed, and this is routed from memory to the processor for processing.

On completion signals are sent to the control sub-system which responds by entering the Fetch phase.

The Display Unit

Some microcomputers especially those commonly found in homes use a television set to display data. Some with special modifications use monitors giving a sharper display. Display can be in colour or black and white. The colour facility depends on the circuitry of the display unit as well as the capability of the CPU to activate colours. Graphic capability in a display is a special feature which depends on programs that can create images. The display is a cathode ray tube and the visible part is normally referred to as the screen. The screen is normally rated according to its diagonal length with a standard aspect ratio of height to width usually about 3:4. The conventional printed page is usually the opposite with the height greater than the width. Screen sizes range from 4" to more than 12" with monitors and television screens going up to 26". Characters are normally displayed in 25 lines of 40 or 80 characters per line.

Screen Layout (FIGURE 4.3)

The screen is divided into horizontal rectangular rows and vertical columns. The intersection of a column and a row is a cell where a character may be displayed. Screen capacity is the number of cells (rows x columns); e.g. for 25 rows of 40 characters, 1000 (25 x 40) characters can be displayed.

Cell Display Method (FIGURE 4.4)

The character in a cell is normally displayed by a matrix of dots. Dots are put close together in a cell to form characters. The number of dots in a cell determine the detail outline of characters. Typical dot matrix sizes are 5x7(5 dots across and 7 dots high), 7x9, 7x11 and 9x14. The more dots used the more expensive is the technology required to provide them. FIG 4.4 shows how the letters are formed in a 7x9 dot matrix. Adjustments to the number of dots are made to accommodate letters with tails, upper and lower cases and spaces between the letters, and between the rows of letters. On power up a cursor appears on

the screen to identify where the next character will be displayed. The transmission rate of data between the computer and the display screen is measured in bauds which are approximately equal to bits per second, (bps). Rates vary between 300 and 39,000 and a rate of 9600 bauds is common. For a standard display screen of 24 rows by 80 characters (= 1920 bytes), with a transmission rate of 9600 bauds (= 1200 bytes per second), it takes about 2 seconds to fill a screen.

The Keyboard

The basic function of the keyboard is to communicate data from the human operator to the computer. Other methods of communicating data from the human operator to the computer include the mouse, as well as graphic and analogue devices. The keyboard generates codes for the characters entered. Characters entered are represented as sets of 8 bits (or 1 byte), see Appendix G for codes. The keyboard is similar to the typewriter with some extra characters. Most keys, especially those common to both typewriters and computer keyboards, when pressed display on the screen. Control keys and others that have no display when pressed have special functions which vary according to the manufacturer.

The Printer

Several types of printers are available:

- (i) The augmented electric typewriter was the earliest form of automatic printer, where an operator hit a key activating a mechanism which was electrically propelled to cause printing. A computer was put between the keyboard and the printing device and the output rate was no more than 15 characters per second, (cps).
- (ii) The dot matrix printer - prints at a much faster rate between 40 to 500cps. Printing is achieved by a set of pins, (dot matrix), arranged to form characters to be printed. The poor quality of print is

compensated for by its speed and low cost.

- (iii) The daisy wheel printer - prints at between 12 to 160cps, providing high quality printing suitable for word processing. Unlike dot matrix, the daisy wheel printer is not suitable for graphics printing.
- (iv) The line printer - prints one line of text at a time instead of one character like most other printers. For this reason it is very fast running, printing between 300 to 3000 lines per minute.
- (v) Laser printers - belong to a new technology and are more sophisticated than the others and more costly.

The External Storage

Initially the tape drive was popular due to the cost of disk drives. With the decline in cost disk drives are more in use leaving the tape drive to computer games enthusiasts and home users. Floppy disks and more recently hard disks are much faster than tapes due to the way data can be accessed. With tape drives data can only be accessed serially, whereas with the disk drive, because of its physical structure, any part of the disk can be reached without accessing any other parts. Floppy disks come mainly in two sizes, 3.5 and 5 inches. Modern microcomputers have the floppy disk drive built into the same casing as the CPU and the keyboard. Floppy disks are removable and data and programs written on disks stay on them until erased. Hard disks are not removable, and have a faster access time.

4.3.1 Hardware Contributions to Enhance Mathematics Teaching

The power of the computer to enhance mathematics teaching and learning comes mainly from the sophistication of software supported by hardware capabilities. Some characteristics of the hardware also enhance the teaching situation.

Physical Attributes

The display screen which performs the functions of the traditional blackboard has certain advantages over its traditional counterpart.

- (i) It is clean and not dusty and displays text and graphics clearly and accurately.
- (ii) Because of the size of the screen it is easily portable, making it easier to reorganise the teaching situation if necessary.
Blackboards are usually fixed and those on wheels are normally too bulky to move and relocate. A disadvantage presented by the physical characteristics is the size of display. The display cannot be seen by a large audience in a demonstration situation. This can be overcome by using more than one screen wired to one computer, but this may prove expensive. There are large screens available, but the author's experience with a 70 inch screen was not very satisfactory due to poor definition.
- (iii) The screen display method provides a ready drawn cartesian coordinate system which is useful in teaching mathematics topics like coordinate geometry. The display of a coordinate point on a blackboard involves the ability to draw straight lines quickly on the board sometimes without a ruler.
- (iv) The display screen is attractive in the sense that when the display is updated the screen has a blinking effect which tends to attract the inattentive user.
- (v) The compactness of the system, which can be fitted in a booth, gives a feeling of privacy to the user. Some users welcome the compactness and privacy enabling them to concentrate on the learning tasks. Mistakes can be corrected without attracting public attention and good work put on permanent record on printer or external storage.

4.3.2 Computer Mathematics Without Hardware

A detailed discussion on hardware will reveal many instances of mathematical exercises. In this way the study of hardware can contribute towards mathematical study and vice versa. Many topics in computer science involving mathematical concepts and problem-solving skills can be experienced without access to computing facilities.

Developing nations like Fiji with scarce resources should take advantage of the opportunity to prepare students for the time when hardware would be available. Schools in rural areas of Fiji are mostly primary schools with very little modern educational technology. Rural electrification has been a national project for several years and it will be many years before it is complete.

Computers will definitely not materialise in rural primary schools in Fiji for a long time to come, but rural primary school pupils of today will be expected to wrestle with computers in the future. Schools in Fiji, with or without access to computer hardware, should prepare pupils for the future by including computers in their school experience even if it is only through mathematics.

Suggestions and sample lessons in teaching computer mathematics without computer hardware are given in Appendix H.

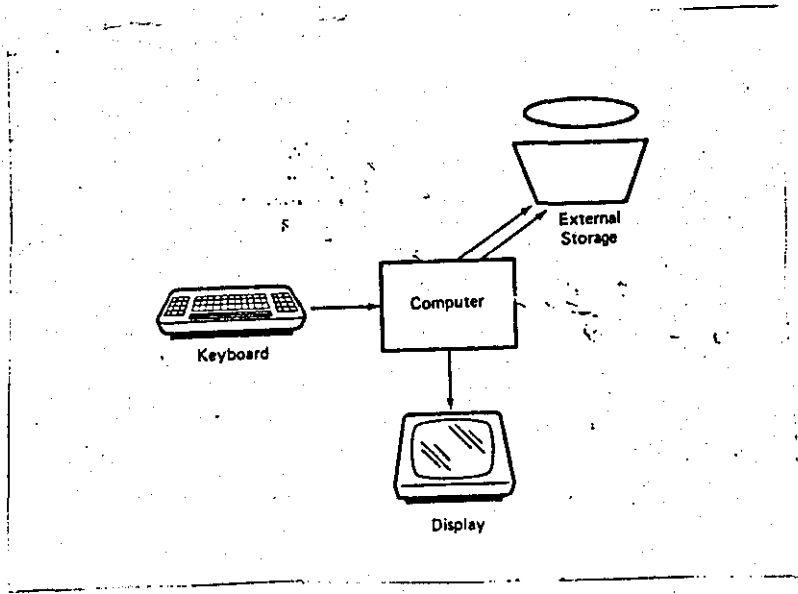


FIGURE 4.1

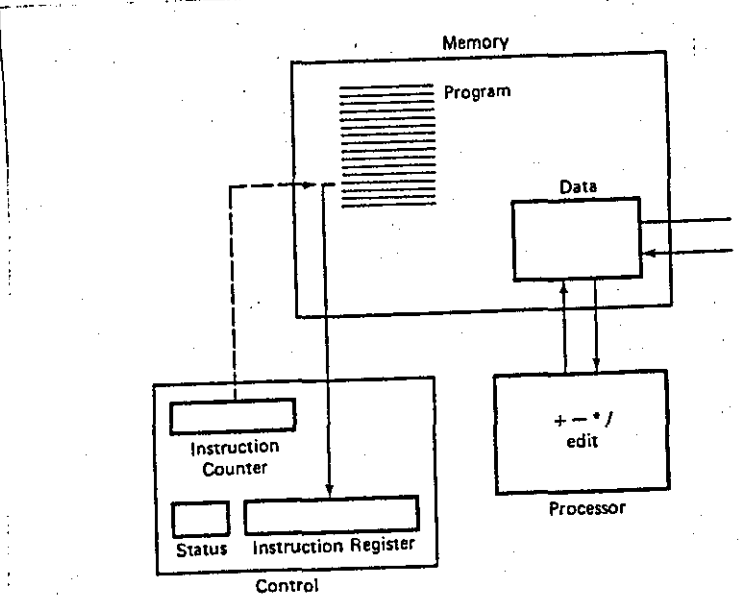


FIGURE 4.2

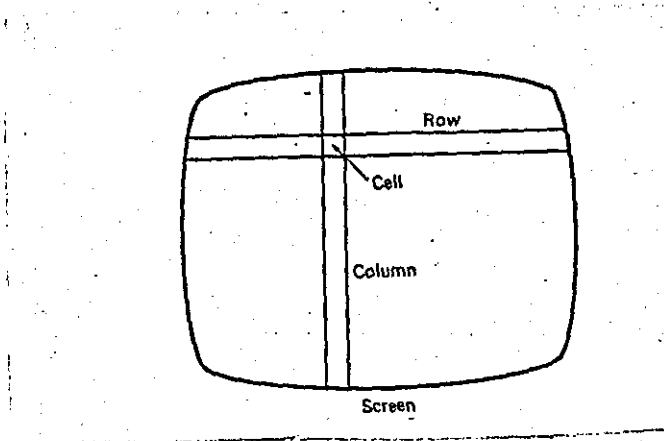


FIGURE 4.3

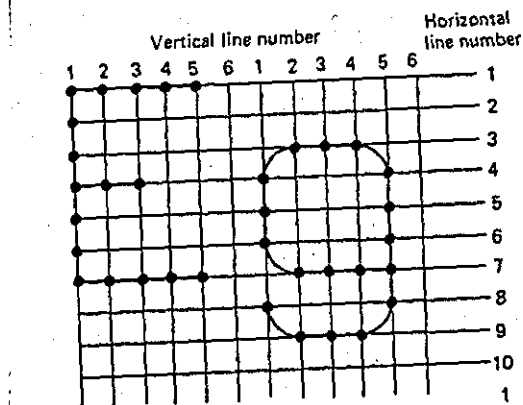


FIGURE 4.4

CHAPTER 5

5 THE ELECTRONIC SPREADSHEET:

A SOFTWARE PACKAGE FOR MATHEMATICS

There are many types of computer software used in mathematics teaching and learning. The software can be classified as good or bad, or, easy or difficult. It may be good to one teacher and not so good to another. Computers in mathematics teaching are not equally acceptable to all teachers, and some may find programs too difficult to operate, providing them with an excuse to avoid using computers in their lessons. Software for mathematics can also be classified into the mathematical topics it supports, but the problem here is that some software may support more than one topic. Another classification is the grouping of programs into primary, secondary and post-secondary mathematics education. This method is suitable where the transition from one stage of mathematics education to another is well defined. Software can also be classified into the type of learning and teaching style they are intended to support. The Cockcroft Report [33] published in Great Britain in 1983 suggests a variety of teaching styles needed at all level of mathematics teaching.

'Mathematics teaching at all levels should include:

exposition by the teacher

discussion between teacher and pupils and between pupils themselves

appropriate practical work

consolidation and practice of fundamental skills and routines

problem solving, including the application of mathematics to everyday situations

investigational work. ' [33]

The current trend of mathematics software supports one or more of the styles of teaching defined in the Cockcroft Report.

5.1 Software Development

Early educational software concentrated on simple teaching techniques which were found to be procedural and easily adapted to automation. Programmed Instruction (PI) was identified as ready made for automation. The early software was found wanting, but the simplicity of the approach and ease of writing drill and practice exercises have made the early computerised assisted learning programme techniques popular. Computer software has gone through several generations of development and labels like:

Computer Assisted Instruction (CAI)

Computer Assisted Learning (CAL)

Computer Managed Learning (CML)

Computer Illustrated Text (CIT)

Computer Based Learning (CBL)

and the latest, coined by Professor Bajpai of Loughborough University, Computer Enhanced Learning (CEL) [1]. The labels are descriptive of the type of learning situation the software is intended for.

The need for careful thought by authors and programmers when producing software for enhancing learning cannot be overemphasised. Most commercially produced computer-assisted learning material is of poor quality due to its lack of learning theories. The situation has tended to deteriorate since the advent of inexpensive microcomputers with limited memories. Hartley and Bostrom [34], in a survey in 1982, offered 91 programs to teachers in four large secondary schools in an attempt to gain the teachers' evaluation of existing computer assisted learning programs for microcomputers. Only fifteen programs were taken up by the teachers, the rest being considered irrelevant, inflexible, inaccurate or difficult to use. Those accepted by the teachers were mostly simulations written in Basic and were used in the main to consolidate previously taught concepts.

There is much educationally poor quality computer software on the market today. This is a source of concern for places like Fiji, which do not have the facilities and resources to develop or evaluate their own software. They run the risk of becoming a dumping place for poor quality material from elsewhere.

Educational software design principles should cater for a wide range of users and applications in addition to basic considerations like educational value and screen layout. There are three types of users :

- (i) the individual student
- (ii) the individual teacher
- (iii) groups of students with or without a teacher.

The range of applications should cater for different users and the different teaching and learning styles which in mathematics were recommended by the Cockcroft Report [33].

A critical issue in computer assisted instruction is the development and sharing of quality software. Bajpai [1], in his concluding remarks, stresses the high cost of quality software production and the need for cooperation and communication between computer users in education. With this philosophy of software design, and an emphasis on sharing, Fiji and other developing countries can greatly benefit by sharing the software developed by countries which have the resources and the expertise. Sharing will mean either:

- (i) the system in developed countries is duplicated by places like Fiji
- or
- (ii) Fiji and other developing countries take the ideas from developed countries and modify them to suit local conditions.

The author believes the second to be more beneficial to Fiji. This point is discussed further in the next chapter on conversion of computer software from the BBC microcomputer to the Atari ST microcomputer. Bajpai et al [6] list some

DO's and DON'T's when writing software:

- (i) do have a definite aim for the software unit
- (ii) do ensure the mathematics is correct
- (iii) do involve the teacher
- (iv) don't use the micro as a textbook
- (v) don't use the micro as a conventional blackboard
- (vi) do excite the user
- (vii) do be consistent
- (viii) don't neglect clarity of screen display
- (ix) do provide good documentation
- (x) don't forget the micro novice
- (xi) don't forget the validation of your software.

The Do's and Don't's listed above provide some criteria for evaluating software.

Computer Facilities Available To The Programmer

The computer offers unique opportunities as a teaching aid. Unless these opportunities are used to the full in educational programs there will be a grave misuse of resources. If a task can be adequately carried out without the use of computers it is totally wrong to go and computerise the task. Computer technology in education should not be applied for the sake of technology, but for the enhancement of education. This consideration is most important to developing nations like Fiji, which need to maximise benefits derived from scarce resources. Microcomputers of today have the power and ability of the large and expensive computers of the past at a very reduced cost, due to the development of microchip technology. Their power and sophistication give the educational software developer a vast array of teaching and learning styles to explore. Some of the computer characteristics will now be considered.

Graphics and Animation

Pictures say more than words and the high resolution graphics of microcomputers

give a very accurate and more convincing graph than one drawn by hand, see FIGURE 5.1 There is in computer animation a precision of line and smoothness of movement that manages to convey the essence of mathematics itself. With conventional graphics students see only particular examples of the mathematics they study, but with computer generated graphics they see mathematics in action. For example, to understand fully the quadratic function:

$$y = ax^2 + bx + c$$

a study of a whole family of parabolas is necessary. FIG 5.1 shows a set of four such parabolas. With computer animation the transition of the parabola from one shape to another can be viewed, and the intermediate stages studied. An appreciation of the intermediate stages is important to allow students to grasp the idea that there are an infinite number of parabolas each corresponding to particular values of a, b, c in the quadratic function, $y = ax^2 + bx + c$.

FIGURE 5.2 taken from a computer display screen, will convey more information about the quadratic function than one drawn on paper, slide or blackboard. A video film might show the build up in animation, but it will be the same curve at every screening of the video. The ability to vary parameters in a computer program has a definite advantage over the same pictures provided by a video film. Harding [35] describes the use of computer graphics:

∴ the ability to display results in graphical form added a new dimension to the computer's capability. If results had to be obtained in printed numerical form, the speed with which the qualitative aspects of the results could be absorbed would be lost. This would discourage most students from attempting more than a very small number of cases, with corresponding loss of educational value.'

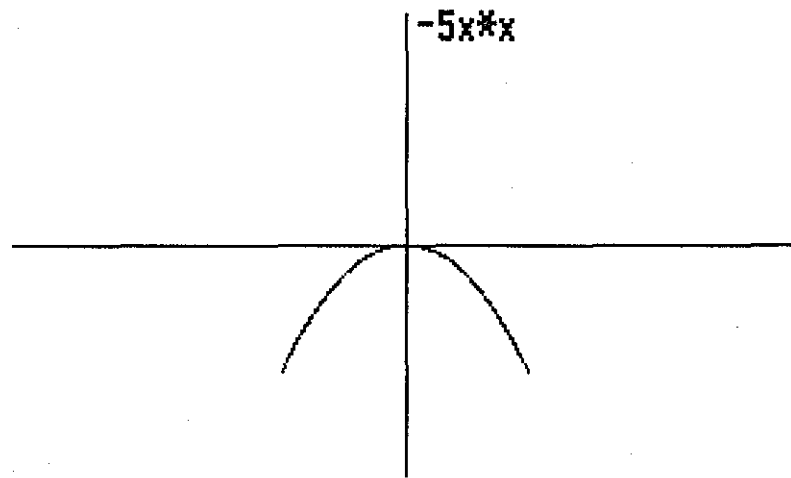
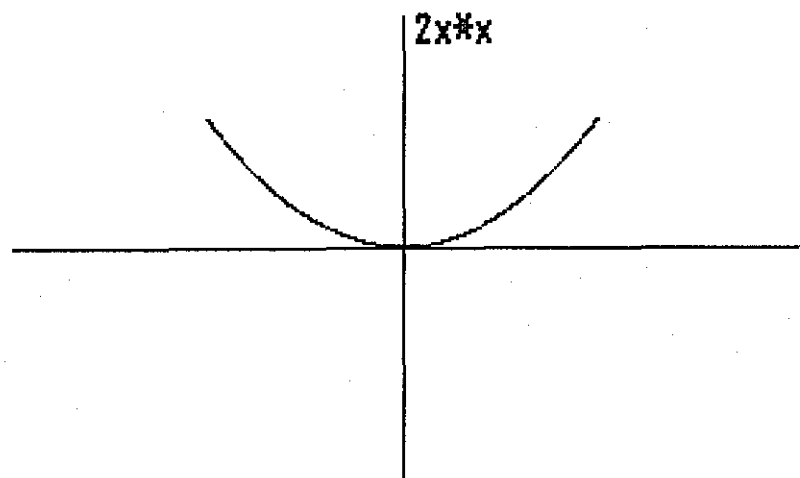
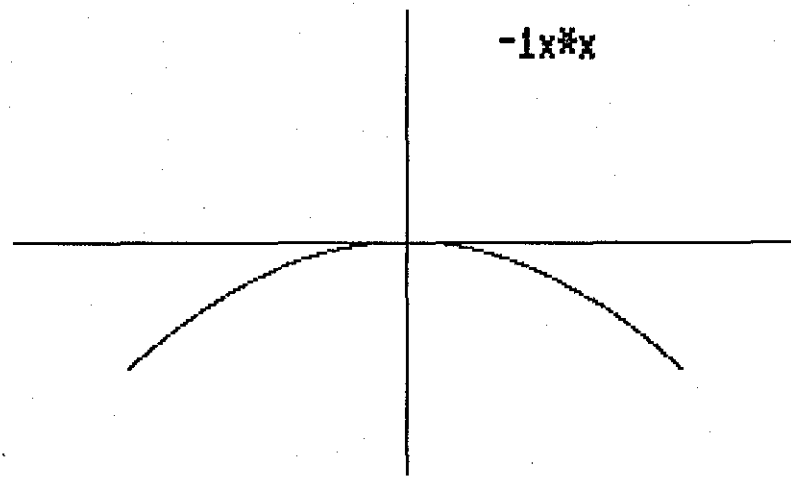
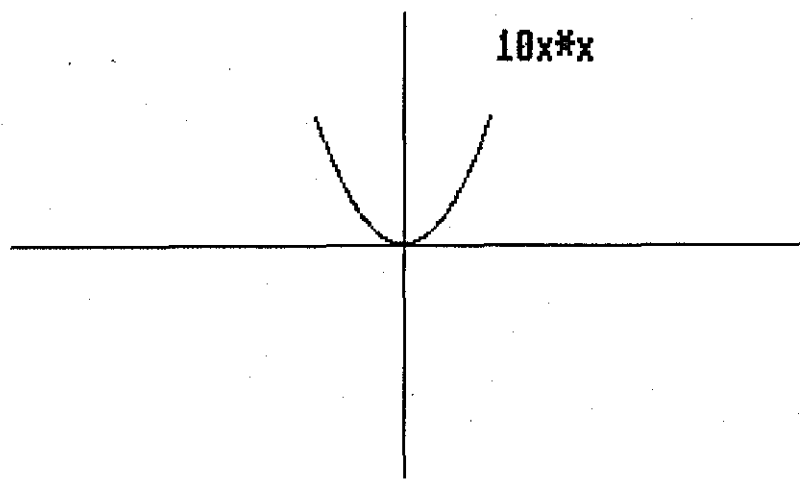
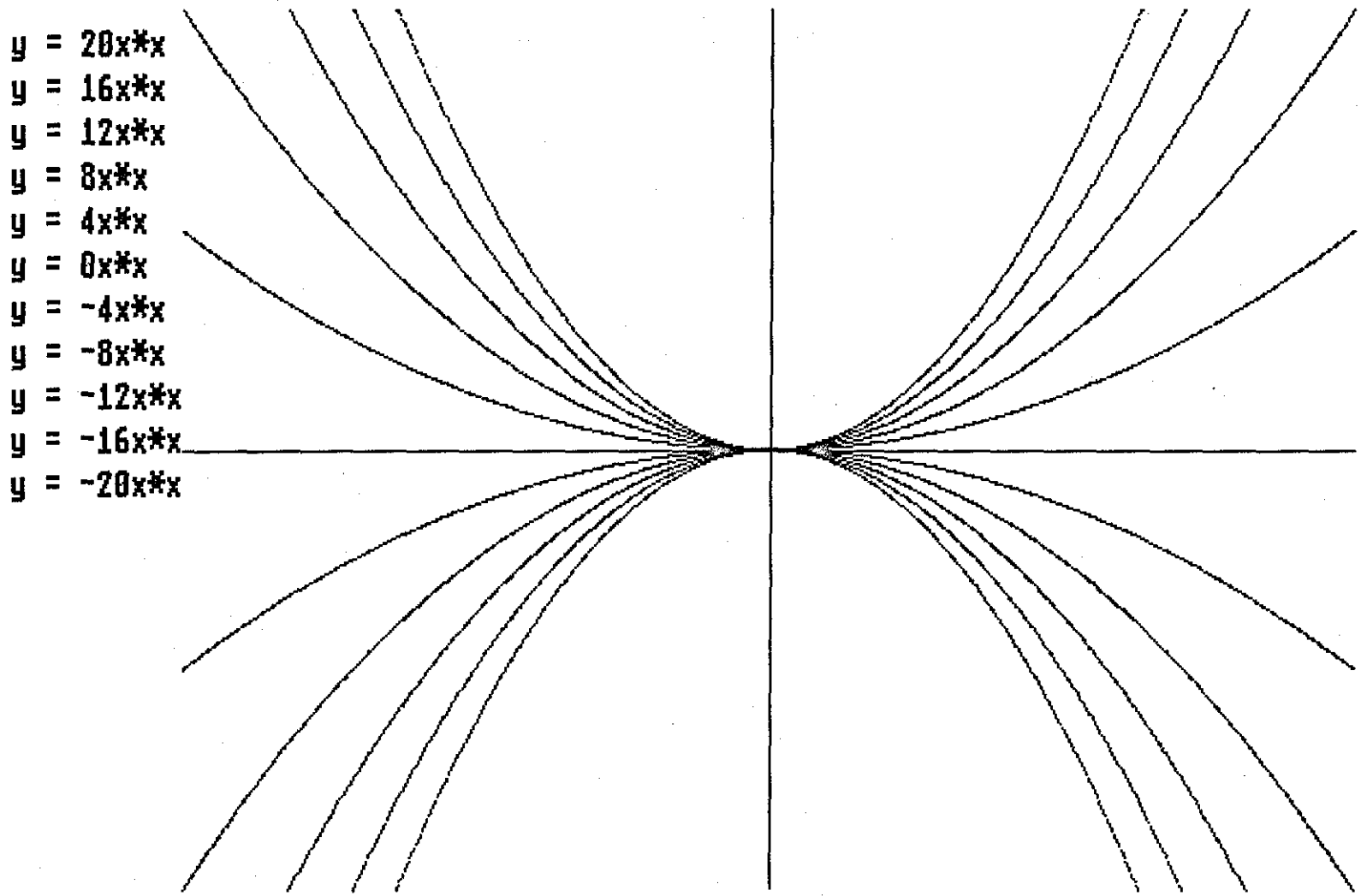


FIGURE 5.1



- y = 20x*x
- y = 16x*x
- y = 12x*x
- y = 8x*x
- y = 4x*x
- y = 0x*x
- y = -4x*x
- y = -8x*x
- y = -12x*x
- y = -16x*x
- y = -20x*x

FIGURE 5.2

VECTORS

PART	CONTENTS
0	Inexperienced user guide
1	DISPLACEMENT VECTORS
2	EQUALITY AND OTHER EXAMPLES
3	ADDITION AND SUBTRACTION
4	MORE ADDITION/SUBTRACTION
5	PERPENDICULAR COMPONENTS
6	RESULTANTS
7	3-D CARTESIAN VECTORS
8	SCALAR/VECTOR PRODUCTS
9	Exit from unit

Enter number, then press RETURN

VECTORS

current status

0	Inexperienced user guide
1	DISPLACEMENT VECTORS
2	EQUALITY AND OTHER EXAMPLES
3	ADDITION AND SUBTRACTION
4	MORE ADDITION/SUBTRACTION
5	PERPENDICULAR COMPONENTS
5.1	Resolution into two perpendicular components
5.2	Example of force components
5.3	Example of velocity components
5.4	2-D cartesian vectors
6	RESULTANTS
7	3-D CARTESIAN VECTORS
8	SCALAR/VECTOR PRODUCTS
9	Exit from unit

FIGURE 5.3

137a

Loughnane [36] describes the use of high resolution graphics to 'drive home' a mathematical technique that has already been dealt with in the traditional lecture and concludes that this is extremely effective. He further identifies three interesting points during an investigation into teaching mathematics with high resolution graphics

- (a) Students who enjoyed computing tended to improve their standard of mathematical reasoning.*
- (b) Students who were naturally shy found it easier to ask the computer a question rather than ask the teacher.*
- (c) Students tended to take a greater interest in mathematically related areas following exposure to the algorithms." [36]*

Colour

Coloured images are more appealing than monochrome images. Features that are not visible in monochrome become apparent when coloured. Colour enables parts of the screen to be highlighted to emphasise text or graphics.

FIGURE 5.3 ^{are two} screen display^s from a MIME (Micros In Mathematics Education) Project Unit on Vectors. The program is discussed more fully later in the next chapter. The display^s shown in FIGURE 5.3 adds one more option to the 4 colours available by allowing some parts of text to flash on and off to attract attention. Films and texts can be attractively coloured but they are static compared to coloured computer outputs on screen. Computer screen colouring is flexible in that a colour can easily be changed and areas filled in at the touch of a key and this can be taken advantage of to attract attention. Microcomputers can have 2, 4 or 16 colours available for display at the same time depending on the screen mode available. A curve and its function label in FIGURE 5.2 can be displayed in the same colour to draw attention to their correspondence, while

different curves can be in different colours. In FIGURE 5.3, correspondence between label and Vector is shown by flashing the label while the vector is being drawn. However, there is a danger in using colour just for decorative purposes as this can be unimaginative, irrelevant and even distracting.

Sound

Sound, like colour change, attracts attention. It can be used to remind the user to respond to a prompt from the program or draw attention to an incorrect or correct input. Spelling checkers in some wordprocessors use sound to indicate when a wrong spelling is encountered. Sound generators of microcomputers can be programmed to make sounds indicative of the mood of the interaction between user and program. Some people may argue that sound on microcomputers distracts users and is unnecessary. By the same token it is accepted that noise is present in a technological environment so why not make the sound meaningful in a computer environment. For young learners sound could enhance a dull presentation.

Speed

The speed of response of computers is evident in most programs and especially in games programs. In mathematics, speed of calculation can be used to great advantage. Tedious arithmetic calculation which could distract the learner from the concept being studied can be carried out easily by the computer. This leaves more time to concentrate on the task of understanding the concepts involved.

Speed of calculation and presentation of output is taken advantage of in FIGURE 5.2, where the values of the function $y = ax^2$ are evaluated for a range of x and also for a range of values of a . The diagram represents the value of the function: $y = ax^2$ for $a = \pm(20, 16, 12, 8, 4, 0)$ and for x from -10 to 10 at intervals of 0.1 . For each curve in FIGURE 5.2, 2000 values of y have to be calculated and plotted. To increase the interval size from 0.1 to 0.5 thus

reducing the number of points to be plotted will distort the curve.

There are 11 curves requiring $11 \times 2,000 = 22,000$ calculations and points to be plotted. The computer completes all calculations and the drawing of the curves in less than a minute. To do this amount of calculation by hand, even with the help of a hand calculator, is a daunting job. The best one can hope for, doing it by hand, is to use an interval of 0.5 or even 1, which would provide a sketchy curve. With the speed available on a computer the variation of the shapes of the graphs can be instantly appreciated. The fuss and delay experienced when working without computers tend to shift the focus of thinking from the initial objective of the exercise, which is the study of parabolas, to that of calculating coordinates and plotting points.

It is not to be assumed that there is no place for plotting graphs by hand. This is still a worthwhile exercise in its own right. Once the concept of how a function defines points has been established, curves of other functions can then be studied. There are instances when the plotting of the graph is not the main topic of instruction and that is when the use of computers for a quick display of the graph is unrivalled.

The speed of computers is also useful for simulating time consuming processes. An activity often used in the teaching of probability is that of rolling dice. Students are asked to roll a pair of fair dice and add the numbers showing on the upturned faces. The results of the whole group are pooled and the students are asked to draw a relative frequency histogram of the collective result. The resulting histogram is then used to estimate the probability that the sum of the two upturned faces is say 7. A major problem in this activity is the lack of time and the monotony experienced by students when throwing the dice. The maximum number of throws which can be expected from two students, one throwing and the other recording, cannot be more than 100, and from a class of 40 (a

normal class size in Fiji), this would add up to 2000 at the most. To perform and collect all the results would thus take the best part of a 50 minute lesson. Then the class would probably be asked to draw the histogram for home work. Probability theories are better demonstrated by results of a vast number of trials or experiments, which are easily simulated by a computer. Small samples tend to inhibit any realistic results being derived. The speed of computers allows the simulation of large number of throws. FIGURE 5.4 a,b,c,d show the results of 100, 500, 5000, and 10000 throws. As in the study of parabolas, once the basic concepts of the derivation of the histogram from data, as in the homework, is understood more realistic results can be obtained using the computer. The availability of the random number generator of the computer enables the simulation of random selection necessary in the study of statistics and probability. There is a place and need for students to carry out the experiment of throwing the dice and drawing the histogram. But to make the idea of say symmetry convincing a computer simulation is essential. An investigational approach to learning is another teaching mode made feasible by the fast data access time of computer systems. Fast access time, the ability to store vast amounts of information and the graphics ability of computers can create a lively environment for mathematical investigation. An extension of this feature using interactive disks is being developed but may prove too expensive for Fiji.

Interactive Ability of Computers

Colour, graphics, animation and speed all combine to give the microcomputer some of its unique features. These unique features are supplemented by its interactive ability. The computer is able to recognise that a certain numerical quantity is less than, greater than or equal to another mathematical quantity.

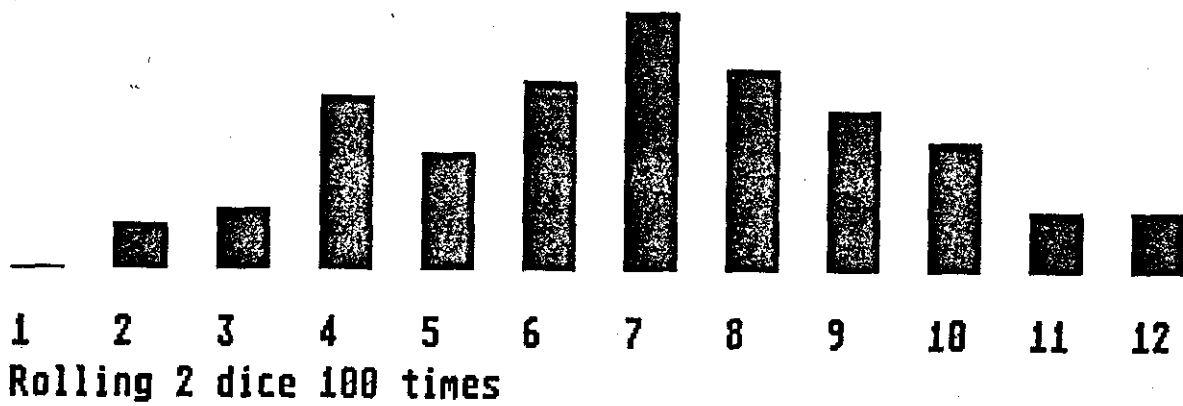
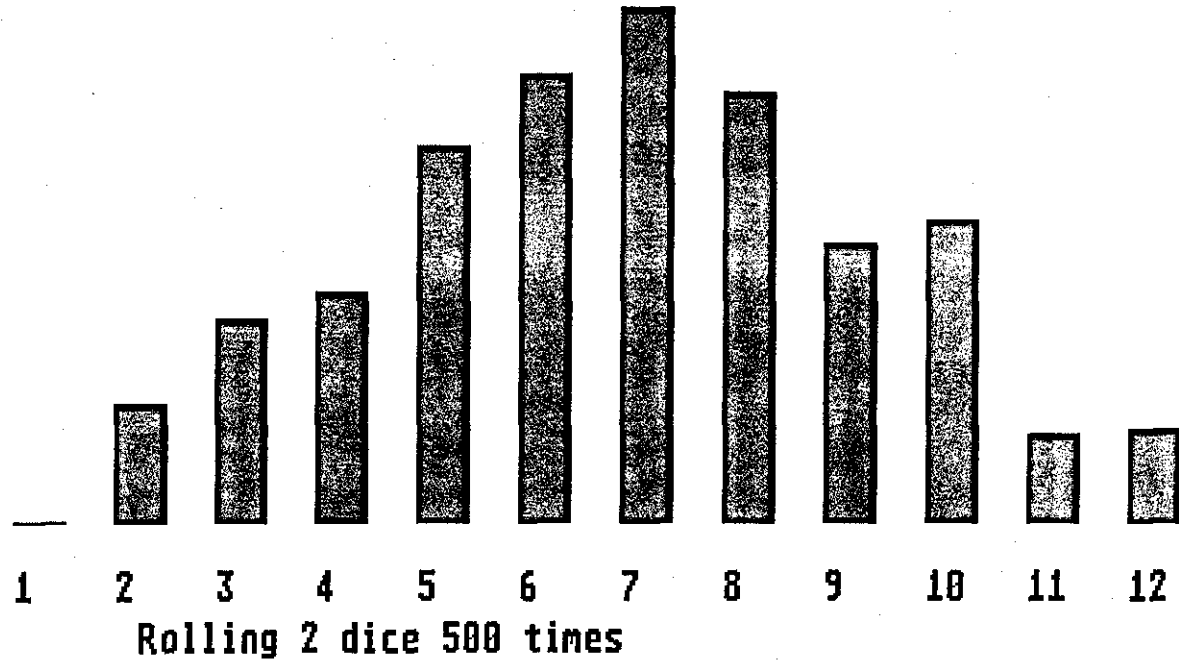


FIGURE 5.4a

FIGURE 5.4b



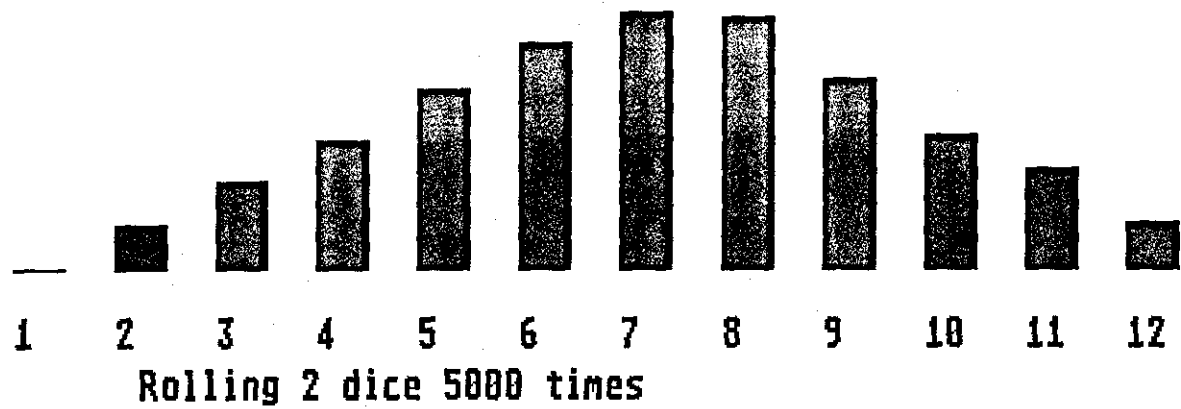


FIGURE 5.4c

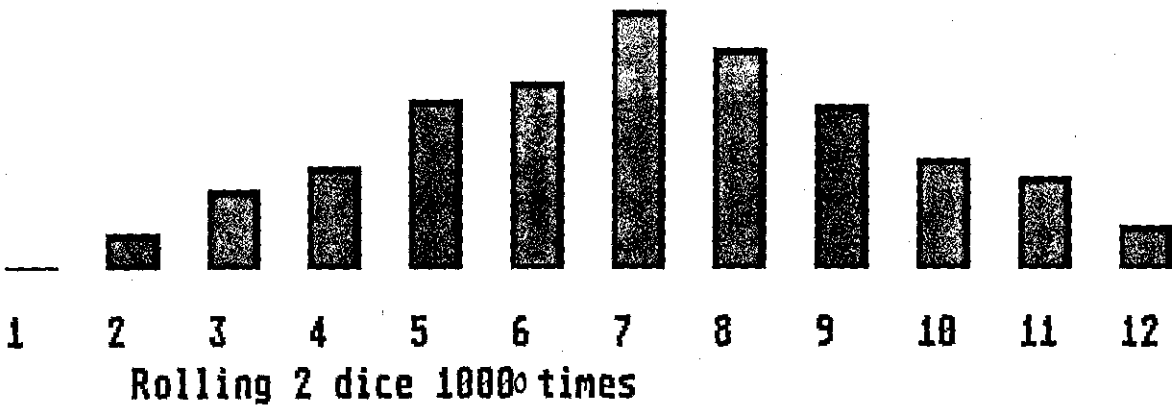


FIGURE 5.4d

After identifying the relationship between quantities the computer is capable of selecting an item from a number of options offered. It is able to respond to prompts from the user and is also able to prompt the user into making a selection from a given set of options. The interactive ability of computers enables programs to be written which employ a menu driven format, where options are offered to the user. The user makes a selection and the computer responds by executing the selected routine. This feature gives the computer a dramatic improvement over earlier teaching machines. The use of interactive programs gives the feeling of communicating with the computer. FIGURE 5.5 is a menu from a MIME Project Unit translated to an Atari ST. The menu offers several options which are highlighted by a different colour from that of the background. Selection is made by the user manipulating a pointer with the use of a mouse and is indicated when the option selected flashes. The selection is confirmed by clicking the mouse telling the program to execute the chosen (flashing) option routine. FIGURE 5.6 is another display from the same MIME Project Unit as that in FIGURE 5.5 and the choice of option can be made with the mouse or keyboard. The choice is displayed by the program and deletions of the choice are possible either with the Backspace key on the keyboard or clicking the mouse on ERASE. Termination of inputs is indicated by the Return key on the keyboard or clicking the mouse on RETURN. The interactive ability of the computer enables the setting up of an investigative environment in the teaching and learning situation. Drill and practice is made possible with the ability of the computer to interact with the user. Simulations and answers to 'what if' situations are possible with an interactive mode.

V E C T O R S

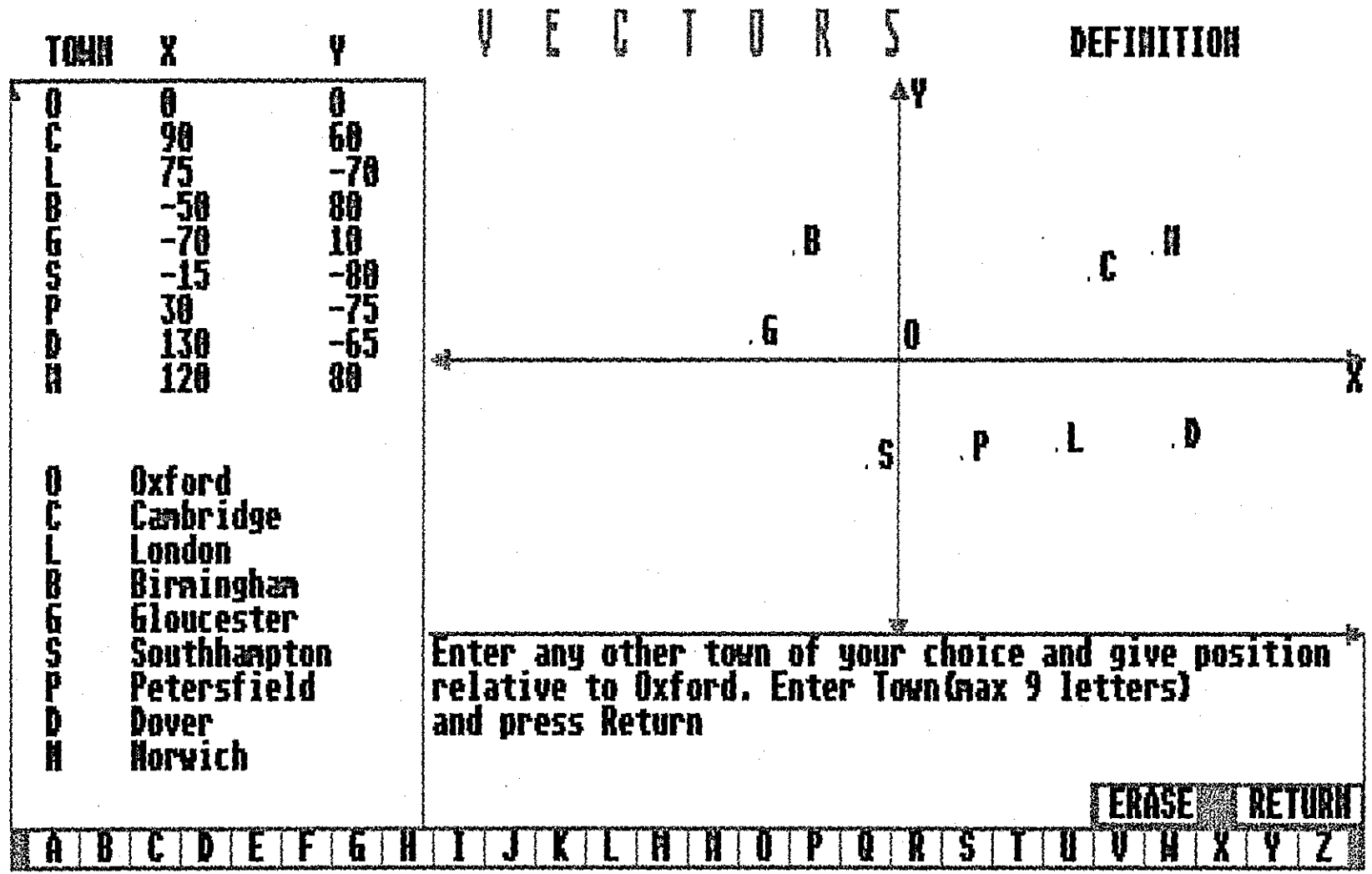
C O N T E N T S

Part 1	Displacement Vectors
Part 2	Equality and Other Examples
Part 3	Addition and Subtraction
Part 4	More Addition/Subtraction
Part 5	Perpendicular Components
Part 6	Resultants
Part 7	3-D Cartesian Vectors
Part 8	Scalar/Vector Products

Q U I T

FIGURE 5.5

FIGURE 5.6



Computer Enhanced Learning (CEL) programs, as defined by Professor Bajpai, try to exploit to the full all facilities offered by the computer to enhance mathematics learning in a way that is only possible with the use of computer technology. The philosophy of CEL programs encompasses all that is possible with the hardware - speed, colour, interaction, sound, animation and much more. With the current rate of development in hardware technology software technique lags very far behind.

5.2 Computer Software Styles

Drill and Practice and Tutorial

The early application of computers to mathematics education was to automated drill and practice. This was a result of the method employed in the selection of areas for computerisation which sought out education practices that were procedural, and drill and practice were identified as such. Even though drill and practice have been found wanting as a teaching technique, they have remained popular due to their simplicity. The popularity of drill and practice has been reinforced by its inclusion in Paragraph 243 of the Cockcroft Report of 1983

[33] A routine suggested is given below:

- presents a problem to the pupil
- assesses the student's response
- reports on the student's response
- presents the next problem.

Two well-known drill and practice projects already discussed are:

PLATO (Programmed Logic for Automatic Teaching Operation) based at the University of Illinois and TICCIT (Time-shared Interaction Computer Controlled Information Television Project) funded by the National Science Foundation of America in 1971 and managed by the Mitre Corporation.

The typical drill and practice programme presents the student with a set of

problems reflecting a sequence of skills to be practised. The programme contains elaborate branches to be followed according to the student's response.

Tutorial

In contrast a tutorial programme presents new information and follows with a series of questions that guide the student to an understanding of the new concept. According to the student's response a new concept is introduced or the old sequence is repeated until the student responds correctly to the questions. Tutorial programs may have in store responses, to anticipated correct or incorrect student's answers. To restrict expected responses, tutorial programs sometimes use a multiple choice format to accompany the questions.

Computer Managed Instruction (CMI)

Computer Managed Instruction (CMI) combines a record keeping routine within the drill and practice or tutorial programs.

Drill and Practice Philosophy

Three philosophies are at the heart of drill and practice and tutorial programs:

- (i) basic skills are learned, like physical skills, through repeated practice
- (ii) more complex ideas and skills can be learned by being broken down into appropriate sequences of sub-ideas and sub-skills
- (iii) students will replicate behaviour that is reinforced with a pleasant experience.

In short the theory is, students learn by repeating problems that are grouped in a developmental sequence when correct responses are reinforced. Critics of drill and practice programs maintain they are boring and monotonous. Tutorial programs are claimed to be limited not only by the imagination of the programmer but also by the computer technology. Most drill and practice programmes in mathematics

education are used for practising basic arithmetic drills and exercises.

Simulation Programs

Simulation is a representation of a real world situation in which a specified number of factors can change; as they do they produce other changes throughout the simulated world. Simulation programs enable costly or dangerous situations to be studied without incurring high cost, or running the risk of endangering lives. Relationships between the many variables that are involved in real life situations are complicated and their outcomes are often unpredictable. Simulation programs create problem solving situations where decisions are made in the light of previous experiences and projected into the future. A critical consideration in simulation programs is the number of variables to be included. One of the early computer programs, 'Lemonade', is a simple illustration of a simulation program. The object in Lemonade is to make a profit. Each student (lemonade trader), at the beginning, decides how many glasses of lemonade to make and how much to sell them for. The student may also spend money on advertising which should increase sales. A weather report is provided by the computer and tells the student the effect on the sale of lemonade. After all the production decisions have been made and entered into the computer, it produces a financial report. This shows the total number of glasses made, the cost, the extra expenses, the total sold, profit made and the cash in hand. After the financial report, another student is allowed to enter his or her business decisions. Simulations like Lemonade provide a meaningful environment for mathematical problem solving. There is, however, a tendency on the part of students who are left on their own with simulations like Lemonade to estimate their expenditure (instead of doing any actual calculations) to arrive at their decisions, thus defeating the object of the exercise. This might be as valuable an exercise as that intended by the program, but if not, it can be avoided by the teacher requesting a reason for each decision made. Still on the subject of simulations, Lynette et al [37]

describe the use of a microcomputer to simulate the binomial distribution and to illustrate the central limit theorem as being successful with both pre-service and post-service teacher education students at Western Australia College of Advanced Education.

Computer Enhanced Learning (CEL)

The underlying concepts of Computer Enhanced Learning are fully described in [1]. In brief it entails the modification of existing trends in computer software for learning. CEL philosophy transfers what it considers to be a misuse of computer facilities from the software to 'paper ware' and combines some facilities for creating an interactive and simulation environment. The net effect is a user (tutor/student) centred system rather than a micro centred one. CEL philosophy encourages the exploitation of computers in areas that cannot be achieved by other media. For instance text and theory are done away with as text can better be presented on paper and theories can be found in any textbook on the subject. The power of the computer to interact with the user is emphasised by CEL programs providing a simulation environment. This feature is not possible to achieve with any other technology yet available. Features that are seen to be gimmicky like animation are restricted in their use by CEL programs aimed at senior students. Gimmicks are considered useful and motivating for primary children, but senior students are expected to be motivated enough without the extra work involved in animation. Another feature adopted by CEL programs is standardisation making life easier for users and program developers. This is important for those that want to transport programs from one hardware model to another. The conversion of programs from one hardware brand to another is the subject of a later section when a CEL program is used as an example. A more extensive discussion of CEL programs is given in the next chapter, which is on conversion.

5.3 The Electronic Spreadsheet and Mathematics

The versatility of the spreadsheet in the field of commerce and industry is universally recognised. This is due to the fact that the spreadsheet was developed for use in commerce and industry and consequently its use for mathematics learning is not catered for in manuals. The power of the spreadsheet to play its role in commerce and industry depends largely if not wholly on its mathematical functions and abilities. Its application in the teaching of mathematics, by utilising its mathematical functions, adds another dimension to the spreadsheet and makes it an attractive option for countries like Fiji where resources are limited. Due to its role in commerce it is available in a wide range of microcomputers. Unlike other mathematics software, spreadsheet availability on whatever choice of machine is made for Fiji will not present any problem. The versatility of the spreadsheet enables the extension of its use to a variety of different mathematical learning activities. These include the recording and presentation of data in table form or in graphical form, problem solving, investigation and simulation.

Due to much uncertainty prior to the political upheaval in Fiji in 1987-88 it was not possible for the author to carry out any study with reference to software trials in Fiji schools during this period. The author is therefore grateful for the opportunity afforded by a secondary school for girls in Leicestershire, Our Lady's Convent School (OLC), to conduct a study of the spreadsheet for problem solving. Before any mathematical activities could be carried out there was a need for some preparatory work on the spreadsheet itself.

At the Leicestershire school a network of eight BBC microcomputers had been in use for some time. The students were familiar with the basic operation of the network which included:

- (i) switching on and logging on to the network

- (ii) loading a program from the file server
- (iii) editing keyboard entries.

In the author's experience in Fiji the three items listed above can be very time consuming if students are not familiar with them, especially (iii). They are a severe stumbling block in Fiji because of the lack of exposure to computing facilities and technology in general, and no mathematical activities can be gainfully achieved unless this problem is alleviated. Preparatory work at OLC School entailed the basic principles of the spreadsheet Viewsheets. There was no need to know all the commands and facilities of the spreadsheet to enable some mathematical activities to be carried out. Students were given instructions on:

- (i) identifying the items on the spreadsheet display
- (ii) entering labels, numerals and formulas
- (iii) editing entries
- (iv) formulating formulas
- (v) executing commands
- (vi) saving on disk and printing.

The author is aware that students in Fiji will need more in the way of preparation due to the differences in their technical background. A preparatory course for Spreadsheet in Maths is given in Appendix I. The author worked with third and fourth year students at OLC investigating the use of the spreadsheet in problem solving. The programmes described here are drawn from this experience.

5.3.1 A Project on Using the Spreadsheet for Problem Solving

Appendix F described a project on solving problems using a spreadsheet and a Basic program. The project investigated the solution of a pair of linear equations using a Basic program and a Spreadsheet.

The students agreed on the following points:

- (i) The display of the spreadsheet is neat and easily read. This is due to

the presentation of the spreadsheet data in a grid arrangement. The task of aligning data and results both horizontally and vertically are automatically done by the program. When referring to a particular value it can be easily highlighted by placing the cursor over it, which does not hide the value in any way.

- (ii) The writing of the Basic program took up a lot of time. Even though there was a pre-written Basic program to solve the simultaneous equations, the majority of students preferred to write their own saying it was easier to use a program they had written themselves than to use one written by someone else.
- (iii) They enjoyed the challenge of trying to make the programs work, both the Basic program and the Spreadsheet. The immediate feedback of many different values provided by the spreadsheet was a source of interest to all involved.
- (iv) They understood the solution of simultaneous equations better after having worked on the programs. The use of the spreadsheet was useful in retracing the source of an error, making correction easier. The students were able to see the value of variables in the spreadsheet which reinforced the understanding of the variables.
- (v) There were a lot of mathematical activities and verbalisation during the lesson.
- (vi) Mathematical topics discussed between students were not confined to simultaneous equations but went outside the scope of simultaneous equations.
- (vii) There were a lot of questions and answers by trial and error method.
- (viii) There was no need to understand all the facilities of the spreadsheet in order to use it for certain mathematical activities.
- (ix) *More effort was devoted to non-mathematical activities while using*

the Basic program than during the use of the spreadsheet.

- (x) Mathematics activities on the spreadsheet were centred mainly on:
 - (1) The immediate calculation and display of formulae and values providing instant feedback.
 - (2) The manipulation of the algebraic concept of variables, which in a spreadsheet gave a visual display of the value.
- (xi) in addition to enhancing mathematics the project provided a good introduction to the understanding of the spreadsheet.

5.3.2 Spreadsheet and Numberwork in the Primary School

The programs described here and the spreadsheet 'SwiftCalc' were developed on the Atari ST microcomputer. A description of the relevant Swiftcalc commands and functions are given in Appendix I. Number work in primary school can be enhanced with the use of the spreadsheet. Investigations of sequences and series can be done using the automatic calculation ability of the spreadsheet. The facility that allows formulae to be entered, values calculated and displayed without the formula itself, present an inquiry situation for the learner. The investigation environment is supported by the 'what if' situation provided by the spreadsheet. This is when a cell value in a spreadsheet is changed, all other cell values affected automatically change and display the new values. It is not suggested that a primary school should purchase a spreadsheet package for the sole purpose of enhancing mathematics learning, but if the spreadsheet is made available by some other means there is no reason not to use it in mathematics teaching. Secondary schools and further education institutions can justify the acquisition of the spreadsheet to use with business studies as well as mathematics.

Program COUNTER

The program COUNTER written in Basic is available on the BBC, RML 380Z and RML 480Z microcomputers, and can easily be adapted to the spreadsheet. Some More

Lessons in Mathematics with a Microcomputer [38], describes the program COUNTER thus:

'COUNTER exploits the simple idea of counting and displaying the number on the screen.

It displays numbers on the screen in large numbers and proceeds counting at a rate that can be set.

The starting number can be changed and the gaps between the numbers can be altered.

Decimal and negative numbers can be used.

Two sequences of numbers can be displayed at the same time on the screen.

The user may also have the option of listening to the counting as well as watching the sequences.'

Program Counter can be applied to many different ideas and provides practice on arithmetical skills and insights for pupils of a wide range of abilities.

Translating COUNTER to the Spreadsheet

Figures 5.7a, 5.7b

The translation of the program COUNTER to a spreadsheet is simple due to the power of the spreadsheet. Any cell in a spreadsheet can count, for instance cell D5 can be made to count by the the following entries:

CELL	ENTRY
D5	D5 + 1

With SWIFTCAL the above entry will display the counting numbers in cell D5 starting with 1. Successive counting numbers can be displayed by pressing function key F5. Changing the entry in D5 to say:

D5+4

will result in the display 4,8,12,16 etc. FIGURE 5.7a shows the spreadsheet

entry for cell D5 to display the counting numbers and FIGURE 5.7b shows the display after three presses of the function key F5. Various activities can be initiated by the counting:

- (i) The teacher could cover the display after it has counted and displayed a few numbers. Keeping the display covered, function key F5 is pressed a few more times. The children are then asked to write down what the display is at this point. This could be tried with various other sequences like $D5+2$, $D5+3$, $D5+4$
- (ii) Questions such as the following could be asked:
 - Can you tell us a bigger number the computer will display ?
 - Will the computer display the number n ?
 - What can you say about the last digit of each of the numbers ?

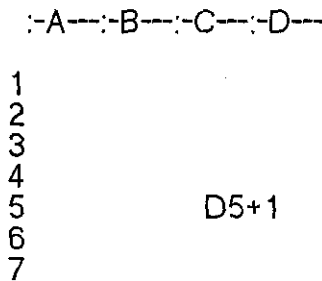


FIGURE 5.7a

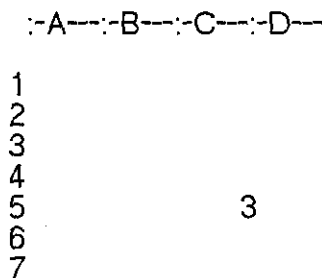


FIGURE 5.7b

Displaying One Term of Two Sequences

Figures 5.8a, 5.8b

The spreadsheet can be made to display two sequences. One sequence could be displayed in B3 and the other in D3, for example:

CELL	ENTRY
B3	B3+1
D3	D3+2

The above entries will display the following numbers every time function key F5 is pressed:

CELL	DISPLAY
B3	1, 2, 3, 4,
D3	2, 4, 6, 8,

The displays in the two cells could be changed by altering the formula in the respective cells. FIGURE 5.8a shows the entries for the two sequences in cells B3 and D3, and FIGURE 5.8b is the display after five counts, i.e. the fifth term of the sequences.

	A	B	C	D
1				
2				
3		B3+1		D3+2
4				
5				

FIGURE 5.8a

	A	B	C	D
1				
2				
3		5		10
4				
5				

FIGURE 5.8b

	--A----	--B----	--C----	--D----	--E----	--F----	--G----	--H----	--I----	--J----
1				B1*2		B1/2		form1		form2
2		B1+1		B2*2		B2/2				
3				B3*2		B3/2				
4				B4*2		B4/2				
5				B5*2		B5/2				
6				B6*2		B6/2				
7				B7*2		B7/2				
8				B8*2		B8/2				
9				B9*2		B9/2				
10				B10*2		B10/2				

FIGURE 5.9a

	--A--	--B----	--C----	--D----	--E----	--F----	--G----	--H----	--I----	--J----
1	1	1	2		0.5		1		1	
2	2	2	4		1		3		4	
3	3	3	6		1.5		6		9	
4	4	4	8		2		10		16	
5	5	5	10		2.5		15		25	
6	6	6	12		3		21		36	
7	7	7	14		3.5		28		49	
8	8	8	16		4		36		64	
9	9	9	18		4.5		45		81	
10	10	10	20		5		55		100	

FIGURE 5.9b

Displaying More Than One Term of a Sequence(s)

Figures 5.9a, 5.9b

Instead of displaying one term of a sequence the spreadsheet could be programmed to display more than one term of a sequence or sequences.

FIGURE 5.9a shows the entries to display ten terms, FIGURE 5.9b is the actual display of the five sequences:

n , $2*n$, $n/2$, $n(n+1)/2$ and $n*n$ for $n=1$ to 10.

In FIGURE 5.9a enter:

$B1*(B1+1)/2$ in place of form1 in cell H1, and

$B1*B1$ in place of form2 in cell J1.

Cell B2 entry: the entry $B1+1$ in cell B2 is copied into cells B3 to B10. This will display the counting numbers 1 to 10 in cells B1 to B10.

Cell D1 entry: the entry $2*B1$ in cell D1 is copied into cells D2 to D10. This will display the sequence $2*n$ for $n=1$ to 10.

Cell F1 entry: the entry $B1/2$ in cell F1 is copied into cells F2 to F10. This will display the sequence $n/2$ for $n=1$ to 10.

Cell H1 entry: the entry $B1*(B1+1)/2$ in cell H1 is copied into cells H2 to H10. This will display the sequence $n(n+1)/2$ for $n=1$ to 10.

Cell J1 entry: the entry $B1*B1$ in cell J1 is copied into cells J2 to J10. This will display the sequence $n*n$ for $n=1$ to 10.

Number Squares

Figures 5.10a, 5.10b

Number squares present another activity which primary school pupils can do on the spreadsheet. The number square shown here:

1	2	3
4	5	6
7	8	9

can be set up in the spreadsheet and the class asked to rearrange the numbers to give a total of 15 in each row, column and diagonal. FIGURE 5.10a shows the entries for the number square and FIGURE 5.10b shows the totals display.

The numbers 1 to 9 which make up the number square are entered in cells:

B2,C2,D2,B3,C3,D3,B4,C4 and D4. The formula $B2+C2+D2$ replaces form1 in cell F2.

Then the sum of the first row of the number square will be displayed in F2. The formula $B3+C3+D3$ replaces form2 in cell F3 and the sum of the second row will be

displayed in F3. The formula $B4+C4+D4$ replaces form3 in F4 and the sum of the third row will be displayed in F4. The formula $B2+B3+B4$ replaces form4 in cell B6. This will display the sum of the left column in B6. The formula $C2+C3+C4$ replaces form5 in cell C6, and will display the sum of the middle column in cell C6. The formula $D2+D3+D4$ replaces form6 in cell D6 and will display the sum of the right column in cell D6. Lastly formula $B2+C3+D4$ replaces form7 in cell F6. This will display the sum of the top left/bottom right diagonal.

The spreadsheet can calculate and display the sums of each row, column and the diagonal as the class make suggestions on how to rearrange the numbers. The new arrangement is typed into the cells and the new sums are immediately displayed. The instant display of the new values when a number is changed encourages mathematical discussion and perseverance. The numbers used in the square and the size of the square can be changed to give variations. It was found that less able students particularly enjoyed this activity, since the spreadsheet was doing the adding up and checking the sums. At first the students guessed the arrangement but in the later stages they were working with pencil and paper which gave them practice in number skills and logic. They were able to complete several different number squares.

	A	B	C	D	E	F	G
1							
2		1	2	3		form1	
3		4	5	6		form2	
4		7	8	9		form3	
5							
6		form4	form5	form6		form7	
7							

FIGURE 5.10a

	A	B	C	D	E	F	G
1							
2		1	2	3		6	
3		4	5	6		15	
4		7	8	9		24	
5							
6		12	15	18		15	
7							
8							

FIGURE 5.10b

Formulas

Figures 5.11a, 5.11b

The power of the spreadsheet hinges on its ability to calculate the value of a formula which uses values entered in other cells. A class can be introduced to formulas by making up a multiplication table on the spreadsheet. A column of numbers 1 to 10 is first entered, say in cells B1 to B10 in the second column of the spreadsheet. The pupil is then asked to enter the formulas to give the values of two times tables in the fourth column of the spreadsheet. The correct entry in each cell of the fourth column, which should include the entries in the cells from the second column should yield the correct values of the two times table. FIGURE 5.11a shows the entries for the two times and the five times tables in the fourth and sixth columns respectively and FIGURE 5.11b shows the results displayed. Note that the display of the tables could be achieved more quickly using the copy facility, but this will defeat the purpose of the exercise which is to practise writing formulas. Pupils should be instructed to use the star(*) in place of the multiplication symbol. This is a good start to making up formulas as the pupils will already have some idea of what the display should be.

As another exercise, pupils could be given two sets of numbers and asked to find the relationship. Given the display in FIGURE 5.12a pupils could be asked to

write formulas to do the following:

- (i) to display in column F cells F2 to F10 the same numbers as in column D, the formulas are to include B1 to B10 and the addition sign(+).
- (ii) to display in column H cells H1 to H10 the same numbers as column D, the formulas to include B1 to B10, the multiplication sign(*), and the addition sign(+).

FIGURE 5.12b shows the entries required to duplicate column D in columns F and H.

	---A---	---B---	---C---	---D---	---E---	---F---
1		1		2*B1		5*B1
2		2		2*B2		5*B2
3		3		2*B3		5*B3
4		4		2*B4		5*B4
5		5		2*B5		5*B5
6		6		2*B6		5*B6
7		7		2*B7		5*B7
8		8		2*B8		5*B8
9		9		2*B9		5*B9
10		10		2*B10		5*B10

FIGURE 5.11a

	---A---	---B---	---C---	---D---	---E---	---F---
1		1		2		5
2		2		4		10
3		3		6		15
4		4		8		20
5		5		10		25
6		6		12		30
7		7		14		35
8		8		16		40
9		9		18		45
10		10		20		50

FIGURE 5.11b

	:--A----	:--B----	:--C----	:--D----	:--E----
1		1		3	
2		2		5	
3		3		7	
4		4		9	
5		5		11	
6		6		13	
7		7		15	
8		8		17	
9		9		19	
10		10		21	

FIGURE 5.12a

	:--A----	:--B----	:--C----	:--D----	:--E----	:--F-----	:--G----	:--H-----
1		1		3		B1+2		2*B1+1
2		2		5		B2+3		2*B2+1
3		3		7		B3+4		2*B3+1
4		4		9		B4+5		2*B4+1
5		5		11		B5+6		2*B5+1
6		6		13		B6+7		2*B6+1
7		7		15		B7+8		2*B7+1
8		8		17		B8+9		2*B8+1
9		9		19		B9+10		2*B9+1
10		10		21		B10+11		2*B10+1

FIGURE 5.12b

These activities can be carried out with pencil and paper but the advantage with using the spreadsheet is that pupils get an immediate response to their solutions and can compare it with the given solution. To get instant feedback to reassure themselves when working with pencil and paper the pupils will need to seek approval from the teacher; otherwise the pupils proceed without knowing if their procedure is correct. With a poor teacher to pupil ratio situation (1 to 40 is not unusual in Fiji), the tendency is for pupils not to get individual attention from the teacher or, if they do, it is only after wading through several exercises. Should the procedure used be incorrect then the pupil will have performed the faulty procedure several times, before being corrected. The

repetition of a faulty procedure before being corrected reinforces the procedure making it more difficult to unlearn it. This does not mean that pencil and paper ^{are} to be discarded as entries and displays should be copied, preferably on squared paper, for future reference. The act of copying from screen to paper will also add to the consolidation of the work and reinforce the concepts involved. In addition it is also good practice to put on paper first what is to be entered before coming to the keyboard.

Data Collection and the Spreadsheet

Children like collecting data, especially about themselves, such as height, weight, waist size, neck size, hand span, arm span, how fast can they run a certain distance, etc. The spreadsheet is ideal for recording data of this type. Totals, averages, maximum, minimum values are some of the mathematical activities that can be derived from data of this kind. The graphing facility of the spreadsheet can be used to draw graphs of the data. Food prices are often given in varying quantities as a result of several factors. A collection of food prices and weights can be gathered and tabulated in a spreadsheet. A formula can be entered to calculate the cost of say 1 kilogram of each item of food.

Education should be presented in such a way that the pupils find meaning in what they are investigating. If pupils are in no position to collect data themselves then previously collected data from local surveys could be used. In this way pupils can relate to the ideas and any names used and the reason for the surveys and the investigation sometimes can take on a personal interest. Current topical items in local newspapers are a good source of ideas for collecting local data.

FIGURE 5.13a shows the Provincial Population Distribution in Fiji between 1966 and 1976 as given in Fiji's Eighth Development Plan, 1981-1985, volume one, presented to Parliament of Fiji under Parliamentary Paper No. 35 of 1980. FIGURE 5.13b is a pie chart and FIGURE 5.13c is a horizontal bar chart depicting the provincial population distribution in 1966. Both FIGURES are drawn by the

graphics facility of the spreadsheet using the data tabulated in the spreadsheet shown in FIGURE 5.13a. The collection, tabulation and drawing of accurate charts by the spreadsheet is a great help in enhancing the mathematics involved in the exercise. More time can be spent in discussing the shape of the bar charts, which in this instance will be as accurate as the data allows. Without the use of the spreadsheet the production of accurate charts will be very time consuming and detract from the mathematics.

Note that the first item - Tailevu/31141 is placed at the beginning of the first quadrant of the pie chart. Using this feature the spreadsheet graphics facility can be utilised to demonstrate angles. FIGURE 5.14a shows the values of ^{six angles} that make a circle, and FIGURE 5.14b is the piechart drawn by the spreadsheet graphics. Other values can be entered in a table like in FIGURE 5.14a to demonstrate other angles.

The spreadsheet has the facility to dump charts accurately on paper. This added feature allows pupils to keep copies of the work they have put together.

Children, especially primary school children, enjoy keeping pieces of work they have produced.

	A	B	C	D
1 Tailevu	31141		39952	
2 Naitasiri	39485		65111	
3 Rewa	69901		87257	
4 Namosi	2721		3292	
5 Ra	22298		25523	
6 Ba	135968		167095	
7 Serua	8181		11263	
8 Nad/Navos	37494		45929	
9 Bua	9758		11457	
10 Cakaudrov	30053		34251	
11 Lau	15988		14452	
12 Lomaiviti	13264		13568	
13 Kadavu	8631		8699	
14 Rotuma	3365		2805	
15 Macuata	44433		57414	

FIGURE 5.13a

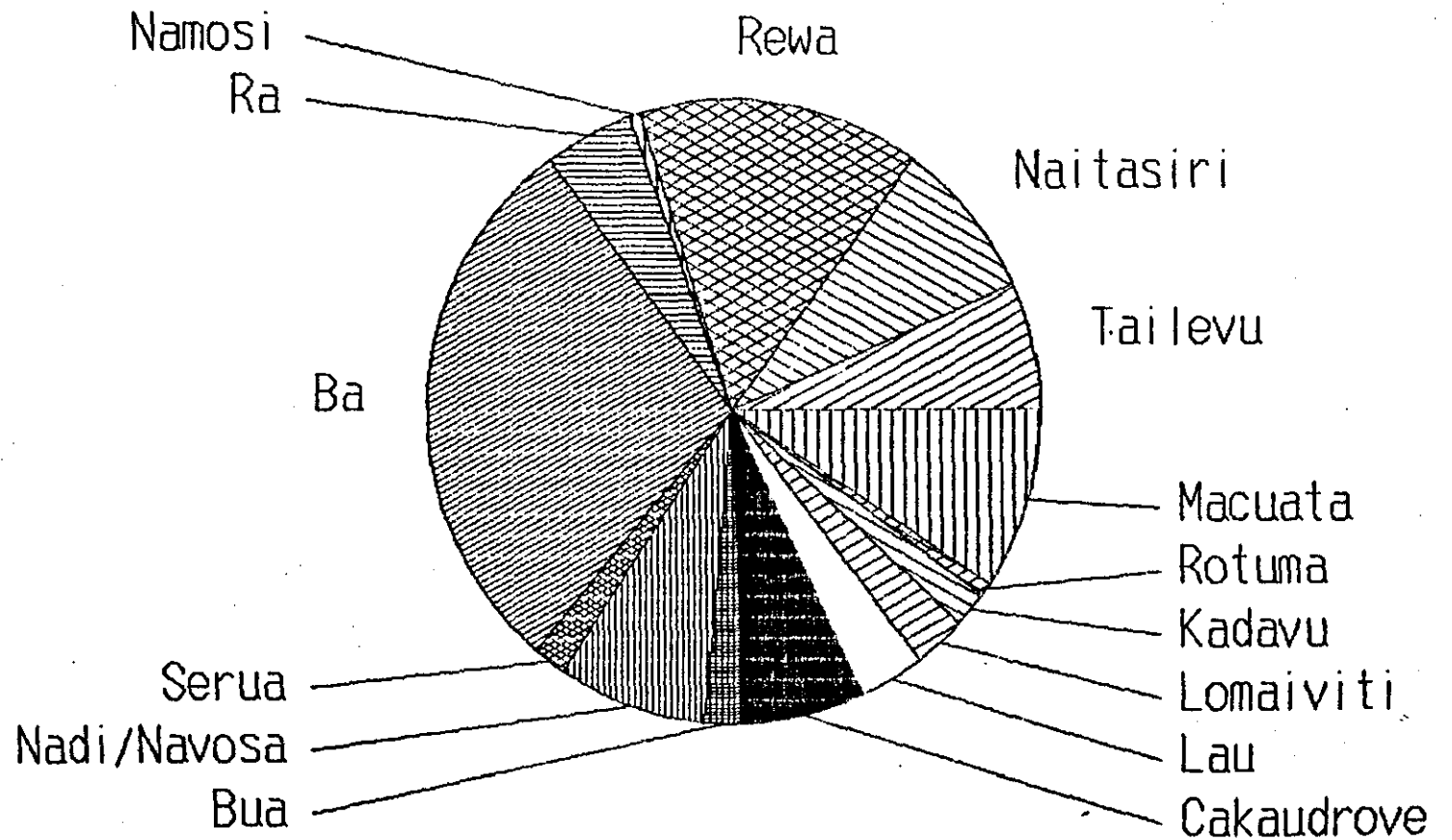


FIGURE 5.13b

167

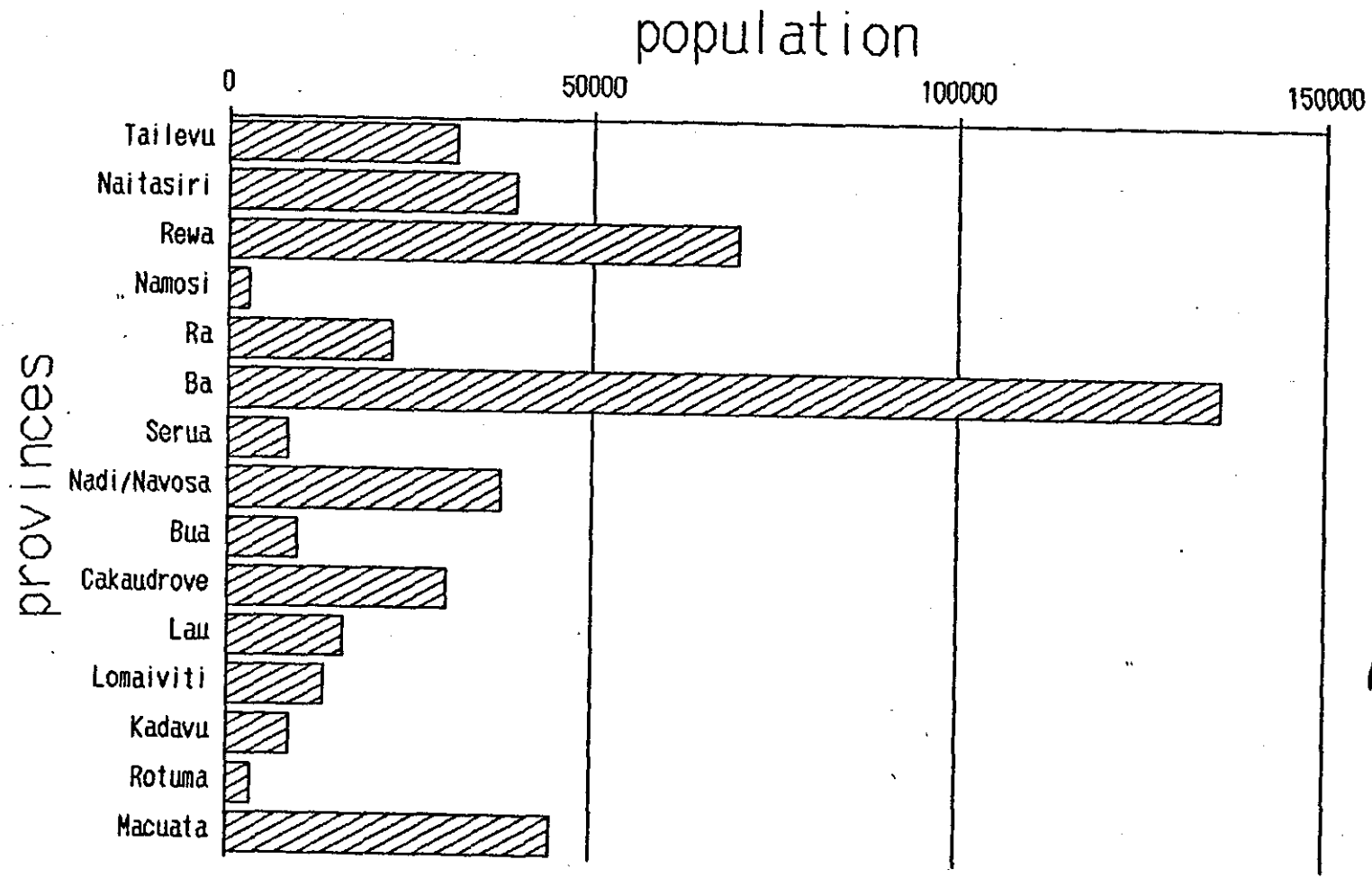


FIGURE 5.13c

167a

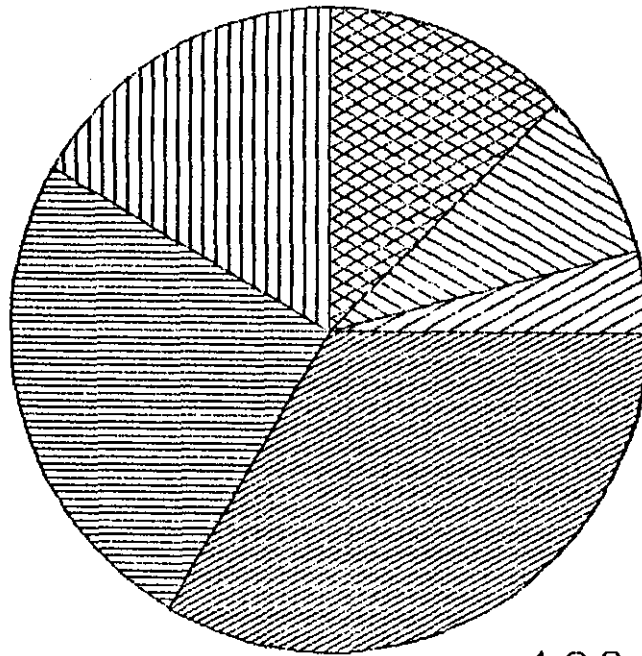
60 degrees

45 degrees

30 degrees

15 degrees

90 degrees



120 degrees

:-----A-----:-----B-----

1	15 degrees	15
2	30 degrees	30
3	45 degrees	45
4	60 degrees	60
5	90 degrees	90
6	120 degrees	120
7		
8	FIGURE. 5.14a	

FIGURE 5.14b

5.4.3 Secondary School Mathematics and The Spreadsheet

Programming the Spreadsheet

Programming the spreadsheet to solve mathematical problems is a useful exercise that can be tackled by secondary students. A particular application is the solution of algebraic equations.

Solution of Linear Equations

Figures 5.15a, 5.15b

The linear equation in the form usually found in secondary school textbooks is:

$$ax + b = c \text{ where } a, b, c \text{ are constants.}$$

FIGURE 5.15a shows the entries for the solution of the linear equation:

$$3x + 2 = 3 \text{ where } a=3, b=2, c=3.$$

The values of the constants a,b and c are entered in the cells:

B2, B3, B4

The formula for the solution given by $(c-b)/a$ is entered in cell B6 in place of form1. In terms of cell locations the formula entered is:

$$(B4-B3)/B2 \text{ which is equivalent to } (c-b)/a$$

The labels 'a =', 'b =', 'c =' and 'x =' are entered in column A cells A2, A3, A4, and A6 respectively.

FIGURE 5.15b is the actual display with the solution given as 0.333.

The spreadsheet could be used to reinforce the idea of balancing the two sides of an equation, Left Hand Side (LHS) and Right Hand Side (RHS). Applied to the equation:

$$3x + 2 = 3 \text{ the LHS} = 3x+2 \text{ and the RHS} = 3$$

Values of x can be entered and the spreadsheet displays the values of the LHS and RHS. When the correct value of x is entered the two values of LHS and RHS will be equal. FIGURE 5.16a shows the entries and FIGURE 5.16b the actual display.

Constants, arithmetic expressions and formulas can be entered in cells. Some cells are protected to prevent entries by the user.


```

:--A--:--B--
1
2   a =      3
3   b =      2
4   c =      3
5
6   x = (B4-B3)/B2
7

```

FIGURE 5.15a

```

:--A--:--B--:--C--:--D--
1
2   a =      3
3   b =      2
4   c =      3
5
6   x = 0.33333333
7
8

```

FIGURE 5.15b

```

:--A--:--B--:--C--:--D--
1
2   a =      3
3   b =      2
4   c =      3
5
6 input x=      3
7
8 LHS  B2*B6+B3
9 RHS  B4
10

```

FIGURE 5.16a

	A	B	C	D
1				
2	a =		3	
3	b =		2	
4	c =		3	
5				
6	input x =		3	
7				
8	LHS		11	
9	RHS		3	
10				

FIGURE 5.16b

Solution of Simultaneous Equations

Figures 5.17a, 5.17b, 5.18a, 5.18b

The simultaneous equations are in the form commonly found in secondary school textbooks:

$$ax + by = c$$

$$dx + ey = f \quad \text{where } a, b, c, d, e, f \text{ are constants.}$$

FIGURE 5.17a shows the entries for the solution of:

$$3x + 2y = 5$$

$$4x - y = 3$$

The equations are input by entering the coefficients of x and y and the values of the constants. The first equation is entered in the cells of row 2 :

$$A2=3, B2=2, C2=5$$

and the second equation is entered in the cells of row 3:

$$A3=4, B3=-1, C3=3.$$

The first operation is to equalise the coefficients of x in the two equations.

This is achieved by multiplying the first equation by the coefficient of x in the second equation, and multiplying the second equation by the coefficient of x in the first equation. The resulting products are displayed in row 5 for equation 1, and in row 6 for equation 2. The two equations in rows 5 and 6, now

with equal coefficients of x , are subtracted one from the other to eliminate the x 's. The resulting equation with one unknown, y , is displayed in row 8. The solution for y is displayed in row 9. Row 11 is equation 1 rewritten with the value of y from row 9 substituted. The resulting equation in one unknown, x , is then displayed in row 12. The solution for x is shown in row 13. All row references in the description above apply to both FIGURE 5.17a and the actual display shown in FIGURE 5.17b. To solve another pair of simultaneous equations, the coefficients and the constant terms are entered into row 2 and row 3, and the solution will automatically show up in cell C9 and cell C13.

	:---A---	:---B---	:---C---	:---D---
1		x	y	
2		3	2	5
3		4	-1	3
4				
5	A2*A3	B2*A3	C2*A3	
6	A3*A2	B3*A2	C3*A2	
7				
8	A5-A6	B5-B6	C5-C6	
9		B8/B8	C8/B8	
10				
11	A2	B2*C9	C2	
12	A11	B11-B11	C11-B11	
13	A12/A12		C12/A12	
14				

FIGURE 5.17a

	:---A---:	:---B---:	:---C---:	:---D---:
1		x	y	
2		3	2	5
3		4	-1	3
4				
5		12	8	20
6		12	-3	9
7				
8		0	11	11
9			1	1
10				
11		3	2	5
12		3	0	3
13		1		1
14				

FIGURE 5.17b

	:---A---:	:---B---:	:---C---:	:---D---:
1		x	y	
2		3	2	5
3		6	4	4
4				
5		18	12	30
6		18	12	12
7				
8		0	0	18
9			ERR	ERR
10				
11		3	N/A	5
12		3	N/A	N/A
13		1		N/A
14				

FIGURE 5.18a

	:---A---	:---B---	:---C---	:---D---
1	x	y		
2	2	2		5
3	6	4		10
4				
5	18	12		30
6	18	12		30
7				
8	0	0		0
9		ERR		ERR
10				
11	3	N/A		5
12	3	N/A		N/A
13	1			N/A
14				

FIGURE 5.18b

Some displays in the solution of simultaneous equations, FIGURE 5.17b, may be used to check that correct entries have been made and the program is working accurately. For example displays in cells A5 and A6 should always be equal to the product of the entries in cells A2 and A3, and displays in cells A8 and B12 should always be zero. An extension to the work with simultaneous equations is to investigate why some equations result in displays like FIGURES 5.18a and 5.18b.

Investigations Using the Spreadsheet

Instead of a straight forward solution to algebraic equations the spreadsheet can also be used to investigate the behaviour of algebraic equations and expressions.

Point of Intersection of Two Straight Lines

Figures 5.19a, 5.19b

Given the equations of two straight lines their point of intersection can be investigated using the program shown in FIGURE 5.19a. The equations are in the form normally given in textbooks:

$$y = ax + b \text{ where } a, b \text{ are constants.}$$

The equation of the straight line is turned round to the form

$$ax + b = c$$

then c is equivalent to y in the equation of the straight line above.

Given the two equations:

$$y = 2x + 7 \quad (1)$$

$$y = x - 2 \quad (2)$$

the constants are entered as shown in FIGURE 5.19a. The first equation is entered in the cells of row 3:

$$B3=2, C3=7,$$

and the formula for calculating y is entered in D3. To calculate the value of y , a value for x is needed, and this will be entered by the user at cell A1. The formula to replace form1 in cell D3 is:

$$\text{form1} = A1*B3+C3$$

Equation (2) is entered in the cells of row 4:

$$B4=1, C4=-2 \text{ and } \text{form2} = A1*B4+C4$$

form3 in cell E4 will calculate the difference between the values of y displayed in cells D3 and D4, and will be :

$$\text{form3} = \text{abs}(D3-D4)$$

The user enters a value for x in cell A1. The program calculates the two values of y , defined by the two equations (1) and (2), and displays the result in cells D3 and D4 respectively. The solution for the intersection of the two lines will cause the two y values (in cells D3 and D4), to be equal. How near they are to being equal will be given by the display in cell E4 which displays the difference between the two y values for every x entered. FIGURES 5.19b, 5.19c, 5.19d, 5.19e show the results of $x=3, 1, -5, -9$ respectively. With an input of $x=3$ (cell A1), $y_1=13$ (cell D3), and $y_2=1$ (cell D4), with a difference of 12(cell E4).

The inputs and results tabulated will be:

TABLE 5.1

	input(x)	y1	y2	difference	FIGURE
cell	A1	D3	D4	E4	5.19a
	3	13	1	12	5.19b
	1	9	-1	10	5.19c
	-5	-3	-7	4	5.19d
	-9	-11	-11	0	5.19e

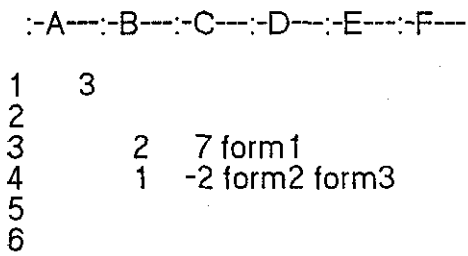


FIGURE 5.19a

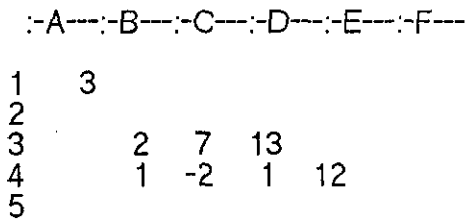


FIGURE 5.19b

	A	B	C	D	E	F
1	1					
2						
3		2	7	9		
4		1	-2	-1	10	
5						
6						

FIGURE 5.19c

	A	B	C	D	E	F
1	-5					
2						
3		2	7	-3		
4		1	-2	-7	4	
5						
6						

FIGURE 5.19d

	A	B	C	D	E	F
1	-9					
2						
3		2	7	-11		
4		1	-2	-11	0	
5						

FIGURE 5.19e

The point of intersection is given by the last entry when the two values of y are equal and the difference is zero:

$$x = -9, y = -11 : \text{point of intersection} = (-9, -11)$$

Coordinates of points on the lines can be deduced from the table;

$$\text{equation (1); } (3, 13), (1, 9), (-5, -3), (-9, -11)$$

$$\text{equation (2); } (3, 1), (1, -1), (-5, -7), (-9, -11).$$

The behaviour of the line as x increases or decreases can also be deduced from the investigation. The presentation of mathematical concepts by using the spreadsheet is different from that of a more traditional approach. It should add variety to the mathematics learning environment and enhance the learning. Points of intersections of other lines and curves may be investigated in a similar way thus providing a different method of presenting traditional topics.

Given the equations of two straight lines their behaviour can be investigated by studying TABLE 5.1 which should provide mental and verbal exercises in mathematical descriptions. This should aid understanding especially if it can be further related to the actual graph. Very often today the equations are given and graphs drawn and students sometimes find it difficult to interpret the graph. In this approach the description of the behaviour is attempted first from the table of values before the graph is viewed.

Simultaneous Equations Investigation

FIGURES 5.20a - 5.20m

FIGURE 5.20a to FIGURE 5.20d show how to set up an initial pair of equations: $4x - 3y = -11$ and $3x - 4y = -10$

FIGURE 5.20e to FIGURE 5.20g show how to enter a second pair of equations.

FIGURE 5.20h to Figure 5.20m show how the solution of a pair of equations is investigated: $2x + 3y = 13$, $3x - y = 13$

FIGURE 5.20a shows the program of entries to set up the spreadsheet to investigate a pair of simultaneous equations. The table of entries for FIGURE 5.20a is given here.

CELL	ENTRY	description
A1	x	label
B1	y	label
C1	c	label

D1	mult	label
E1	x	label
F1	y	label
G1	c	label
H1	add	label
E3	D3*E3+A3	form1
F3	D3*F3+B3	form2
G3	D3*G3+C3	form3
E4	D4*E4+A4	form4
F4	D4*F4+B4	form5
G4	D4*G4+C4	form6
E6	+if(H4="add",E3+E4," ")	form7
F6	+if(H4="add",F3+F4," ")	form8
G6	+if(H4="add",G3+G4," ")	form9
E7	+if(D6<>0,D6*E6," ")	form10
F7	+if(D6<>0,D6*F6," ")	form11
G7	+if(D6<>0,D6*G6," ")	form12
F8	+if(F7=1," y =", " x =")	form13

```

:A---:B---:C---:D---:E---:F---:G---:H---:I---
1  x  y  c  mult  x  y  c  add
2
3  ***  ***  ***  ***  form1 form2 form3
4  ***  ***  ***  ***  form4 form5 form6 ***
5
6          ***  form7 form8 form9
7          frm10 frm11 frm12
8          frm13 frm12
9

```

FIGURE 5.20a

```

:A---:B---:C---:D---:E---:F---:G---:H---:I---
1  x  y  c mult x  y  c add
2
3  4 -3 -11  1  0  0  0
4  3 -4 -10  1  0  0  0
5
6          0  0  0
7
8          0

```

FIGURE 5.20b

```

:A---:B---:C---:D---:E---:F---:G---:H---:I---
1  x  y  c mult x  y  c add
2
3  4 -3 -11  1  4 -3 -11
4  3 -4 -10  1  3 -4 -10
5
6          0  0  0
7
8          0

```

FIGURE 5.20c

```

:A---:B---:C---:D---:E---:F---:G---:H---:I---
1  x  y  c mult x  y  c add
2
3  0  0  0  1  4 -3 -11
4  0  0  0  1  3 -4 -10
5
6          ERR ERR ERR
7
8          ERR

```

FIGURE 5.20d

```

:A---:B---:C---:D---:E---:F---:G---:H---:I---
1  x  y  c mult x  y  c add
2
3  -2  6  24  1  4  -3  -11
4  0  3  13  1  3  -4  -10
5
6          ERR ERR ERR
7
8          ERR

```

FIGURE 5.20e

```

:A---:B---:C---:D---:E---:F---:G---:H---:I---
1  x  y  c mult x  y  c add
2
3  -2  6  24  1  2  3  13
4  0  3  13  1  3  -1  3
5
6          ERR ERR ERR
7
8          ERR

```

FIGURE 5.20f

```

:A---:B---:C---:D---:E---:F---:G---:H---:I---
1  x  y  c mult x  y  c add
2
3  0  0  0  1  2  3  13
4  0  0  0  1  3  -1  3
5
6          ERR ERR ERR
7
8          ERR

```

FIGURE 5.20g

	-A-	-B-	-C-	-D-	-E-	-F-	-G-	-H-	-I-
1	x	y	c	mult	x	y	c	add	
2									
3	0	0	0	-1.5	2	3	13		
4	0	0	0	1	3	-1	3		
5									
6					ERR	ERR	ERR		
7									
8						ERR			

FIGURE 5.20h

	-A-	-B-	-C-	-D-	-E-	-F-	-G-	-H-	-I-
1	x	y	c	mult	x	y	c	add	
2									
3	0	0	0	-1.5	-3	-4.5	-19.5		
4	0	0	0	1	3	-1	3		
5									
6					ERR	ERR	ERR		
7									
8						ERR			

FIGURE 5.20i

	-A-	-B-	-C-	-D-	-E-	-F-	-G-	-H-	-I-
1	x	y	c	mult	x	y	c	add	
2									
3	0	0	0	1	-3	-4.5	-19.5		
4	0	0	0	1	3	-1	3	add	
5									
6					0	-5.5	-16.5		
7									
8						ERR			

FIGURE 5.20j

	-A-	-B-	-C-	-D-	-E-	-F-	-G-	-H-	-I-
1	x	y	c	mult	x	y	c	add	
2									
3	0	0	0	1	-3	-4.5	-19.5		
4	0	0	0	1	3	-1	3	add	
5									
6				-0.18	0	-5.5	-16.5		
7					0	1	3		
8						y =	3		
9									

FIGURE 5.20k

	-A-	-B-	-C-	-D-	-E-	-F-	-G-	-H-	-I-
1	x	y	c	mult	x	y	c	add	
2									
3	0	0	0	1	-3	-4.5	-19.5		
4	0	0	0	-4.5	-13.5	4.5	-13.5	add	
5									
6				-0.18	-16.5	0	-33		
7					3	0	6		
8						x =	6		

FIGURE 5.20l

	-A-	-B-	-C-	-D-	-E-	-F-	-G-	-H-	-I-
1	x	y	c	mult	x	y	c	add	
2									
3	0	0	0	1	-3	-4.5	-19.5		
4	0	0	0	1	-13.5	4.5	-13.5	add	
5									
6				-0.06	-16.5	0	-33		
7					1	0	2		
8						x =	2		

FIGURE 5.20m

Inputs when using the program are restricted only to those cells showing

asterisks(***) in FIGURE 5.20a. Do not enter the asterisks(***) when setting up the spreadsheet, they are there only to show where inputs are to be entered. All inputs are values except for input into cell H4 where the word 'add' is entered when the two equations are ready to be added together to eliminate one of the unknowns. The two equations are input by entering values in columns A,B,C rows 3 and 4. The values entered will depend on what values are in cells E3,F3,G3 and E4,F4,G4. The entries in cells A3,B3,C3 and A4,B4,C4 will be operated on and the result transferred to cells E3,F3,G3 and E4,F4,G4. Cells E3,F3,G3 and E4,F4,G4 will hold the equations before the investigation begins. Multipliers are input in column D row 3,4 and 6. Entries in cells E3,F3,G3 and E4,F4,G4 are multiplied by the multipliers in cells D3 and D4 and the products are added to the entries in cells A3,B3,C3 and A4,B4,C4 and the results put back in E3,F3,G3 and E4,F4,G4 i.e.

$$E3 = E3*D3 + A3, \quad F3 = F3*D3 + B3, \quad G3 = G3*D3 + C3,$$

$$E4 = E4*D4 + A4, \quad F4 = F4*D4 + B4, \quad G4 = G4*D4 + C4.$$

To input equations:

$$4x - 3y = -11 \quad (1)$$

$$3x - 4y = -10 \quad (2)$$

With zeros in cells E3,F3,G3 and E4,F4,G4 the coefficients and the constant terms are entered in the following cells:

$$\text{equation (1): } A3 = 4, \quad B3 = -3, \quad C3 = -11$$

$$\text{equation (2): } A4 = 3, \quad B4 = -4, \quad C4 = -10$$

Next input multipliers, 1, in cells D3 and D4. FIGURE 5.20b shows the inputs.

Initial setting up of the spreadsheet may display 'ERROR' or zeros in some cells where formulas are entered. Correct inputs in cells A3,B3,C3 and A4,B4,C4 taking into consideration the values in cells E3,F3,G3 and E4,F4,G4 should display the simultaneous equations in cells E3, F3, G3 and E4, F4, G4 after recalculation is

activated by pressing function key F5. With the above inputs, recalculation will display the equations as shown in FIGURE 5.20c. A word of caution, while setting up the simultaneous equations ensure the multipliers in cells D3 and D4 are 1. Once the correct equations are set up in cells E3,F3, G3 and E4, F4, G4 return all input cells A3, B3, C3 and A4, B4, C4 to zero, FIGURE 5.20d. The reason for this is, whenever a recalculation is carried out entries in columns E3, F3, G3 are multiplied by the multiplier in D3 added to entries in A3, B3, C3 respectively and the results put back in E3, F3 and G3. The same applies to equation (2) in row 4. With zeros in columns A, B, C and 1 in column D a recalculation will leave the entries in columns E, F and G unchanged. Equations (1) and (2) as shown in FIGURE 5.20d are ready for processing. To change the equations to say:

$$2x + 3y = 13 \quad (3)$$

$$3x - y = 3 \quad (4)$$

the inputs will be:

$$\text{cell A3} = (2 - \text{the content of cell E3}) = 2 - 4 = -2$$

$$\text{cell B3} = (3 - \text{the content of cell F3}) = 3 - (-3) = 6$$

$$\text{cell C3} = (13 - \text{the content of cell G3}) = 13 - (-11) = 24$$

The entries are shown in FIGURE 5.20e. To display equations (3) and (4) in their proper cells in E3,F3,G3 and E4,F4,G4 press function key F5 to recalculate. FIGURE 5.20f should result with equations (3) and (4) in their correct cells. Entries in cells A3,B3,C3 and A4,B4,C4 are now zeroed and FIGURE 5.20g is now ready to investigate equations (3) and (4). If there is an error adjust the inputs into cells A3,B3,C3 and A4,B4,C4 accordingly and recalculate. To process equations (3) and (4), two options are available:

- (1) eliminate x and find y first
- (2) eliminate y and find x first.

Eliminate x by entering the appropriate multipliers in cells D3 and D4 of

FIGURE 5.20g. With the spreadsheet doing the arithmetic several multipliers can be considered:

- (1) multiply equation (3) by $-3/2$ and equation (4) by 1
- (2) multiply equation (4) by $-2/3$ and equation 3 by 1
- (3) multiply equation (3) by 3 and equation (4) by 2
- (4) multiply equation (3) by -1 and equation (4) by 3
- (5) multiply equation (3) by $1/3$ and equation (4) by 1
- (6) multiply equation (3) by 1 and equation (4) by 3.

Enter $-3/2$ in D3 and leave D4 with 1 as in FIGURE 5.20h and recalculate to display FIGURE 5.20i which shows that x can be eliminated by adding the two equations. Before another recalculation is carried out return the multiplier in cell D3 to 1. To add the two equations type the word 'add' in cell H4 and recalculate. FIGURE 5.20j shows the result of adding the two equations in FIGURE 5.19h. Row 6 of FIGURE 5.20j reads:

$$-5.5y = -16.5$$

To solve for y , the equation is multiplied by $-1/5.5$, which is entered in cell D6 and the values are recalculated. FIGURE 5.20k shows the result and the solution :

$$y = 3$$

To solve for x , appropriate multipliers are entered in cells D3 and D4 to eliminate y . With the display as in FIGURE 5.20k, the second equation multiplied by -4.5 would enable y to be eliminated. Enter -4.5 in cell D4 and recalculate and the result is shown in FIGURE 5.20l which shows the incorrect solution: $x = 6$. The error is due to the incorrect multiplier($=-0.18$) left in cell D6 from the previous investigation. Cells E6, F6, and G6 reads: $-16.5x = -33$ and the multiplier to solve for x should be $-1/16.5$. Changing the multiplier in cell D6 to $-1/16.5$ and returning the multiplier in D4 to 1, recalculation results in the solution given in FIGURE 5.20m:

$$x = 2.$$

The investigation offers many choices of multipliers which the user can input to achieve the required values to solve the given simultaneous equations. The traditional blackboard and chalk or pencil and paper workings tended to restrict choices of multipliers to whole numbers. The restricted choice applies to the kinds of problems suitable for solving by students. With the spreadsheet doing the arithmetic more realistic problems could be tackled without restrictions imposed by the need to keep the arithmetic simple.

The Quadratic Function

A concept that could be demonstrated with numerical values is that dealing with the behaviour of a quadratic, in fact with any polynomial function, near a critical point. Take the stationary point of the quadratic:

$$f(x) = 2x^2 - x + 1$$

The theory is:

- (i) as $f(x)$ increases $f'(x)$ is positive
- (ii) as $f(x)$ decreases $f'(x)$ is negative
- (ii) when $f(x)$ is changing from increasing to decreasing or vice versa, $f'(x)$ is zero.

The turning point occurs at the max/min point of the function. Apart from showing the above properties using a graph of the function, it is sometimes necessary to give numerical values to emphasise the ideas being presented. Numerical values can clarify concepts such as: as x increases, $f(x)$ increases and $f'(x)$ is positive. FIGURE 5.21a shows the entries to investigate values of $f(x)$, $f'(x)$ near a turning point. To investigate the turning point of $f(x) = 2x^2 - x + 1$, with x going from -1.5 to 1.75 at points $.25$ apart the following entries are made:

CELL	ENTRY
A3	-1.5
B3	2*A3*A3-A3+1
C3	4*A3-1
A4	A3+.25

When copying formulas the copying facility of the spreadsheet should be used. If typed in individually ensure that cell references are altered (see FIGURE 5.21a).

A similar entry as that in cell A4 is copied into cells A5 up to A16. An entry like that in cell B3 is copied into cells B4 up to B16. The entry in cell C3 is copied into cells C4 up to C16.

FIGURE 5.21b shows the values of:

the function $f(x) = 2x^2 - x + 1$

the derivative $f'(x) = 4x - 1$

for values of x from -1.5 to 1.75 at points .25 apart.

Note that the interval above includes the critical point under investigation, the turning point, $x = .25$. The values of x given in column A of the spreadsheet start from -1.5 and increase by .25 up to and including 1.75. This can be used to emphasise the mathematical concept of the notation:

$$-1.5 \leq x \leq 1.75$$

As the value of x increases the value of $f(x)$ varies as shown by column B beginning at cell B3 with value 7.00000. The values in column B can be seen to decrease as far as 0.87500 which occurs at $x = 0.25$. The first seven values of the derivative $f'(x)$ given in column C can all be seen to be negative starting with the value -7.00000 given in cell C3. When the value of $x = .25000$, given in cell A10, the value of $f(x) = 0.87500$ in cell B10 and the value of $f'(x) = 0$ in cell C10. This is the turning point, $x = 0.25000$. As x increases past 0.25000, $f(x)$ changes from decreasing to increasing, and the values of $f'(x)$ are

positive. The symmetry of the quadratic function can also be seen from studying the values.

Points equidistant from the turning point have equal function values. A column to show the second derivative could also be included, which would show a constant value 4. Different intervals of x can be investigated. FIGURE 5.21c investigates the interval defined by $-0.75000 \leq x \leq .87500$, in steps of 0.125. The layout of the spreadsheet encourages the student to set out the work systematically thus encouraging logical thinking.

The Cubic Function

The entries displayed in FIGURE 5.22 show the values of:

$$f(x) = x^3 - 6x^2 + 11x - 6$$

$$f'(x) = 3x^2 - 12x + 11$$

$$f''(x) = 6x - 12$$

CELL	ENTRY
A3	0
B3	A3*A3*A3-6*A3*A3+11*A3-6
C3	3*A3*A3-12*A3+11
D3	6*A3-12
A4	A3+0.25

The copying refers to using the copy facility of the spreadsheet when cell references are automatically adjusted.

Cell A4 is copied into cells A5 up to A18.

Cell B3 is copied into cells B4 up to B18.

Cell C3 is copied into cells C4 to C18.

Cell D3 is copied into cells D4 up to D18.

	:---A---:	:---B---:	:---C---:
1	x	f(x)	f'(x)
2		$2x^2 - x + 1$	
3	-1.5	$2*A3*A3-A3+1$	$4+A3-1$
4	A3+0.25	$2*A4*A4-A4+1$	$4*A4-1$
5	A4+0.25	$2*A5*A5-A5+1$	$4*A5-1$
6	A5+0.25	$2*A6*A6-A6+1$	$4*A6-1$
7	A6+0.25	$2*A7*A7-A7+1$	$4*A7-1$
8	A7+0.25	$2*A8*A8-A8+1$	$4*A8-1$
9	A8+0.25	$2*A9*A9-A9+1$	$4*A9-1$
10	A9+0.25	$2*A10*A10-A10+1$	$4*A10-1$
11	A10+0.25	$2*A11*A11-A11+1$	$4*A11-1$
12	A11+0.25	$2*A12*A12-A12+1$	$4*A12-1$
13	A12+0.25	$2*A13*A13-A13+1$	$4*A13-1$
14	A13+0.25	$2*A14*A14-A14+1$	$4*A14-1$
15	A14+0.25	$2*A15*A15-A15+1$	$4*A15-1$
16	A15+0.25	$2*A16*A16-A16+1$	$4*A16-1$

FIGURE 5.21a

	:---A---:	:---B---:	:---C---:	:---D---:	:---E---:
1	x	f(x)	f'(x)		
2		$2x^x-x+1$	$4x-1$		
3	-1.5	7	-7		
4	-1.25	5.375	-6		
5	-1	4	-5		
6	-0.75	2.875	-4		
7	-0.5	2	-3		
8	-0.25	1.375	-2		
9	0	1	-1		
10	0.25	0.875	0		
11	0.5	1	1		
12	0.75	1.375	2		
13	1	2	3		
14	1.25	2.875	4		
15	1.5	4	5		
16	1.75	5.375	6		

FIGURE 5.21b

	A	B	C	D	E
1	x	f(x)	f'(x)		
2		$2x^2 - x + 1$	$4x - 1$		
3	-0.75	2.875	-4		
4	-0.625	2.40625	-3.5		
5	-0.5	2	-3		
6	-0.375	1.65625	-2.5		
7	-0.25	1.375	-2		
8	-0.125	1.15625	-1.5		
9	0	1	-1		
10	0.125	0.90625	-0.5		
11	0.25	0.875	0		
12	0.375	0.90625	0.5		
13	0.5	1	1		
14	0.625	1.15625	1.5		
15	0.75	1.375	2		
16	0.875	1.65625	2.5		
17					

FIGURE 5.21c

	A	B	C	D	E	F
1	X	f(x)	f'(x)	f''(x)		
2						
3	0.000000	-6.000000	11.000000	-12.000000		
4	0.250000	-3.609375	8.187500	-10.500000		
5	0.500000	-1.875000	5.750000	-9.000000		
6	0.750000	-0.703125	3.687500	-7.500000		
7	1.000000	0.000000	2.000000	-6.000000		
8	1.250000	0.328125	0.687500	-4.500000		
9	1.500000	0.375000	-0.250000	-3.000000		
10	1.750000	0.234375	-0.812500	-1.500000		
11	2.000000	0.000000	-1.000000	0.000000		
12	2.250000	-0.234375	-0.812500	1.500000		
13	2.500000	-0.375000	-0.250000	3.000000		
14	2.750000	-0.328125	0.687500	4.500000		
15	3.000000	0.000000	2.000000	6.000000		
16	3.250000	0.703125	3.687500	7.500000		
17						

FIGURE 5.22

Graphics on the Spreadsheet

Most spreadsheet packages have a graphics routine available. SwiftCalc is able to display data in bar graphs, pie graphs, line graphs with overlay facilities.

This is useful for displaying data, but cannot be used in an interactive fashion. The power of the spreadsheet is in its ability to handle algebraic equations and display values instantly. **Conclusion**

The spreadsheet provides a mathematics software package which is available on most machines. It can be used to solve some algebraic problems in a way that is different from the traditional method. The 'if' situation is a feature of the spreadsheet. For example:

if $f(x)$ is a function and $x=x_1$, what is the value of $f(x)$? The function can be evaluated at one value of x , or at a range of values of x . The very fast response using the spreadsheet allows more time to discuss the results of such calculations. Most mathematics software packages are graphics oriented. The teacher can introduce a new function and a graph is drawn to demonstrate the function. The discussion is centred on a visual display of the graph. This may be a disadvantage. In contrast to this the spreadsheet will encourage discussion of a table of values, and this is an important step which is missing when a graphical display is too readily available. Practice in mathematical expression and interpretation of data in a tabular form is important for the student. The graph can be viewed afterwards to confirm the discussion. The author has experienced the inability of students in Fiji to interpret data that is not in a graphical form, possibly due to some language deficiency, but mostly because of a lack of understanding of the interpretation of the table of values.

The availability of the spreadsheet for all machines will be an advantage to places like Fiji that do not have the resources to develop their own software. In addition the spreadsheet is also useful in teaching commercial subjects, which are examined in the Fiji educational system. It is an important tool in the running of a business, and its use in schools will certainly help in the understanding of the subjects concerned.

CHAPTER 6

6 PROGRAM CONVERSION

Program conversion here is taken to mean the transfer of a computer program, to be known as the 'source program', from one brand of machine, to be known as the 'source machine', to another to be known as the 'destination program' and 'destination machine'. The source program to be considered here is written in Basic and the language of the destination program will be Basic as well. The rate at which hardware technology is developing is much faster than software development. It is impossible to produce a piece of software which will be able to run on at least two brands of hardware without any modification. One reads about compatible machines being able to run the same program but with some amendments. A computer magazine on the market today offers a software disk which can be used on both the Amiga and the Atari ST microcomputers. The fact is the disk is formatted to be read by both machines but the machines are reading two different versions of the same program. A possible solution for the problem is a world standardised hardware brand, which is not a practical proposition. So the problem of compatibility of software is going to be with us for a long time to come.

The problem investigated in this chapter is the conversion of a program from a source machine to a destination machine as an alternative to software development in developing countries. The first time the author came across the problem was when supervising the Microcomputer Based Teaching Project in Fiji in 1984 (see Appendix J). The Project investigated ways of using the microcomputer in schools in Fiji given the total lack of computer basics on the part of the teachers. A colleague working on the project decided to use a chemistry program which was written for the BBC microcomputer, but the project

used the Atari 800XL microcomputer. The chemistry program was not available on disk or tape for this machine and was only available in the form of a listing in BBC Basic. Because of the lack of programming language knowledge the re-writing of the program in Atari Basic was difficult. The program had good documentation which indicated that it would be useful.

6.1 Why is Program Conversion Necessary ?

The experience mentioned above led the author to realise the importance of program conversion especially as far as educational programs are concerned. Conversion of other sources of information and ideas are being practised all the time since the Bible was translated into the Fijian language some years ago. Today at the USP materials on handouts which are given to students are gleaned from textbooks written and published abroad. There is no reason why computer software translation should not be acceptable to Fiji. Commercial programs are put out to make money and copyright rules are strictly adhered to where money is concerned. Educational material, the author believes, is for international consumption with less stringent copyright restrictions. With this assumption the conversion of programs is important to developing nations like Fiji for a number of reasons:

- (i) the need for good quality software which is hard to find
- (ii) the scarcity of resources required to produce good quality programs
- (iii) to avoid duplicating efforts already expended
- (iv) a thorough knowledge of the program will be gained by the people doing the conversion. In Appendix F, the students solving simultaneous equations using a spreadsheet and a Basic program preferred a Basic program written by themselves and not one already written for them by someone else. They considered it easier to use the one they wrote themselves. Even though converting a program is not the same as writing the program, the person doing the conversion will have a

thorough knowledge of the program before it can be successfully transferred. The person doing the conversion will be in a position to instruct others on how to use the program.

- (v) during the conversion process the program can be amended to suit local conditions. As with textbooks which are written abroad, references to foreign town names do not help understanding which could be enhanced by the use of familiar towns. In the MIME (Micros In Mathematics Education) Project Unit described below a map of England is used to demonstrate the concept of Vector Direction and Magnitude. When converting this for use in Fiji a map of the South Pacific could be used and directions and distances between islands used for demonstration. The use of say the distance and direction of Tonga from Fiji will do more to enhance the ideas of direction and distance to a student in Fiji than will the distance and direction of London from Peterborough. The Fijian student is already aware of the relative positions of Tonga and Fiji and mathematics learning is merely quantifying it. The task of altering examples in textbooks is a major one and has been left unattended. The alteration in one copy of a computer program can be duplicated many times and will be much less trouble than altering a set of textbooks.
- (vii) the choice of software open to developing countries engaged in software conversion will not be restricted as is the case now when one criterion for software suitability is compatibility with the locally available machine. If conversion was to be carried out this criterion will be removed and the educational value of software given more emphasis when considering software purchase.
- (viii) the choice of hardware also will not be restricted to those with

available software. If the choice of hardware and software is restricted, a monopoly situation will arise and this could be taken advantage of by unscrupulous dealers.

- (ix) new mathematical ideas and theories can be introduced into the country through the use of programs written abroad. This role is at present carried out by the written text only.

6.2 Steps in Program Conversion

Three steps are identified as necessary when converting educational programs:

- (a) identifying the program, (b) the transfer of the program, (c) the training of the destination program users.

6.2.1 Identifying the Program

When identifying a program three items which are to be transferred need to be considered:

- (i) Ideas

The mathematical ideas of the program and the method of applying the programs are two concepts that could be transferred when a program is converted from a source machine to a destination machine. Mathematical ideas are universal and mathematicians are keen to have their ideas shared while developing countries do not have the facilities or resources to initiate new mathematical ideas. But when presenting ideas, one has to be conscious of the level at which the ideas are presented, the level being dependent on the audience. It is possible that sometimes the level of mathematical ideas incorporated in a program may not be suitable for the intended audience in the developing country, although in most instances the ideas incorporated in programs will be acceptable. Programs are developed for a specific

mode of application such as demonstration, simulation, tutorial or investigation. Is the application intended by the source program applicable in the destination situation? Will it be an improvement if the destination situation is amended to accommodate the program? These are some questions that need to be considered when looking at ideas incorporated in a program because they will also be transferred when a program is converted.

- (ii) The next thing to consider is the form the program is available in. It is all very well having ideas to transfer but they need to be in the form of a program. The program can be on any media, disk, tape or paper. On paper it could be in the form of a flowchart which can be coded with little trouble, or it could be ready coded in which case language and hardware considerations are vital. Programs on disk is the major topic of this chapter.
- (iii) The third consideration when identifying a program to convert is documentation. Good documentation is a feature of a good program. Some programs use worksheets with supplementary material on them leaving the computer to handle materials that cannot be presented effectively on paper e.g. graphics and animation. The kind of information provided in the documentation will differ between the source program users and the destination program users in developing countries.

Identifying a program is the initial stage which in a developing country includes where to get the program from and what sort of programs? Various sources of programs are available and they come in different forms. For example, in the Project described in Appendix J the chemistry program was available in a book on computers and not on disk or tape. Kosniowski [41] provides listings of computer programs in mathematics (see for example Listings 6.1 and 6.2) all written in

Basic, in a way that they can be adapted to other microcomputers - low cost home computer, a sophisticated home computer or a business system computer. He provides sample screen outputs and these show what should appear on the screen when the program is running. Before the program listing is given, the basic mathematical ideas incorporated in the program are explained. Elgarten et al [42] provide ready-written programs to produce different outputs and ready-developed flowcharts for coding (see Listing 6.3). In both publications referred to above the programs and the explanations are provided on disk or tape, but also written on paper. Before conversion the opportunity is available to study what the program is about and decide if it is suitable.

Kosniowski [41] provides listings for the Sinclair and Commodore Vic 20 microcomputers, but Elgarten [42] does not specify any particular machine.

Kosniowski [41] gives a description of Polar Coordinates before a program to plot Polar Functions is listed (Listings 6.1 and 6.2). Polar coordinates (r, z) are defined and the equality of $(2, \pi/2)$, $(2, -3\pi/2)$ and $(-2, -\pi/2)$ is proved. A Polar Function is defined, $r = \sin(z)$. The Polar Coordinates (r, z) (normally (r, θ)) are converted to the Cartesian Coordinates $(r \cos(z), r \sin(z))$. The point $(r \cos(z), r \sin(z))$ is plotted with different polar relations.

Kosniowski suggests several equations:

- $r = 1$ circle
- $r = \sin(2z)$ a four-leaved rose
- $r = \sin(7z)$ a seven-leaved rose
- $r = 1 + 2\cos(z)$ a limaçon
- $r = 1 + \cos(z)$ a cardioid
- $r = z/4$ a spiral
- $r = 1 + \sin(2z)$ a two-leaved rose

$r = 1 + 2*\cos(2*z)$ looping the loop

Four samples of screen outputs are then given (see FIGURE 6.1, and 6.2) and two listings of the program are provided (see Listings 6.1 and 6.2)) one in Commodore Vic 20 Basic, and the other in Sinclair Basic.

Elgarten [42] defines a Harmonic Sequence and demonstrates how to find the Harmonic Mean of two quantities with a few examples. A flow chart is then presented (see FIGURE 6.3) followed by a Planned Output and a Basic listing of a program (Listing 6.3). Elgarten does not specify the Basic dialect.

The two examples given provide a source of programs that is available and comes in written text form. The other source of programs is that which comes on a disk or tape with the associated documentation. Programs developed by the MIME Project at Loughborough University are available on disk with workcards to go with the programs. MIME Units are written in BBC Basic and a detailed description of the transfer to Atari ST Basic is given in this chapter.

6.2.1 The Transfer of Programs

An important consideration, when translating a computer program from one version of Basic to another, is the graphics involved. Since graphics and animation give a computer some of its unique features, it is important that these unique features are employed in the destination program in the same way that they were employed in the source program. To lose some of the features of the source program will give the destination program a totally different meaning from that intended. Now screen resolution which dictates graphic definition will differ between machines. The transfer of graphics from a source machine with a screen resolution of 320 pixels across by 200 pixels down to a machine with a screen resolution of say 640 across by 400 down will mean better defined graphics in the destination machine. The two Basic dialects will differ mostly in their graphic commands since they are the machine dependent features of a program.

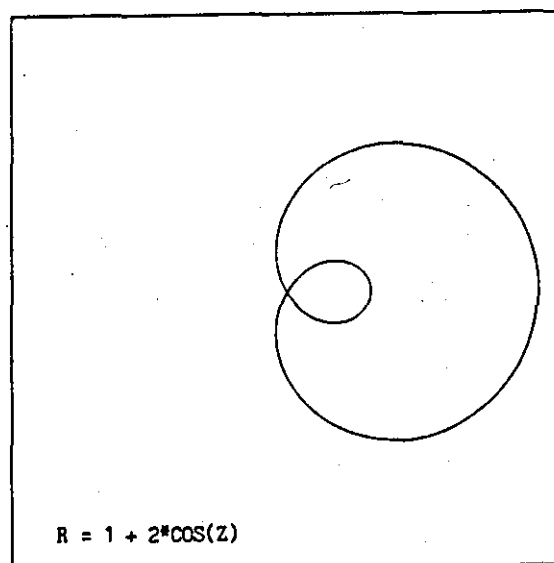
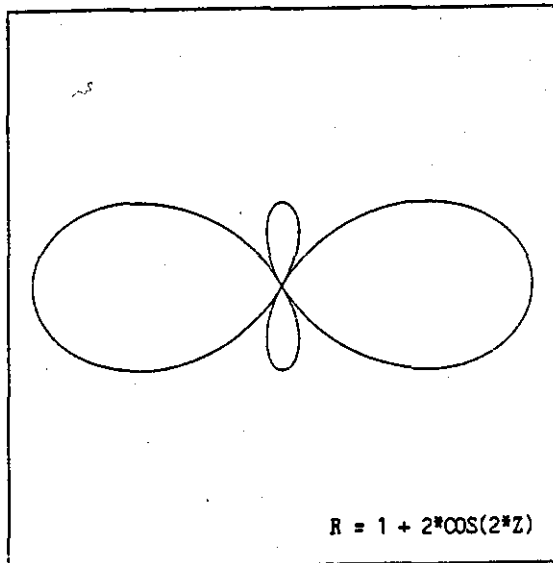


FIGURE 6.1

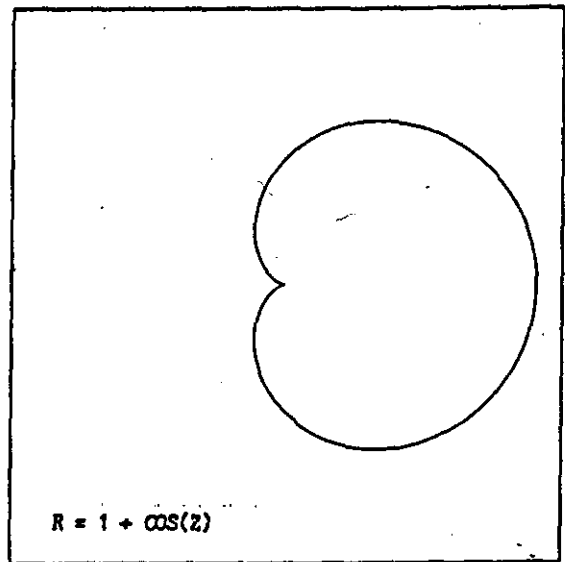
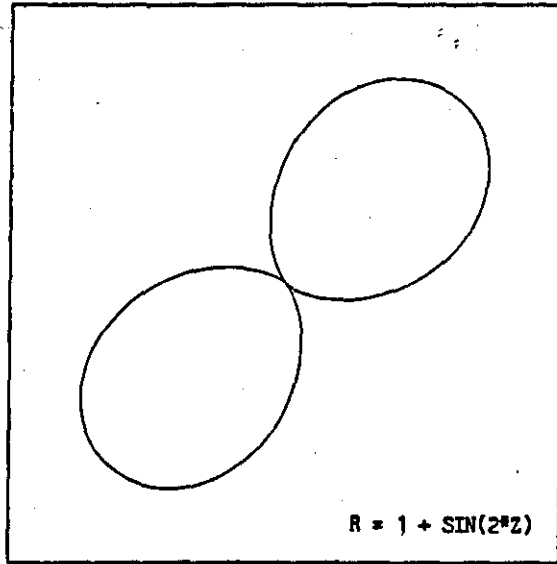


FIGURE 6.2

c. Flowchart

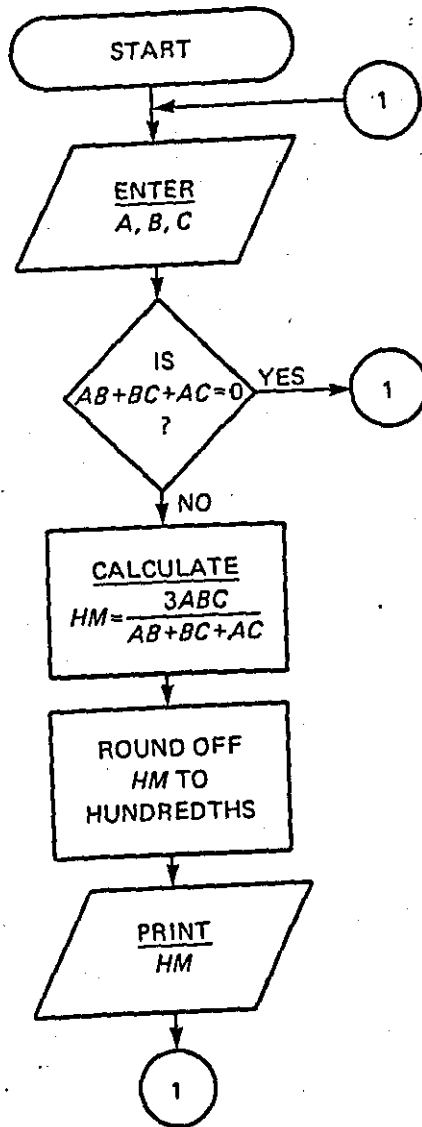


FIGURE 6.3

LISTING 6.1

```

10 REM
20 REM
30 REM
40 REM
50 REM
60 REM
70 REM
100 REM ~~~~~ SETTING UP ~~~~~
120 LET SX=62
130 LET SY=42
140 LET RATIO=0.6
150 LET HY=SY/2
160 LET HX=SX/2
170 CLS
180 PRINT " POLAR GRAPHICS"
190 PRINT
200 PRINT "1. R = 1"
210 PRINT
220 PRINT "2. R = SIN(2*Z)"
230 PRINT
240 PRINT "3. R = SIN(7*Z)"
250 PRINT
260 PRINT "4. R = 1+2*COS(Z)"
270 PRINT
280 PRINT "5. R = 1+COS(Z)"
290 PRINT
300 PRINT "6. R = 1+SIN(2*Z)"
310 PRINT
320 PRINT "7. R = 1+2*COS(2*Z)"
330 PRINT
340 PRINT "TYPE IN THE NUMBER OF"
350 PRINT "THE EQUATION ";
360 INPUT N
365 PRINT N
370 IF N=1 THEN LET A$="1"
380 IF N=2 THEN LET A$="SIN(2*Z)"
390 IF N=3 THEN LET A$="SIN(7*Z)"
400 IF N=4 THEN LET A$="1+2*COS(Z)"
410 IF N=5 THEN LET A$="1+COS(Z)"
420 IF N=6 THEN LET A$="1+SIN(2*Z)"
430 IF N=7 THEN LET A$="1+2*COS(2*Z)"
440 PRINT
450 PRINT "FOR STANDARD PLOT USE A=1 AND B=1"
460 PRINT
470 PRINT "VALUE OF A ";
480 INPUT A
485 PRINT A
490 PRINT
500 PRINT "VALUE OF B ";
510 INPUT B
515 PRINT B
520 PRINT
600 REM ~~~~~ CALCULATING RANGE OF R ~~~~~
610 PRINT "CALCULATING RANGE OF R"
620 LET M=1.0E-30
630 FOR Z=0 TO 2*PI STEP 0.1
640 LET R=ABS(VAL(A$))
650 IF M<R THEN LET M=R+0.1
660 NEXT Z
670 PRINT "READY FOR PLOTTING"
680 FOR I=1 TO 100
690 NEXT I
700 CLS
800 REM ~~~~~ PLOTTING ~~~~~
810 FOR Z=0 TO 2*PI STEP 0.01
820 LET R=VAL(A$)
830 LET U=HX+HY*RATIO*COS(A*Z)*R/M
840 IF U<0 OR U>SX THEN GOTO 880
850 LET V=HY+HY*SIN(A*Z)*R/M
860 IF V<0 OR V>SY THEN GOTO 880
870 PLOT U,V
880 NEXT Z
900 REM ~~~~~ ENDING AND ANOTHER GO ~~~~~
910 LET G$=INKEY$
920 IF G$="" THEN GOTO 910
930 PRINT " ANOTHER GO? Y OR N"
940 LET G$=INKEY$
970 IF G$<"Y" AND G$<"N" THEN GOTO 960
980 IF G$="Y" THEN GOTO 170
990 STOP

```

SX and SY denote the number of points that can be plotted on the screen. Put in the values appropriate for your computer. The number RATIO is used to make a circle look like a circle. Try other values if 0.6 does not work. For the ZX Spectrum use 0.92.

This part calculates the range of R (approximately, to save time). The graph is then scaled to fill your screen.

This PLOTS the graph. A check is made to ensure that only the points that will fit on the screen are plotted.

LISTING 6.2

The program POLAR GRAPHICS, which is an adaptation of the GRAPH PLOTTING program, enables you to plot the graphs of polar functions. It has a library of several different polar functions which you can experiment with. A version for Sinclair microcomputers is also included.

```

10 REM
20 REM
30 REM
40 REM
50 REM
60 REM
70 REM
100 REM *****
110 LET CS#=CHR$(147) : REM CODE FOR CLEAR SCREEN
120 LET SX=144 : REM SCREEN SIZE HORIZ
130 LET SY=176 : REM SCREEN SIZE VERT
140 LET RATIO=0.6 : REM TO MAKE HORIZ & VERT LINES SAME LENGTH
150 LET HY=SY/2
160 LET HX=SX/2
165 GOSUB 1310 : REM EXTRA VIC 20 SETTINGS
170 PRINT CS# : REM CLS
180 PRINT " POLAR GRAPHICS"
190 PRINT
200 PRINT "1. R = 1"
210 PRINT
220 PRINT "2. R = SIN(2*Z)"
230 PRINT
240 PRINT "3. R = SIN(7*Z)"
250 PRINT
260 PRINT "4. R = 1+2*COS(Z)"
270 PRINT
280 PRINT "5. R = 1+COS(Z)"
290 PRINT
300 PRINT "6. R = 1+SIN(2*Z)"
310 PRINT
320 PRINT "7. R = 1+2*COS(2*Z)"
330 PRINT
340 PRINT "TYPE IN THE NUMBER OF"
350 PRINT "THE EQUATION";
360 INPUT N
370 IF N=1 THEN DEF FNA(Z)=1
380 IF N=2 THEN DEF FNA(Z)=SIN(2*Z)
390 IF N=3 THEN DEF FNA(Z)=SIN(7*Z)
400 IF N=4 THEN DEF FNA(Z)=1+2*COS(Z)
410 IF N=5 THEN DEF FNA(Z)=1+COS(Z)
420 IF N=6 THEN DEF FNA(Z)=1+SIN(2*Z)
430 IF N=7 THEN DEF FNA(Z)=1+2*COS(2*Z)
440 PRINT
450 PRINT "FOR STANDARD PLOT USE A=1 AND B=1"
460 PRINT
470 PRINT "VALUE OF A";
480 INPUT A
490 PRINT
500 PRINT "VALUE OF B";
510 INPUT B
520 PRINT

```

*
* POLAR GRAPHICS *
*

SX and SY denote the number of points that can be plotted on the screen. Put in the values appropriate for your computer. The number RATIO is used to make a circle look like a circle. Try other values if 0.6 does not work.

LISTING 6.2 (continued)

```

600 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX CALCULATING RANGE OF R XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
610 PRINT "CALCULATING RANGE OF R"
620 LET M=1.0E-30
630 FOR Z=0 TO 2*PI STEP 0.1 : REM PI           This part calculates the range
640 LET R=ABS(FNA(Z))                          of R (approximately, to save
650 IF M<R THEN LET M=R+0.1                    time). The graph is then
660 NEXT Z                                       scaled to fill your screen.
670 PRINT "READY FOR PLOTTING"
680 FOR I=1 TO 1000
690 NEXT I
700 PRINT CS$ : REM CLS
710 GOSUB 1010 : REM PREPARE SCREEN IF NECESSARY
800 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX PLOTTING XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
810 FOR Z=0 TO 2*PI STEP 0.01 : REM PI        This PLOTS the graph. A check
820 LET R=FNA(Z)                               is made to ensure that only
830 LET U=HX+HY*RATIO*ICOS(A#Z)*R/M           the points that will fit on
840 IF UC0 OR UDX THEN GOTO 830                the screen are plotted. Use
850 LET V=HY+HV*SIN(B#Z)*R/M                   the screen are plotted. Use
860 IF VC0 OR VDY THEN GOTO 830                PLOT or POKE as appropriate.
870 GOSUB 1110 : REM PLOT U,V
880 NEXT Z
900 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX ENDING AND ANOTHER GO XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
910 GET G$ : REM LET G$=INKEY$
920 IF G$="" THEN GOTO 910
930 GOSUB 1210 : REM RESTORE SCREEN IF NECESSARY
940 PRINT CS$ : REM CLS
950 PRINT " ANOTHER GO?  Y OR N"
960 GET G$ : REM LET G$=INKEY$
970 IF G#<"Y" AND G#<"N" THEN GOTO 960
980 IF G#="Y" THEN GOTO 170
990 END : REM STOP
1000 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX PREPARE HI-RES SCREEN FOR VIC 20 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1010 POKE 36869,R9+12:POKE 36867,(PEEK(36867) AND 128) OR 25
1020 POKE 36866,R5-4:POKE 36864,R3+4
1030 FOR I=RR TO SS:POKE I,0:NEXT I
1040 FOR I=0 TO 219:POKE PP+I,I-32#0:POKE QQ+I,2:NEXT I
1050 RETURN
1100 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX PLOT VIA POKE FOR VIC 20 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1110 V=SY-V
1120 J=INT(U/8)
1130 L=INT(U-9#J)
1140 I=INT(V/16)
1150 K=INT(V-16#I)
1160 W=RR+I*208+J*16+K
1170 POKE W,PEEK(W) OR 21(7-L)
1180 RETURN
1200 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX RESTORE SCREEN FOR VIC 20 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1210 POKE 36869,R9:POKE 36867,R6
1220 POKE 36866,R5:POKE 36864,R3:POKE 198,0
1230 RETURN
1300 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX VIC 20 SETTINGS XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1310 Q=PEEK(44)=18:PP=7680+Q#3584:QQ=38400+Q#512
1320 IF Q=-1 AND PEEK(44)<32 THEN PRINT "PROGRAM ABORTED - SEE APPENDIX":END
1330 RR=4096-Q#512:SS=RR+3583:R8=PEEK(36869):R6=PEEK(36867)
1340 R5=PEEK(36866):R3=PEEK(36864)
1350 RETURN

```

Use the appropriate POKEs for your microcomputer.

LISTING 6.3

d. *Planned Output*

```
FINDING THE HARMONIC MEAN OF 3 NUMBERS  
ENTER THREE NUMBERS ? 2, 8, 10  
FOR THE NUMBERS 2, 8 AND 10  
THE HARMONIC MEAN IS 4.14
```

```
ENTER THREE NUMBERS ?
```

e. *The Program*

```
10 PRINT "FINDING THE HARMONIC MEAN OF 3 NUMBERS"  
20 INPUT "ENTER THREE NUMBERS": A, B, C  
30 IF A*B+B*C+A*C=0 THEN GOTO 100  
40 HM=3*A*B*C/(A*B+B*C+A*C)  
50 HM=HM+.005  
60 HM=INT(100*HM)/100  
70 PRINT "FOR THE NUMBERS"; A; ", "; B; "AND"; C  
80 PRINT "THE HARMONIC MEAN IS"; HM  
90 PRINT:PRINT: GOTO 20  
100 PRINT "THE HARMONIC MEAN IS UNDEFINED FOR" A; B; "AND"; C  
110 GOTO 90  
120 END
```

Educational programs rely very much on displays which can be coloured and animated. In Kosniowski's [41] programs above the variable quantity `RATIO` is used to make a circle look like a circle on the screen (see line 140 in both Listings 6.1 and 6.2). The normal value is 0.6 but the value 0.92 is suggested for the Sinclair machine. The variable `SX` stands for the number of points that can be plotted across the screen and `SY` is the number of points that can be plotted vertically on the screen (see lines 120 and 130 in both listings). These values are used to calculate the range of points that can be plotted by the machine. Without knowing the range the machine will try and plot points that are not on the screen and delay execution time. The Commodore Vic 20 Basic uses the commands `POKE` and `PEEK` to plot points (see line 1170 in listing 6.2) while the Sinclair Basic uses the command `PLOT` (see line 870 listing 6.2). With the Commodore Vic 20 microcomputer the screen has to be prepared for a graphics display (see lines 1010-1050) and restored later to display text (see lines 930, and 1210 - 1230). In the preparation and restoration routines the commands `PEEK` and `POKE` are used extensively. The Sinclair microcomputer prepares the screen with the command `CLS` (see line 700) which clears the screen of any display and it does not then require a restoration routine to display text. The complicated routines involved with the screen preparation and restoration on the Commodore Vic 20 were also necessary with the Commodore 64 and was one of the reasons the author rejected the Commodore 64 in favour of the Atari 800XL during the early days of computing in Fiji. When the plotting of the display is completed the program is halted to allow time for the user to view the screen. This technique is employed to give the user some control over the running of the program, which can be resumed by an input from the user. The Commodore Vic 20 Basic uses the routine in lines 910 - 920:

```
910GET G$
920 IF G$=" " THEN GOTO 910
```

In Sinclair Basic this is handled slightly differently in lines 910-920:

```
910 LET G$ = INKEY$  
920 IF G$ = "" GOTO 910
```

The program Listing 6.3 by Elgarten [42] contains the Basic commands PRINT, INPUT, IF ...THEN, LET, GOTO and END. These commands are not hardware dependent and they do not belong exclusively to one dialect of Basic, or shared only by some dialects of Basic. They are present in all dialects of Basic and that is why Elgarten does not need to specify a machine for the program, which does not display any graphics (see Planned Output in Listing 6.3). This is the type of program that was much used in early computer programming courses, and which the author is now rejecting because of its lack of graphic display (see Appendix B).

Data input methods can also differ between machines. In the programs discussed above the only method of input employed is through the keyboard, though the method of accepting and identifying the inputs are slightly different. The prompt in the two programs is displayed as a menu. Say the choice is the function $R = \text{SIN}(7*Z)$. In the Commodore Basic the input is identified and handled by:

```
390 IF N=3 THEN DEF FNA(Z)=SIN(7*Z)
```

to calculate the y coordinate(R) of a point

```
820 R=FNA(Z)
```

In the Sinclair Basic this is done by:

```
390 IF N=3 THEN LET A$="SIN(7*Z)"
```

```
820 R=VAL(A$)
```

The VAL(A\$) in Sinclair Basic, also available in BBC Basic, will allow the function to be keyed in directly from the keyboard by the user instead of restricting the choices of functions to those in the menu. This could be handled by:

```
10 INPUT A$
```

```
20 R=VAL(A$)
```

Later models of microcomputers allow inputs by a 'mouse' manipulating a pointer on the screen. This is used by the Atari ST in the BBC/Atari ST conversion discussed later.

6.2.3 The Training

The training of people to use an educational program is an important function that needs to be carried out before the program is released to schools. This could be achieved by good documentation and the teacher spending time studying the program before using it with a class. This might seem unnecessary with programs such as those discussed above which are short, and where the demand on the user for inputs is not excessive, but inactivity in the middle of running a program in class due to lack of input or wrong input can be annoying and disruptive. With programs such as the Units developed under MIME Project, teacher training in the use of the programs is definitely essential. Training of users is normally carried out by the designer of the program, which in the MIME Project would include a subject specialist and a programmer. In some cases the subject specialist eventually becomes a programmer. In the situation where the program has been converted, the person who did the conversion will be in a position to carry out the training of users. During training revised documentation of the program could also be designed with the help of the trainees, who will be using the program in the field. Trainees' comments and criticism should be welcomed by the conversion specialist, not only while they are in training, but also when they are out using the program in the classroom. Continuous feedback from users and constant revision of the program conversion should eventually result in a successful program. Areas in which trainees should receive guidance include:

- (i) the mathematical ideas dealt with in the program
- (ii) the teaching style intended by the program and the possible style that can be applied
- (iii) interpretation of program prompts and expected inputs
- (iv) interpretation of screen graphic displays
- (v) actions that may cause the program to crash, and how to recover from the crash (normally it should not be possible to crash a good educational program).

6.3 Conversion of MIME Project Unit on Vectors

The availability of MIME Units

The MIME project is based at CAMET (Centre for Advancement of Mathematical Education in Technology) at Loughborough University of Technology. The programs are written in BBC Basic and are aimed at A Level students in British Schools.

There are MIME programs which are suitable also for students who are not studying A Level mathematics and the program VECTORS is one. Mime programs are available on disks for use on the BBC microcomputer and some on the IBM PC.

They are published by John Wiley & Sons Ltd, Baffins Lane, Chichester, Sussex, PO19 1UD, England, and are also available from their New York Office, John Wiley & Sons, 605 Third Avenue, New York NY 10016 USA. These programs have been extensively tested in schools, whose comments and suggestions have been noted and incorporated where possible. The source programs available in MIME Units require a BBC microcomputer to enable the programs to be viewed in action. This will mean the expense in purchasing one source machine, which once purchased would be available for use in any future conversions involving the same source machine. Most educational programs are available on disks with some documentation making the programs very much hardware dependent. An advantage seen in conversion is the elimination of the dependency on hardware when selecting software. Should Fiji continue using the Commodore 64 microcomputer in

schools all it needs is one BBC, one IBM, etc and software developed for the BBC, IBM, etc will be available to the schools on Commodore 64 once conversion is available.

The philosophy, which has to be transferred as well, behind MIME programs is the use of the ability of micros to give graphic displays and movement on the screen. Interaction is an important feature which the authors of MIME Units hope will encourage investigation, experimentation and simulation of practical situations. Particular problems can be demonstrated in class by the teacher, entering parameters related to the problems. These ideas incorporated in MIME programs must be transferred to the destination program to make it as effective as the source program. The program Vectors is available on two disks which are formatted to run on the BBC/B 40T (40 track disk drive) microcomputer. Two sets of documents accompany the unit, a 'User's Guide and Teacher's Notes' and a set of Workcards. The User's Guide and Teacher's Notes describe the content of the unit and the Workcards present the theory of Vectors. The User's Guide also contains instructions on how to start the Unit.

Organisation of the Unit on Vectors

The Unit is organised into Parts 0 to 9, and each Part is divided into Sections. Each Section is referred to by two numbers e.g. Section 4.2 is the second section of Part 4. Part 0 contains instructions to enable an inexperienced user to operate the program. Parts 1 to 9 contain subject matter as shown below:

- PART 0 *Inexperienced User Guide*
- PART 1 *Displacement Vectors*
 - 1.1 *Definition*
 - 1.2 *Magnitude and Direction*
- PART 2 *Equality and Other Examples*
 - 2.1 *Equality of Displacement Vectors*

- 2.2 Examples of Other Vectors
- PART 3 Addition and Subtraction
 - 3.1 Addition of Two Vector Displacements
 - 3.2 Addition of Three Vector Displacements
 - 3.3 Subtraction
- PART 4 More Addition/Subtraction
 - 4.1 Two Forces
 - 4.2 Two Velocities
- PART 5 Perpendicular Components
 - 5.1 Resolution into Two Perpendicular Components
 - 5.2 Example of Force Components
 - 5.3 Examples of Velocity Components
 - 5.4 2-D Cartesian Vectors
- PART 6 Resultants
 - 6.1 Resultant of Two Vectors
 - 6.2 Resultant of More Than Two Vectors
 - 6.3 Equilibrium of a Space-craft
- PART 7 3-D Cartesian Vectors
 - 7.1 The Unit Vectors
 - 7.2 Coordinate Direction Angles
 - 7.3 Addition of Several Vectors
 - 7.4 Position Vectors
- PART 8 Scalar/Vector Products
 - 8.1 The Scalar Product
 - 8.2 The Vector Product
- PART 9 Exit from Unit

The program is loaded and a part executed when selected from a Menu. The problems of conversion are investigated here by considering the conversion of

the first Part, Displacement Vectors, of the Unit.

6.3.1 Conversion Approach

The program on Displacements Vectors (PART 1) being on disk and the availability of a BBC B 40T microcomputer enabled the author to study the program in action, in addition to being able to read the documentation and a program listing. This is in contrast to programs which are available only as listings. It is much more difficult to understand what is happening in a listed program than in a program that is up and running. Two alternatives for tackling the conversion are available with a program that is available with its associated hardware i.e. it can be studied while running:

- (i) the author can translate the source program listing to the destination program version. This would entail a line by line or sub-routine by sub-routine translation process which would be troublesome if the source program employs machine code routines which are called up from Basic. Each command, statement and function of the source program has to be interpreted which will place extra demands on the translator.
- (ii) the translator can study the documentation and the screen outputs of the program then develop a program in the destination Basic to give the same result as the source program. The conversion author will by this method concentrate on the one Basic dialect to achieve the results which are visible on the screen. This will require the conversion author to be a specialist in the subject matter of the program.

The author after studying the Vector program decided to carry out the conversion by the second method above. In keeping with MIME stated policy the program on Vectors is graphics oriented to the extent that well over fifty percent of the screen area is devoted to graphics with the exception when the Menu is

displayed. The second method of approach does not require the author to be an expert in BBC Basic as well; all it requires is a knowledge of vectors and the GFA Basic language which runs on the Atari ST microcomputer. The procedure in the translation of the Vectors program will now be described.

Observation and Study of Source Program: Vectors

Due to the length of the MIME Project Unit on Vectors (PART 1 - PART 9) it was decided to transfer PART 1 only which dealt with Displacement Vectors in two sections:

- (i) 1.1 Definition
- (ii) 1.2 Magnitude and Direction

Section 1.1 defines a displacement vector by:

- (i) providing a scaled map of an area of England on the screen, see FIGURE 6.4
- (ii) drawing a pair of axes and placing Oxford town at the origin and drawing displacement vectors to eight other towns on the map, see FIGURE 6.9
- (iii) allowing the user to choose any two towns on the map, and drawing the displacement vector between the towns.

Section 1.2 defines magnitude and direction by allowing the user to choose any two towns and it will:

- (i) display the displacement vector
- (ii) calculate the magnitude and direction of the displacement vector
- (iii) display the magnitude and the direction on the map and in a table.

The program is very much graphics oriented and this is evident in:

- (i) the allocation of half the screen area to graphic displays
- (ii) the number of different screen graphics displays used. In section 1.1

there are more than forty different screen displays from the first display shown in FIGURE 6.4 to the end of the section.

There is excessive use of the Space Bar response by the user. From the start the Space Bar has to be pressed more than twenty times before the expected response is changed to another character - up to nine letters for the name of a town.

Then two numerical inputs are requested, the distance East and North of the town before it is back to psb (press space bar). While using the program with a class, one of the students commented it was like playing the game of 'Spot the Difference'. She was finding it difficult to differentiate between the displays in between the psb's. Two kinds of menus and a current status menu are available in the program. Menu 1 allows the user to choose which PART of the Unit to use, while Menu 2 allows the user to choose the section to use. The status menu Menu 3 tells the user which part of the unit is being used.

MENU 1

VECTORS

PART	CONTENTS
0	INEXPERIENCED USER GUIDE
1	DISPLACEMENT VECTORS
2	EQUALITY AND OTHER EXAMPLES
3	ADDITION AND SUBTRACTION
4	MORE ADDITION/SUBTRACTION
5	PERPENDICULAR COMPONENTS
6	RESULTANTS
7	3-D CARTESIAN VECTORS
8	SCALAR/VECTOR PRODUCTS
9	EXIT FROM UNIT

ENTER NUMBER THEN PRESS RETURN

MENU 2

VECTORS

DISPLACEMENT VECTORS

SECTION CONTENTS

- 1 Definition
- 2 Magnitude and Direction

ENTER NUMBER THEN PRESS RETURN

MENU 3

VECTORS

CURRENT STATUS

- 0 INEXPERIENCED USER
- 1 DISPLACEMENT VECTOR
 - 1.1 Definition
 - 1.2 Magnitude and Direction
- 3 ADDITION AND SUBTRACTION
- 4 MORE ADDITION AND SUBTRACTION

1.1 psb

The Current Status menu displays all the PARTS and shows a break down of the PART in use which is also highlighted by displaying it in a different colour from the rest of the text in the menu. It is displayed at the end of each section before going on to the next section. Pressing the BREAK key during the running of the program returns the user to Menu 1. Pressing the ESCAPE key restarts the current PART or Section.

The program starts off by offering the user Menu 1, then Menu 2 to which the

user responds with a number indicating the choice of PART and Section. Menu 3 is then displayed to which the response is psb. The first four displays are shown in FIGURE 6.4 - FIGURE 6.7. The diagrams show the screen display of the destination machine, the Atari ST.

As the source program is essentially a graphic display of displacement vectors, it is essential for the destination program Basic dialect to have good graphic facilities. A discussion with reference to graphic facilities of the Basic language dialect used in the conversion is given here.

6.3.2 GFA Basic On the Atari ST

The destination language used is the GFA Basic Interpreter. There is also a compiled version of GFA Basic but facilities provided by the Interpreter version are considered ample for the task and throughout the discussion GFA Basic will be taken to mean the Interpreter version.

The commercial description on the packaging of the GFA Basic v 2.0, which comes on one 3.5 disk with a 290 page manual, is that it is a compact high speed interpreter with 11 digit accuracy, it is structured, it uses GEM (Graphics Environment Management) and has a user friendly editor. Three essential differences from traditional Basic are listed:

- (i) there are no line numbers in GFA Basic
- (ii) only one command is allowed per line
- (iii) there are a few new structured commands and the structure of some traditional commands have been adapted.

An extra feature in GFA Basic is the availability of a program called GFABASRO.PRG on the language disk and it allows the running of a GFA Basic program GFA Basic interpreter. It is called the 'Run Only' version of GFA Basic and it cannot be used to write programs. The converted program in a place like Fiji could be passed on to schools with just the Run Only program which will not

allow users to tamper with the programs, but only to use them. A copy of the converted program is available on disk accompanying the thesis. The disk also holds a copy of GFABASRO.PRG which has to be run first before the converted program can be run.

Any reference to Basic commands from here on will, unless otherwise stated, refer to GFA Basic on the Atari ST microcomputer.

6.3.3 Features in the Conversion of the Screen Layout

Three Screen Areas

The demarcation of the screen into graphics and text areas is a feature of the source program that had to be transferred. GFA Basic provides the graphic command:

```
BOX x1,y1,x2,y2
```

which draws a rectangular box with diagonally opposite corners at (x1,y1) and (x2,y2).

Mixing of Text and Graphics

In the source program, text is mixed with graphics in the graphics area in the top right box of the screen display. GFA permits the writing of text anywhere on the screen by the graphics command:

```
TEXT x,y,[l,]a$
```

which writes the string a\$ at point (x,y) on the screen, and 'l' is an optional parameter which determines the length of the text to be displayed. The colour, size, rotation and style of the text can be set by the graphics command DEFTEXT.

Screen Size

The destination machine, Atari ST, offers three standards of screen resolution:

- (i) low resolution with 320 pixels across and 200 pixels down the screen
- (ii) medium resolution with 640x200 pixels

(iii) high resolution with 640x400 pixels.

The destination program is written in medium resolution which gives a satisfactory definition to the graphics display.

The screen origin with coordinates (0,0) is at the top left of the screen.

6.3.4 Other Graphics Commands

LINE and DEFLINE

LINE x_1, y_1, x_2, y_2 draws a line from point (x_1, y_1) to point (x_2, y_2) and DEFLINE, which determines the type of line to be drawn, are two very useful commands in the conversion. DEFLINE sets the line style, line width and type of line, beginning and end. The line ends facility allows for the arrow head in drawing vectors.

DEFLINE [s],[w],[a],[e]

s defines the style i.e. dotted, dashed etc

w the width in graphics dots

a the type of beginning

e the type of end.

Beginning and end type are:

0 for normal

1 for arrow

2 for rounded.

PLOT

PLOT x, y draws a dot on the screen at point (x, y)

DRAW

DRAW x, y also plots a point at (x, y)

DRAW TO x, y connects the point (x, y) to the previous point drawn by
PLOT, LINE or DRAW

DRAW x1,y1 TO x2,y2

draws a line from (x1,y1) to (x2,y2)

COLOR

COLOR x determines the colour used for drawing and plotting. In low resolution x can be any number from 0 to 15, in medium from 0 to 3, and in high 0 or 1.

6.3.5 Other Useful GFA Basic Commands

Another feature of the source program is the interaction with the user where the program prompts the user and waits for the user to respond with a psb. The source program employs this technique often. GFA Basic can handle the situation with the following routine:

```
REPEAT
A$ = INKEY$
UNTIL A$<>""
```

when any key pressed will cause the computer to continue with the execution of the program. The command(s) between REPEAT and UNTIL will keep being executed until the condition specified in the UNTIL command is satisfied. The command in this case means allocate to string variable A\$ the character INKEY\$ which is generated by the keyboard. If no key is being pressed INKEY\$ will hold the empty character indicated by the two double quotes with nothing in between(""). This value will be passed on to A\$. As soon as a key is pressed INKEY\$ will no longer contain the empty value ("") and A\$ will also be empty i.e A\$<>"". The key pressed can be specified by changing the bottom line to:

```
UNTIL A$=CHR$(32)
```

where CHR\$(32) is the character (non printable on screen) generated by the keyboard when psb is pressed. Any key can be specified by replacing 32 with its ASCII code (see TABLE G.1)

Mouse

The user of the source program can respond only by means of the keyboard, whereas the user of the destination program has the option of using the 'mouse', which controls a pointer on the screen in order to respond to the program. As an illustration take the psb response. To use the mouse for this response the letters psb are displayed on the screen at a location starting at a point $(x1,y1)$. There are three characters to be displayed so that will take up $3 \times 8 = 24$ pixels across. Each character in the Atari ST screen is 4 pixels high, therefore the psb display will take up an area of 24×4 pixels as shown (enlarged and not to scale):

```
.....  
.....  
.....  
.....  
.....
```

If the bottom left hand corner of this rectangle is point $(x1,y1)$ then the top right hand corner is $(x1+24,y1-4)$. Remember that the origin of the screen has coordinates $(0,0)$ at the top left hand corner of the screen. The command:

```
MOUSE x,y,k
```

will determine the position of the mouse (x,y) and also the status of the mouse button (k) . To wait the psb response in the illustration above the routine will be:

```
REPEAT
```

```
    MOUSE a,b,c
```

```
UNTIL a>x1 and a<x1+24 and b>y1-4 and b<y1 and c=1
```

where the variables a and b will keep reading the position of the mouse as the mouse travels around the screen. c will read the state of the buttons on the mouse:

```
    if c=0 none of the two buttons on the mouse is being pressed
```

if c=1 the left button is being pressed

if c=2 the right

if c=3 both are being pressed.

The values for a,b, and c specified in the last line of the routine are to be satisfied before the program proceeds and this will be achieved by moving the mouse to the area of the screen containing the letters psb and clicking the left button of the mouse. The availability of the mouse on the destination machine provides a useful alternative to keyboard entry.

Students who tried out the source program were pleasantly surprised by how mathematics could be presented in such a colourful way, and even though they did not understand all the mathematics, they were happy to use the program, except for the monotony of psb. In the destination program the author has incorporated the use of the mouse.

Mathematical Functions

In addition to traditional mathematical functions found in most Basic dialects, GFA Basic includes:

PI for the value of 22/7

HEX\$(x) which changes the value x into a string expression of the hexadecimal value of x

BIN\$ changes a decimal to binary

OCT\$ changes a decimal to octal.

6.3.5 Conclusion

There is more to the GFA Basic, but the author has given here the features which have helped in the conversion of the MIME program Vectors, PART 1. This particular conversion has helped the author tremendously in many ways:

- (i) understanding the program, which is important if one is to use an

- educational program successfully
- (ii) understanding the mathematical concepts presented in the program, which is necessary to avoid underestimating or overestimating the level of the program
 - (iii) increased knowledge of the destination language GFA Basic, which will be useful as it will be available locally in Fiji
 - (iv) increased knowledge of the destination hardware, the Atari ST microcomputer
 - (v) some skills in programming have been gained, especially in graphics. The ability to control the mouse on the screen is really pleasing and very attractive.

With languages like GFA Basic around the quest for compiled languages should be unnecessary.

There are great rewards to be gained by students and teachers, especially in developing countries, from a conversion exercise. It provides software for local consumption as well as training for skills that are in great demand.

A copy of the destination program is available on disk.

V E C T O R S

DEFINITION

N
E
S
W

We shall draw a 'scale' map with directions
North, South, East, West

QUIT MAIN PART 1 SECTION 1 PSB

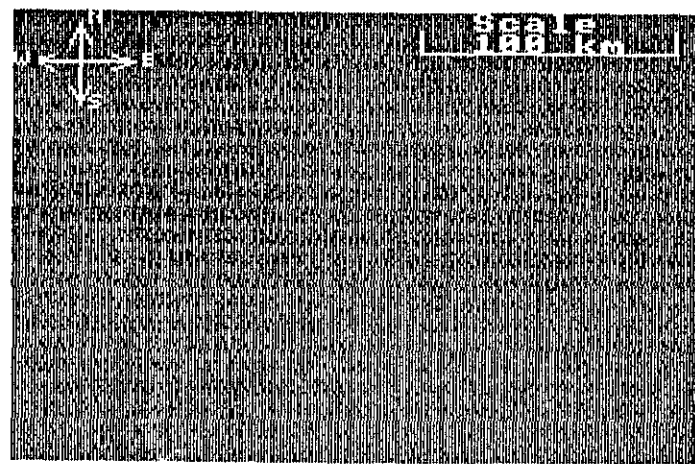
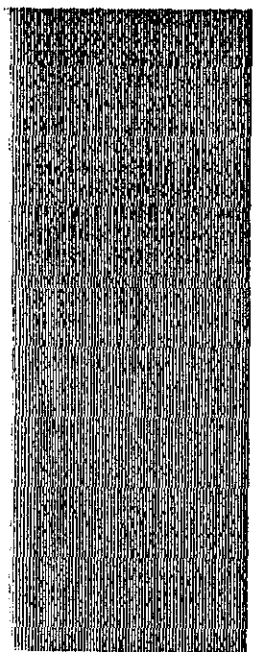
FIGURE 6.4

222a



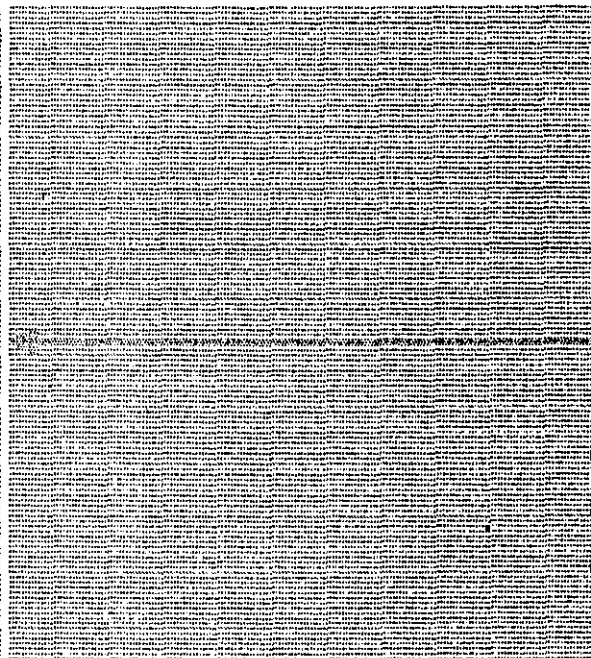
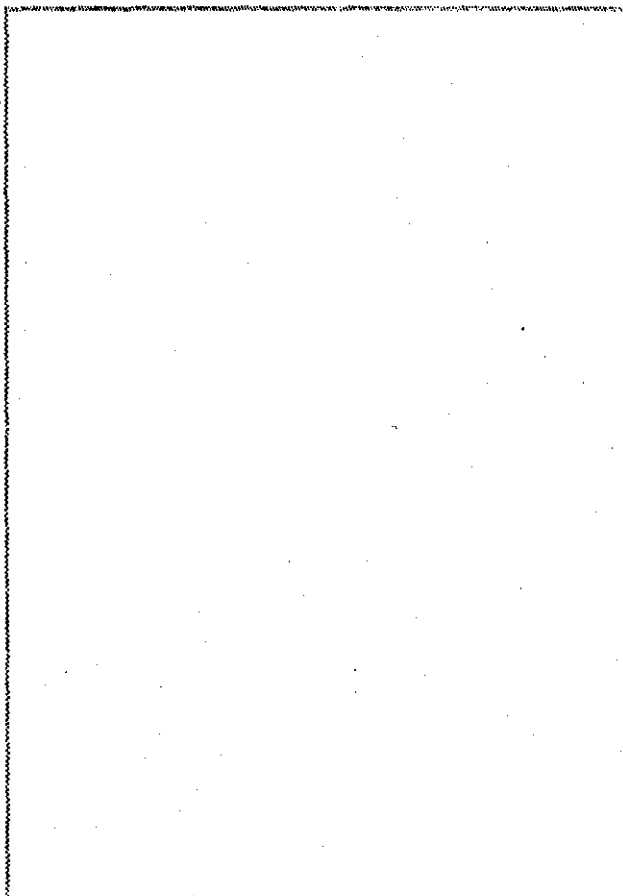
We shall draw a 'scale' map with directions North, South, East, West and scale as shown

MAP I GARDEN PART II



We shall draw a 'scale' map with directions North, South, East, West and scale as shown.

FIGURE 6.5

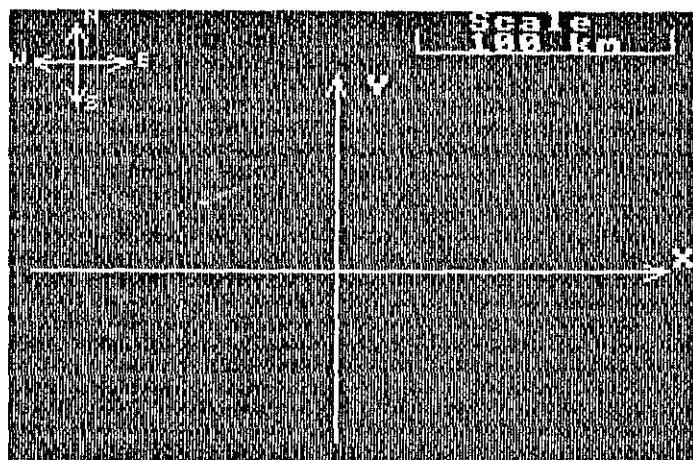
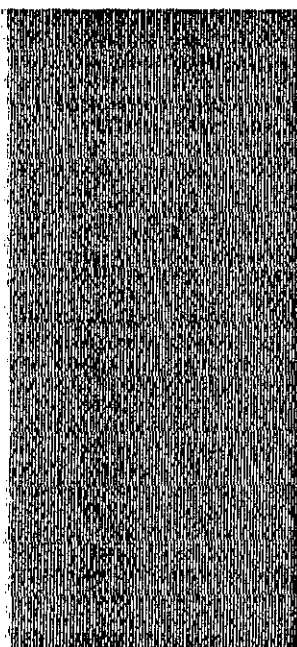


We shall choose Oxford
and draw X and Y axis

PART I

PART II

PART III



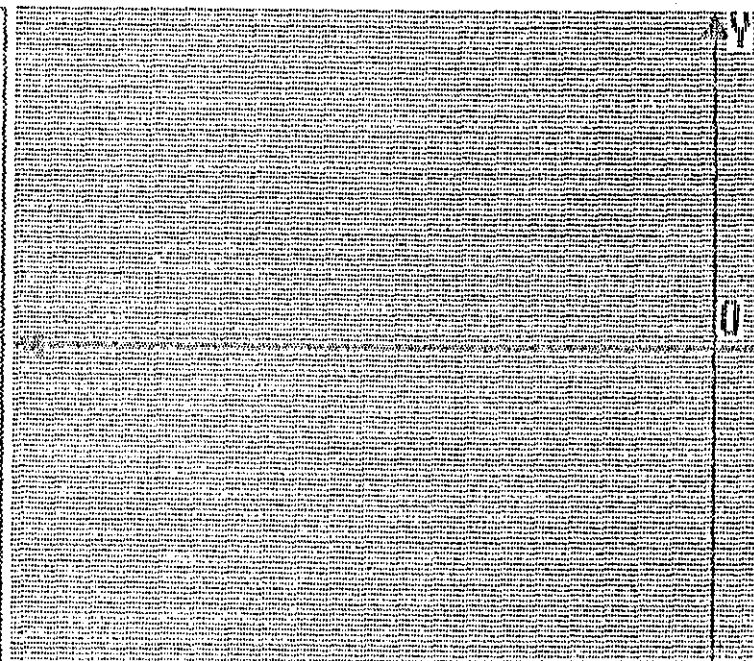
We shall choose Oxford as
the origin of our map and
draw X and Y axes

FIGURE 6.6

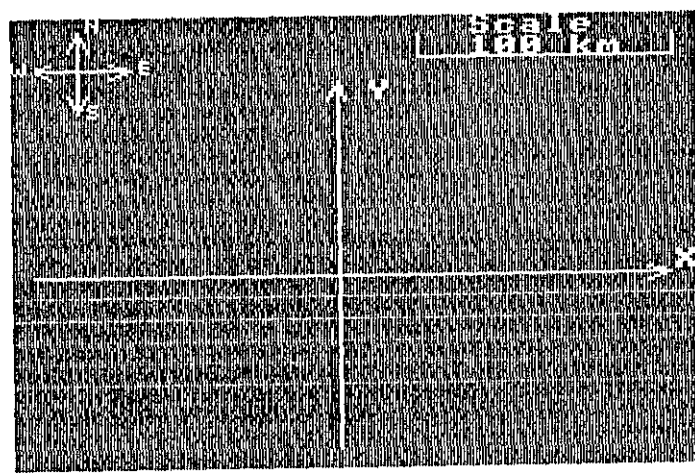
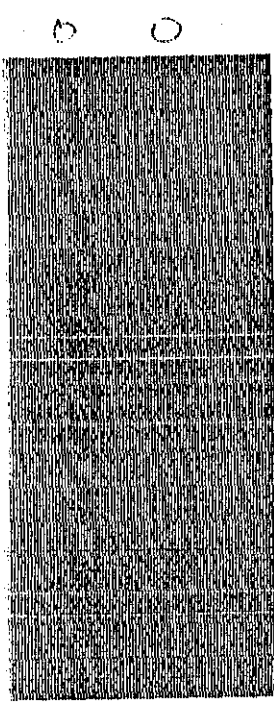
V E C T O R S

TOWN	X	Y
0	0	0

0 Oxford



Oxford is at the point $(0, 0)$



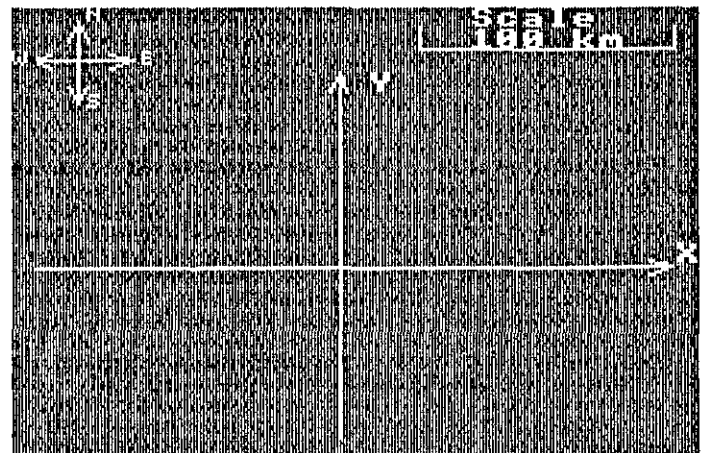
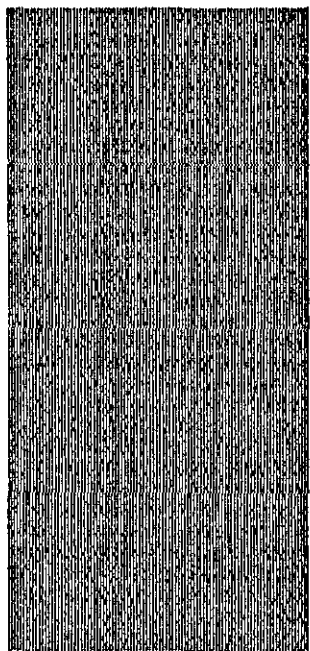
We shall choose Oxford as the origin of our map and draw X and Y axes
Oxford is at the point $(0, 0)$ relative to the axes

FIGURE 6.7

TOWN	X	Y
O	0	0
C	90	60

O Oxford
 C Cambridge

Cambridge is 90 Km East
 That is position (90, 60)



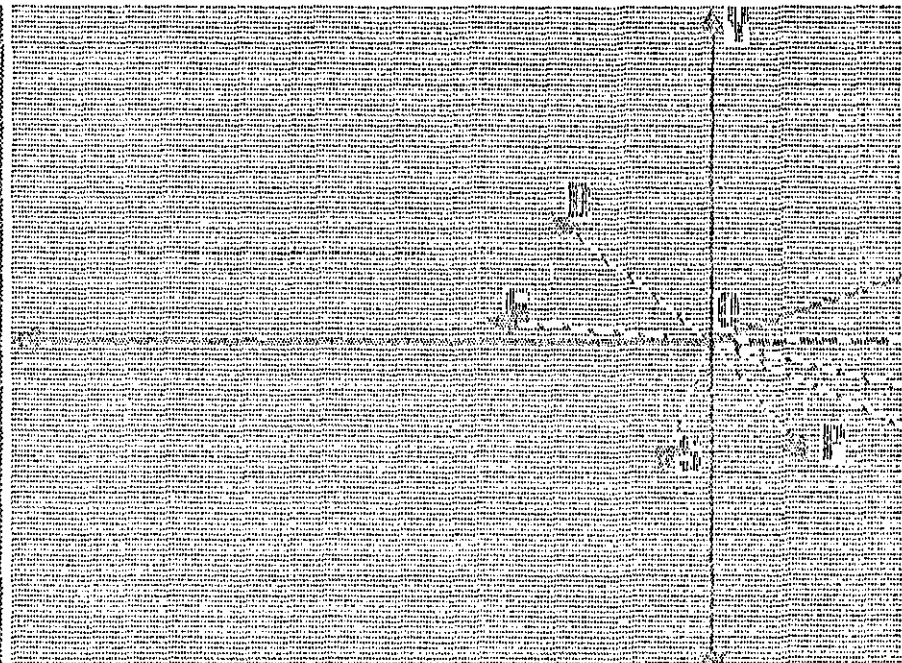
Cambridge is 90 km East
 60 km North of OXFORD.
 That is in pos'n (90, 60)

FIGURE 6.8

V E C T O R S

X	Y
80	60
75	70
50	80
70	10
15	40
30	75
130	65
120	0

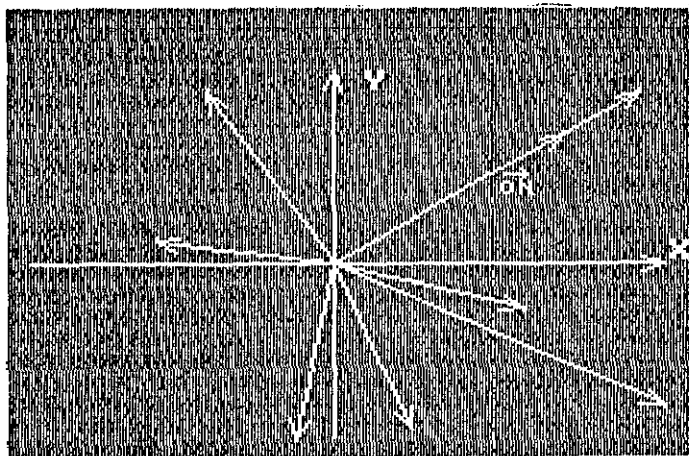
- Oxford
- Cambridge
- London
- Birmingham
- Gloucester
- Southampton
- Petersfield
- Dover
- Norwich



Position of Norwich can be represented by the displacement vector \vec{ON}

PART II

128 39
Norwich



Position of Norwich can be represented by the displacement vector: \vec{ON}

FIGURE 6.9

CHAPTER 7

7 SUMMARY, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

Computer literacy will be an essential qualification in the next century in which children born today will be spending their working lives. Developing countries cannot afford to be left in the dark about advances in computer technology, and at the same time they cannot afford to lead the way. They must as a matter of survival depend on developed nations who are willing to share their expertise and other resources. Fiji, like other developing nations, must be ready to take advantage of what developed nations have to offer and not passively accept new technological innovation. By this the author means Fiji must investigate how best to utilise the advanced technology to gain maximum benefit for its own situation and not accept it on its face value. Computer technology is in Fiji to stay and it is up to the people there to use it to maximum benefit. Without the active participation of researching and investigating the best way of implementing that technology, Fiji will be deprived of its benefits. The author has researched the use of computers in the teaching and learning of mathematics in Fiji, and this chapter summarises this research, makes recommendations and suggests areas for further investigation.

7.1 Summary

The thesis began with the background to the investigation by describing the country, its education system and the state of the art. Microcomputers arrived for use in the classrooms in Fiji in 1984 and were put there by the government. Because of what the author has termed the passive acceptance of this introduction of computers into education by the Ministry of Education in Fiji, problems have dogged the innovation from the very first day. The thesis has highlighted these problems which include:

- (i) The Ministry did not have a definite policy on what role the computers were to have within the education system. Fiji schools are run on very traditional lines where an examination syllabus is drawn up and the curriculum follows it closely. There is no provision for experimentation or innovation that is not part of the examination curriculum. With an inflexible curriculum, new innovations like computers were taken on as a voluntary extracurricular activity.
- (ii) Physical amenities were not provided to accommodate the computers. Resources are scarce and schools depend on the government for much of their needs. Because of security reasons the storage of expensive items creates an additional problem to that of the lack of laboratory space for use in teaching.
- (iii) Proper pre-service or in-service training of teachers was not provided. For a new innovation to be successful it needs skilled manpower to coordinate activities. Some computers were still in their packaging and were unopened one year after being issued to schools, due to lack of even the most basic knowledge of computers on the part of teachers. Work on use of computers in teaching should also form part of pre-service programmes.
- (iv) Suitable software was not available. Without software and skilled teachers to write programs, the computer in the classroom is a waste of resources.
- (v) The maintenance of hardware was not available. In some schools hardware problems remained unattended for long periods due to non-availability of expert assistance.
- (vi) Information on the technology was not provided to enable self help groups to be formed. There was no forum for consultation or means of disseminating information which would help the novice. Teachers who

wanted to learn more were unable to get any information on the subject.

The Ministry of Education did not explore all sources of expertise available within Fiji to help the introduction of computers into schools. An attempt by the USP to establish liaison was totally ignored by the Ministry of Education. The pooling of resources, and whatever contributions are available from persons outside the education sector, is important in a place like Fiji. In view of the problems caused by the introduction of computers into education in Fiji the thesis set out to explore ways of solving them, with particular reference to the teaching of mathematics.

A definition of computers, relevant to education, was presented which should initiate discussion on the role of computers in the Fijian education system. This should involve a review of educational principles and aims, and this can only benefit the system, even if computers are not to be used. A practical description of a simple computer system was given to support suggestions for the teaching of computer mathematics without access to hardware. Computer mathematics is defined as those topics in mathematics which are applicable to computer hardware, and their inclusion in a mathematics programme will aid the understanding of computers. The point being made is that some benefits of computers can be gained without access to hardware.

To solve the problem of software availability in Fiji the use of the spreadsheet for teaching mathematics was put forward and discussed in detail. This provides a source of ready made software which is not machine dependent like most teaching packages. The spreadsheet is available on most brands of hardware. Software development may not be keeping up with hardware development, but the spreadsheet, being a commercial software package, is put out by software houses as an early priority when a new machine is launched. The author believes that the spreadsheet can be applied in the teaching of mathematics, and that this is

a possibility well worth considering for Fiji. The power of the spreadsheet to manipulate numbers and formulas make it suitable for processing numbers and algebraic expressions. In addition, it must be remembered that most packages come with a graphics routine which will display data in different types of graphs, making them very suitable for primary, secondary and higher mathematics.

The conversion of a program, developed for a particular brand of machine, to run on another machine was discussed in detail. This is suggested as a source of software for developing countries, who do not have the facilities to develop their own. It has the following advantages:

- (i) developing countries will not be restricted to buying a certain brand of computer
- (ii) the choice of software available is wider when conversion is available
- (iii) the opportunity to amend imported software and give it a local flavour is available during conversion
- (iv) during conversion the converter is able to study the program in depth, and so later can instruct others on how to use it.

The illustration used in the investigation is the conversion of a MIME Unit program on Vectors, developed on the BBC microcomputer, to run on the Atari ST under GFA Basic. The most time-consuming features of the conversion are those which deal with the graphics, which is the machine dependent part of the program. It is noted by the author that conversion from a program listing is more complicated than that done by studying the program displays while the program is running. The conversion of programs as an alternative to developing programs is put forward as an important source of software for Fiji.

7.2 Recommendations

The recommendations given here are drawn from the author's research in Fiji

during the period before the two Military Coups in 1987, which prevented any more work being done in the country. Travelling within, into and out of Fiji during the interim period between the two coups and after, was then and still is impossible, and computer disks and program documentation sent by the author to colleagues in Fiji went astray and to-date remain unvalidated and untested. Consequently further research by the author was carried out in Leicestershire schools and by consulting other professionals at CAMET. The author makes the following recommendations which the Government of Fiji should initiate:

- (i) A detailed policy paper on computers in education should be drawn up.
This has been long overdue.
- (ii) A chain of communication for the administration of, and dissemination of information about, computing should be set up. A suggested structure is shown in FIGURE 7.1.

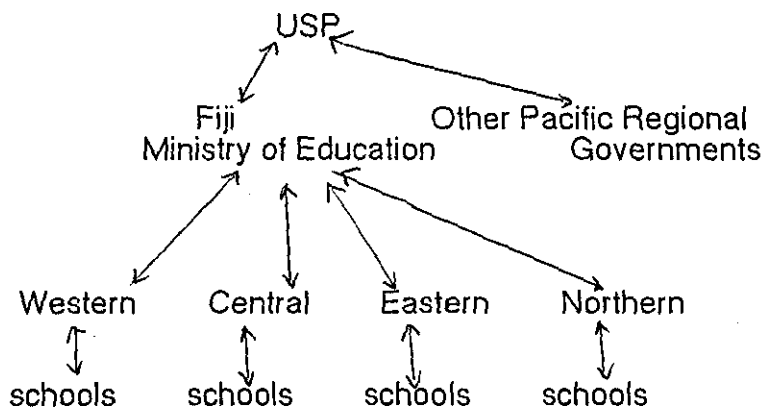


FIGURE 7.1

There is already in existence a structure of administration which divides the country into four Divisions, Western with its headquarters at Lautoka, Central with its headquarters in Suva, Eastern with its headquarters in Levuka and Northern with its headquarters in Labasa. A

Director should be appointed to the Ministry of Education headquarters in Suva and each Divisional headquarter should have an officer to be responsible to the Director, and also to liaise with the schools in the area. USP should establish an Institute of Computer Studies to initiate Computer Studies activities in the South Pacific Region. The Director should liaise with the Institute, which would take over the Computer Centre at Nasinu, presently run by the Ministry of Education.

- (iii) The in-service training of teachers should be intensified to replace the six-monthly two week courses currently held during the school holidays. Courses should be formal and take place during term time to emphasise the importance that the technology should be afforded. Teachers on the course should represent all the four Divisions.
- (iv) Computer Science students at the USP should carry out conversion of programs as part of their course requirements. This should provide two benefits; knowledge of hardware and software by students, and programs for schools. In this way the Institute at USP could quickly build up a library of software for the use of schools in the region.
- (v) Hardware purchase should be negotiated with manufacturers instead of with High Street stores. Negotiations should include assistance with maintenance, which should be managed by the Institute at USP in conjunction with the Computer Science Course.
- (vi) Schools should be strongly recommended to use the spreadsheet as a teaching resource package for 3 main reasons:
 - (1) it is available as it stands for use in mathematics teaching
 - (2) accountancy is an examination subject and spreadsheets are much used there
 - (3) trading by Cooperative Associations is an established

commercial enterprise in Fiji, for which knowledge of the spreadsheet will be useful.

- (vii) A review of the mathematics syllabus in schools should take place with a view to the inclusion of computer studies and some computer mathematics which could be taught without having access to hardware. The aim here is to provide information to as wide an audience as possible.
- (viii) A programme of 'computer awareness'/'computer literacy' courses for the general public should be mounted using the media of daily newspapers and radio broadcasts.
- (ix) Computers on wheels is an option to make software and hardware available to as wide an audience as possible. Instead of bussing students to a computer centre, the computing facilities could be installed in vehicles and transported to the schools. The adoption of this option is strongly recommended in order to solve the immediate problem of shortage in computing facilities and to help spread computer awareness to pupils in remote areas.
- (x) The pre-service training programme for teachers must include 'computers in education'. These recommendations should be treated with urgency, otherwise the nation will find itself further disadvantaged as a result of the rapid development in computer technology.

7.3 Suggestions for Further Research

During the investigation the author identified other areas that could be of benefit to Fiji that need researching to establish their feasibility. These areas are:

- (i) There is an application for solar powered microcomputers in the country, where solar power is in use for lighting, fencing and powering light domestic appliances. (A rural primary school teacher

has written to the author expressing his wish to use computers, and saying that he is in a position to persuade the village elders to allow the school to use the community lighting generator for a couple of hours in the day).

- (ii) The use of computers in conjunction with radio and television broadcasts as a teaching medium is an option that should be investigated. Due to geographical features, communication by road is difficult in Fiji especially in the interior of the main island. Radio and television can reach these parts, and also the outer islands of the group. The USP Extension Services employs a HF communication network with other island centres to conduct tutorials and meetings, and this could be the starting point of the research.
- (iii) The assembly of microcomputers for home consumption has many advantages. A project of this nature was put to the government in the early eighties and should be re-examined.
- (iv) The application of computers across the curriculum is an area which has been slow to develop, and needs an initiative.

7.4 Conclusions

The thesis sets out to investigate the application of computers in the teaching of mathematics in Fiji. During the research the author realised that, at this early stage of computers in Fiji, the greatest problem is the implementation of the introduction of computers in education in general. A general lack of information on the part of those that were to carry out the ground work was in evidence, and this has come about due to lack of consultation and dialogue. The author proposes that the implementation of the recommendations will solve the problems identified, and the further research in the areas suggested should ensure that *Fiji is not totally illiterate or too far behind*

other countries in this respect in the next century.

REFERENCES AND BIBLIOGRAPHY

- [1] BAJPAI, A.C., and CARRUTHERS, P.A., 1987, 'Computer Enhanced Learning: The Loughborough Experience', Paper read at Rome Conference ECM/87, 4-6 June 1987 on Educational Computing in Mathematics organised by the University of Rome.
- [2] MORRIS, SIR CHARLES, KCMG, 1966, 'Report on the Higher Education Mission to the South Pacific', known as 'The Morris Report', published by HMSO, London 1966.
- [3] ALEXANDER, SIR NORMAN, 1976, 'Report on the University of the South Pacific' published by the Government printer, Fiji, as 'Legislative Paper No.3 of 1967' and known as 'The Alexander Report'.
- [4] SOUTH PACIFIC (INTERIM COUNCIL) ORDINANCE, 1967, enacted by the Legislative Council of Fiji.
- [5] CARLOS J. LUCINA and LUIZ C. MARTINS, 1975, 'A Multilevel National Approach To Computer Education', in O.Lecarme and R.Lewis (ed), 'Computers in Education', IFIP: North Holland Publishing Company.
- [6] BAJPAI A.C., FARLEY J.A., HARRISON M.C., MUSTOE L.R., WALKER D., and WHITFIELD A.H., 1985, 'Mathematics and the micro: some hints on software development', published in International Journal of Mathematical Education in Science and Technology, Vol 16, No 3, pp 407-412.
- [7] BAJPAI A.C., 1984, 'The role of mathematics in engineering education: a mathematician's view ', International Journal of Mathematical Education in Science and Technology, Vol 16, No. 3, pp 417-430.

- [8] CHOW YOONG-MING, and LEE PENG-YEE, 1975, 'Teaching Computational Mathematics Without Access To Computing Facilities', in Lecarme and R.Lewis (ed), 'Computers in Education', IFIP: North Holland Publishing Company.
- [9] SIEGEL, P., 1961, 'Understanding Digital Computers', New York: Wiley.
- [10] HAWKINS, G., 1965, 'Stonehenge Decoded', New York: Doubleday.
- [11] BORKO, H. (ed.), 1962, 'Computer Applications In The Behavioural Sciences', Englewood Cliffs, N.J.: Prentice Hall.
- [12] BOWDEN, B.V. (ed.), 1953, 'Faster Than Thought', New York: Pitman.
- [13] AITKEN, H., in BERNESTEIN, J., 1963, 'The Analytical Engine', New York: Random House.
- [14] TURING, A.M., 1937, 'On Computable Numbers, with an Application to the *Entscheidungsproblem*', Proceedings of the London Mathematics Society, 42, pp 230-265.
- [15] SKINNER, B.F., 1938, 'The Behaviour of Organisms: An Experimental Analysis', New York: Appleton-Century-Crofts.
- [16] CROWDER, N.A., 1959, 'Automatic tutoring by means of intrinsic programming', in E.Galanter (ed.), 'Automatic Teaching: The State of the Art', New York: Wiley.
- [17] ATKINSON, R.C., 1976, 'Adaptive Instructional Systems: some attempts to optimise the learning process' in D.Klahr (ed.), 'Cognition and Instruction', Hillside, N.J.: Erlbaum.
- [18] SUPPES, P., 1971, 'Computer Assisted Instruction at Stanford', Technical Report No 174, Stanford University, Stanford, p.9.

- [19] SUPPES,P., 1979, 'Current trends in computer-assisted instruction', in Yovits M.C. (ed.), 'Advances in Computers 18', New York: Academic Press.
- [20] LICKLINDER, J.C.R., 1962, 'Preliminary Experiments in Computer-aided Teaching', in Coulson, E.J. (ed.), 'Programmed Learning and Computer-based Instruction', New York: Wiley.
- [21] YOUNG,G.S., 1970, 'Comments on Social, Psychological, and Mathematical Aspects of the Suppes-Morningstar Chapter', in Holtzman W.H., (ed.), 'Computer Assisted Instruction, Testing and Guidance', New York: Harper and Row.
- [22] PAPER, S. and SOLOMON,C., 1971, 'Twenty Things To Do With A Computer', MIT Artificial Laboratory, Cambridge, Mass.
- [23] FUBIN,E.G., 1971, 'Education in Modern Society', in Greenberger, M., (ed.), 'Computers, Communication and the Public Interest', Baltimore: Johns Hopkins.
- [24] ATKINSON,R., 1976, 'CAI-Learning Aspects', in Gwerard,R.,(ed.), 'Computers and Education', New York: McGraw Hill.
- [25] ATKINSON,R., as [24] and see also SUPPES,P., 'On Using Computers To Individualise Instruction' in Bushnell, Allen and Mitter, (ed.), 1967, 'Computers in American Education', New York: Wiley.
- [26] RICHARDS,I.A., 1967, 'Creative Aims In Instruction', in Bushnell, Allen and Mitter, (ed.), 'Computers in American Education', New York, Wiley.
- [27] ZINN,K., 1968, 'A Basic Reference Shelf On Interactive Use Of

- Computers For Instruction', University of Michigan, p.4, mimeographed.
- [28] BUNDERSON,C.V., 1970, 'The Computer And Instructional Design' in Holtzman, (ed.), 'Computer Assisted Instruction, Testing and Guidance', New York: Harper and Row.
- [29] MESTHENE, 1970, 'Computers and the Purpose of Education', in Holtzman,W.H.(ed.), 'Computer Assisted Instruction Testing and Guidance', New York: Harper and Row.
- [30] SCHEFFLER,I., 1966, 'Philosophical Models in Teaching', in Scheffler, I.,(ed.), 'Philosophy and Education', Boston: Allyn and Bacon p. 99, see also Scheffler, I., 1960, 'The Language of Education', Springfield, Ill.,: Charles C. Thomas.
- [31] STAKE,R., 1969, 'Technologically Based Instruction and Materials', in Morphet,R., and Jesser,D., (eds.), 'Designing Education For The Future', No. 6., New York: Citation Press.
- [32] BITZER,D.L., BRAUNFELD,P.G., and LICHTENBERGER,W.W., 1962, 'PLATO-I A Multiple-Student,Computer-controlled, Automatic teaching Device', in Coulson,J., (ed.), 'Programmed Learning and Computer-based Instruction',New York: Wiley.
- [33] MITRE CORPORATION, 1974, 'An Overview of the TICCIT program', Report M74-1, Washington: Mitre Corporation.
- [34] LICKLINDER, J.C.R., as in [20], p. 224
- [35] THE COCKCROFT REPORT, 1983, 'Mathematics Counts', Report of the Committee of Inquiry into the Teaching of Mathematics in Schools, published by HMSO.

- [36] BOSTROM, K., COKLE, A.J., HARTLEY, J.R., LOVELL, K., TAIT, K., 1982, Report to the Social Science Research Council, '*An Evaluation Study of the Effects and Effectiveness of Microcomputer Based Teaching In Schools*'
- [37] HARDING, R.D., 1974, 'A Case Study of the Use of Computer Graphics as an Aid in Applied Mathematics Teaching', in 'Computers in Education', Lecarme, O., Lewis, R., (eds.); IFIP, North Holland Publishing Company, 1975.
- [38] LOUGHNANE, R.J., 1987, 'Teaching mathematics through the media of high resolution graphics', in Int. J. Math. Educ. Sci. Technol., 1988, vol. 19, No.2, 319-330.
- [39] BLOOM, L.M., COMBER, G.A., 1986, 'Using the microcomputer to simulate the binomial distribution and to illustrate the central limit theorem', published in International Journal of Mathematical Education in Science and Technology, Vol 17, No. 2, pp 229-239.
- [40] 'Some More Lessons in Mathematics', published by the Association of Mathematics Teachers of Great Britain
- [41] KOSNIOWSKI, C., 1983, 'FUNMATHEMATICS', Great Britain: Cambridge University Press.
- [42] ELGARTEN, H.G., POSAMENTIER, A.S., MORESH, S.E., 'Using Computers in Mathematics', USA: Addison-Wesley Innovative Division.

APPENDIX A

A Trial Project On Using The Microcomputer As A Teaching Aid

The project was carried out with a group of Foundation Mathematics students at the University of the South Pacific.

Mathematics Topic

This was picked from those topics offered by the Foundation mathematics programme in 1984. To coincide with what the rest of the foundation students were studying, the 'Functions and their Graphs' topic was chosen as the topic for the project. The subject of graphs is also suitable for computer treatment. Functions covered in this topic include polynomial and rational functions, their graphs, x-intercepts and y-intercept.

Software

Mathematical software was not available in Fiji and the author wrote the programs for the project. Two routines were written: 'Poly' for investigating polynomials and 'Rational' for rational functions.

The programs:

- (i) will allow the input of a function
- (ii) will calculate and display coordinate values or draw the graph
- (iii) will draw the graph slowly with high definition or quickly showing the outline only
- (iv) will allow the choice of interval of x to be investigated.

The two programs, both written in Basic, differ only in their function input routine. The function is input by changing line 100 of the programs. To investigate the quadratic $y = 2x^2 + 3x$, the entry in program Poly is:

$$100 \text{ y} = 2*x*x + 3*x$$

To investigate the rational function $y = 2/(x-1)$, the entry in program Rational is:

$$100 \text{ N} = 2 : \text{D} = x-1$$

The function input routine in the program Rational includes:

$$110 \text{ Y} = \text{N/D}$$

which defines the value of Y.

Two separate programs were preferred to emphasise the special differences between polynomial and rational functions. The programs' output included:

- (i) graph or coordinate values
- (ii) x intercepts
- (iii) y intercept.

Hardware

The hardware system consists of:

- (i) screen
- (ii) Atari 800XL microcomputer
- (iii) disk drive.

Three microcomputer systems were shared by forty students.

Administration

The computers were housed in the author's office due to lack of space in the mathematics department. The other alternative was to move them to the classroom and back after the class. This was considered unsatisfactory.

A booking system was used to allow those that wanted to work by themselves the opportunity to do so.

The 'Functions and their Graphs' topic would normally take fifteen sessions of fifty minutes each. The same time was allowed for the project, except that students were allowed to use the programs whenever they were available and many of them took advantage of the opportunity.

The first three fifty minute sessions were spent in the classroom introducing the topics and describing how to operate the programs.

The programs Poly and Rational required the students to be familiar with the following commands and facilities:

LOAD - to load a Basic program

RUN - to execute a basic program

How to insert a new line in a Basic program - this is to enable students to enter a function,

Defining a Function using Basic language - e.g. $y = x*x*x + 3*x$

CONT - to continue running the program after a stoppage,

CLR/SHIFT - to clear the screen and put cursor at the top left hand corner of the screen.

Students were also shown how to respond to prompts, e.g.

[N]EW FUNCTION

[Q]UIT

which require an 'N' or a 'Q' as input.

The other prompt used in the programs is:

READY TO PLOT

which requires the user to press any key as input.

Conclusions

The students found the new experience fascinating and absorbing. The technology with its ability to interpret inputs gave mathematics learning a new meaning. When the program responded to the students' inputs and graphically reflected their theories class activities took on a new turn. Mathematical verbalisation and interaction between students rose to new heights. Students were seen to work problems out to try and prove the program wrong. Students explained to other students why the screen display and the expected theoretical display are not exactly alike though they are both correct. There was friendly rivalry amongst students to see who could come up with the most fascinating graph. This led to the investigations of functions well beyond the scope of the current level of topics.

The speed with which the program responded was a great motivator for students in all activities. The importance of computer graphics is recommended to all students, some of whom commented on its usefulness. The computer screen had a hypnotic effect on the students and the knowledge that they could determine the shape to be displayed added to the attraction. Their fascination with the electronic screen may be partly because of novelty due to the recent introduction of video systems in a country which has no television broadcasting service.

It was noted that even though opportunities to work alone were made available, the students preferred to work on the machine in large groups of four or five. This number enables all to make a contribution, and also there is always a suggestion for the input. With a still larger group, not all will be able to make an active contribution, and with one or two only, suggestions are liable to run out creating a lull in the activities.

Computers can make a significant impact on mathematical experiences and learning at Foundation level at the University of the South Pacific.

APPENDIX B

COMPUTER PROGRAMMING: GRAPHICS FIRST

Many books on introduction to Basic Programming begin with the input, assignment, and output commands;

```
INPUT, LET, PRINT
```

The commands LET and INPUT require a certain level of mathematical knowledge before they can be fully understood. It involves the algebraic concept of variable. Unless PRINT is used with a constant, it too will require the same mathematical pre-requisite as INPUT and LET.

The statements;

```
PRINT 4*3
```

```
PRINT "HELLO"
```

are not as confusing as;

```
PRINT A
```

```
PRINT A$
```

where the numerical variable A, and the string variable A\$, are used and the student is required to cope with two concepts at the same time, that of assignment and output.

Computer courses at the University of the South Pacific, and in the schools in Fiji, followed the trend of introducing INPUT, LET and PRINT at the beginning.

Sample programs at the beginning of computer courses are of the type;

```
10 INPUT "WHAT IS YOUR NAME ";NAME$
```

```
20 INPUT "WHAT YEAR WERE YOU BORN ";YR
```

```
30 LET AGE=1980-YR
```

```
40 PRINT NAME$;" YOU ARE ";AGE;" YEARS OLD"
```

```
50 PRINT"GOOD BYE"
```

Students who are new, not only to computer technology but to any sort of technology, find it very difficult to cope due to a lack of background knowledge most of which is gained from every day experience.

A student at sixteen plus in Fiji needs to cope with a lot of technological experiences in a short time to catch up with his or her counterpart in the developed western world. The sixteen year old Fijian student needs to undergo a crash course on experiences which a student in an industrialised nation lives through from day one. In trying to cope the student in Fiji will resort to learning methods that are less effective than learning by experiences.

The introduction of new technology in Fiji needs to cater for the lack of basic technological experience of Fiji audiences. The problem could be addressed by good public relations, i.e. by making available information about the new technology and by open discussions on the subject. Information provided must be given in very simple terms and an attempt made to educate the public in the technology.

Computer programming should be approached in a way that enables the student to see results. Computer graphic displays are an attractive way of showing results. The practice of teaching INPUT, LET and PRINT first in Basic Programming courses is understandable given the lack of graphic facilities in early microcomputers. At the University of the South Pacific computer programming courses were given using the Pet Commodore microcomputer, which has restricted graphic facilities. Lines drawn on the Pet Commodore microcomputer have different definitions according to their gradients. To give an acceptable description of why the lines look like those in Figure B.1 a certain level of advanced computer knowledge is required, and this is at best very limited.

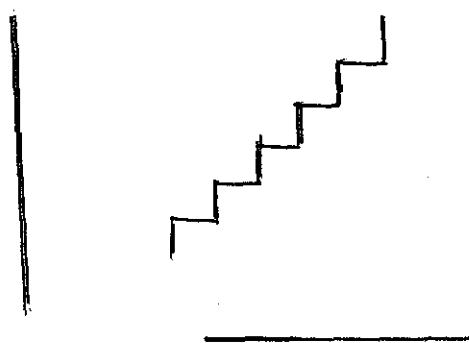


FIGURE B1

In Fiji schools, the Commodore 64 microcomputer is used, and it is possible, with some degree of sophisticated programming, to display graphics on the machine. Unfortunately graphics in Basic on the Commodore 64 are littered with the POKE and PEEK commands, which also need some advanced knowledge of computing to cope with. Consequently programming courses in Fiji began with the input, assignment and output commands.

With the microcomputers available today, graphics capability is a selling point. The BBC microcomputer offers more than one graphic mode with different resolutions. The Atari microcomputer which is available in Fiji has graphic commands available in Basic.

Graphics on the BBC Microcomputer

A graphics approach on introducing programming in Basic was tried out with some third and fourth year secondary students in a Leicestershire school, using the BBC microcomputer.

Worksheets 1 to 5, (W/S 1- W/S 5), investigated the graphic commands, MOVE and DRAW on the BBC. These two Commands are, in the first instance, investigated in the Direct mode; i.e. where the Commands are typed in and the computer responds immediately. This is achieved on the BBC by entering the commands without line

numbers. In W/S 1 a line is first drawn by entering the commands:

```
MOVE 100,100
```

```
DRAW 100,500
```

Succeeding entries of the two commands leave all parameters unchanged except the first parameter of the command DRAW which was increased from 100 up to 500 in steps of 100. The student copies the diagram displayed on the screen on to paper, and is asked to describe any changes observed.

W/S 2 follows the same pattern of activity except for the first line drawn is:

```
MOVE 100,100
```

```
DRAW 500,500
```

and succeeding entries decreased the second parameter of the DRAW command.

In W/S 3 the initial line is:

```
MOVE 100,100
```

```
DRAW 500,500
```

and succeeding entries increased the first parameter of the MOVE command.

In W/S 4 the initial line is:

```
MOVE 500,500
```

```
DRAW 100,100
```

and succeeding entries increased the second parameter of the MOVE command.

In W/S 5 initial line is:

```
MOVE 100,100
```

```
DRAW 500,500
```

and the succeeding entries varied one of the parameters.

A Program is given at the end of W/S 5 using only the commands MOVE and DRAW.

A set of W/S 1 - W/S 5 is on pages B6-B10.

Comments and Observations

There was definitely more interest shown when students could see something for their efforts. This is in contrast to when students are introduced to programming through INPUT, LET and PRINT commands which do not favour Direct mode operation very well. Typing 'LET A = 4.5' on the keyboard does not give a visual effect to show that the assignment has been affected.

A considerable amount of discussion ensued during the session as students compared their results, which depended partly on their keyboard skills.

Some students investigated the effects of changing parameters to values other than those given in the Worksheets.

Many different shapes were drawn by varying the numbers in the program in W/S 5. The shapes produced by each Worksheet were similar in lots of ways and it was difficult for some students to grasp the significance of changing the parameters unless these were pointed out to them.

An introductory Programming course in Basic for Fiji primary schools using the graphics approach is given in Appendix B1.

INVESTIGATION OF THE COMMAND *DRAW*

Type: *MODE 1* (return) to prepare the screen.

A. Now type: *MOVE 100,100* (return)
DRAW 100,500 (return)
Draw the line in the screen area above.
Label the line OA

Now we will change the first number after the Command *DRAW* and observe the effect.

B Type: *MOVE 100,100* (return)
DRAW 200,500 (return)
Draw the line in the screen area above.
Label the line OB.

Do the same for:

C Line OC type: *MOVE 100,100* (return)
DRAW 300,500 (return)

D Line OD type: *MOVE 100,100* (return)
DRAW 400,500 (return)

E line OE type: *MOVE 100,100* (return)
DRAW 500,500 (return)

Describe the effect of increasing the first number after the Command *DRAW*.

What happens if you decrease the number ?

INVESTIGATION OF THE COMMAND DRAW

Type: *MODE 1* (return) to prepare the screen.

A. Now type: *MOVE 100,100* (return)
DRAW 500,500 (return)
Draw the line in the screen area above.
Label the line OA

Now we will change the second number after the Command DRAW and observe the effect.

B Type: *MOVE 100,100* (return)
DRAW 500,400 (return)
Draw the line in the screen area above.
Label the line OB.

Do the same for:

C Line OC type: *MOVE 100,100* (return)
DRAW 500,300 (return)

D Line OD type: *MOVE 100,100* (return)
DRAW 500,200 (return)

E line OE type: *MOVE 100,100* (return)
DRAW 500,100 (return)

Describe the effect of increasing the second number after the Command DRAW.

What happens if you decrease the number ?

INVESTIGATION OF THE COMMAND MOVE

Type: *MODE 1* (return) to prepare screen.

We will do the same as before, but this time we will change the numbers after the command MOVE. Type the following commands, draw and label the lines in the screen above.

A Type: *MOVE 500,500* (return)
DRAW 100,100 (return)

B Type: *MOVE 600,500* (return)
DRAW 100,100 (return)

What has changed ?

C Type: *MOVE 700,500* (return)
DRAW 100,100 (return)

Any more changes ?

D Type: *MOVE 800,500* (return)
DRAW 100,100 (return)

E Type: *MOVE 900,500* (return)
DRAW 100,100 (return)

Describe the effect of increasing the first number after Command Move.

What happens if the number is decreased ?

INVESTIGATION OF THE COMMAND MOVE

Type: *MODE 1* (return) to prepare screen.

We will do the same as in WIS 3, but this time we will change the second number after the command MOVE. Type the following commands, draw and label the lines in the screen above.

A Type: *MOVE 500,500* (return)
DRAW 100,100 (return)

B Type: *MOVE 500,600* (return)
DRAW 100,100 (return)

What has changed ?

C Type: *MOVE 500,700* (return)
DRAW 100,100 (return)

Any more changes ?

D Type: *MOVE 500,800* (return)
DRAW 100,100 (return)

E Type: *MOVE 500,900* (return)
DRAW 100,100 (return)

Describe the effect of increasing the second number after Command Move.

What happens if the number is decreased ?

PROGRAMMING MOVE & DRAW

Type: *MODE 1* (return) to prepare screen.

Now we will combine WIS 1 to 4.

Type: *MOVE 100,100* (return) starting numbers
DRAW 500,500 (return) starting numbers

MOVE 200,100 (return) change first number
DRAW 500,500 (return)

MOVE 100,200 (return) change second number
DRAW 500,500 (return)

MOVE 100,100 (return)
DRAW 600,500 (return) change first number

MOVE 100,100 (return)
DRAW 500,600 (return) change second number

Copy the diagram in the screen above and label the points:

A=(100,100), B=(200,100), C=(100,200)

D=(500,500), E=(600,500), F=(500,600)

10 MOVE 100,100
20 DRAW 500,500
30 MOVE 200,100
40 DRAW 500,500
50 MOVE 100,200
60 DRAW 500,500
70 MOVE 100,100
80 DRAW 600,500
90 MOVE 100,100
100 DRAW 500,600

This Program will draw
the diagram.
Note it is the same
Commands with the same
numbers.

Use the same commands with
different numbers to write
a program to draw a
different shape.

AN INTRODUCTORY COURSE IN COMPUTER PROGRAMMING FOR PRIMARY SCHOOLS IN FIJI

THE GRAPHICS APPROACH

Introduction

The course is intended for Primary school pupils in Fiji with no previous experience of computers. It aims to excite the children's interest in the technology and sustain it until secondary school age. While exciting the children's interest in computer technology, the course also offers mathematical experiences and enhancement through graphics displays.

Hardware Requirements

The course is designed around the Atari ST microcomputer, but it can be modified to suit other machines. A trial of the course using the BBC microcomputer is discussed in Appendix B. The minimum hardware requirement is the Atari ST microcomputer keyboard which has the diskdrive built in and a display screen. This choice of hardware is important in view of past experience with the early version of the Atari microcomputer the Atari 800XL.

Atari 800XL Microcomputer Experience

The author's experience in mounting the same type of course in Fiji using the Atari 800XL, (see Appendix B1), encountered many problems related to hardware. One of the major problems found with the Atari 800XL is the number of items that make up a working station. The minimum hardware configuration for the Atari 800XL is made up of three main units, the display screen, the keyboard and the diskdrive. All together there are 7 hardware items required when using an Atari 800XL microcomputer:

INTRODUCTORY COURSE

- 1 x lead screen/keyboard
- 1 x lead keyboard/disk drive
- 1 x power supply unit (disk drive)
- 1 x power supply unit (keyboard)
- 1 x display unit
- 1 x keyboard
- 1 x disk drive

It was found difficult to have all the items available when required and this could delay and in some instances cancel the lesson altogether. The reduced number of items required with the Atari ST microcomputer should ease this problem.

The Atari ST Microcomputer System consists of:

- 1 x lead (keyboard/screen)
- 1 x lead (keyboard/mains)
- 1 x screen
- 1 x keyboard

There is no significant difference in the physical dimensions of the Atari 800XL and the Atari ST keyboards.

Sharing Hardware Facilities in Fiji Schools

The differences in hardware constituents are an important consideration when schools in Fiji will most likely have to share computing facilities. One mode of sharing is to move the hardware around classrooms within the schools and moving the hardware from one school to another. The other mode is to move pupils to the hardware which is left in one place. This means a computer dedicated room in the school, or bussing students to a computer centre. Both modes need the allocation of extra resources. The role of computers is yet to be defined resulting in the

de-emphasis of the importance of the need for a computer room in the school. There is a computer centre in Fiji managed by the education department but the bussing in of students during school hours has many drawbacks, mainly due to the inefficiency of the transport system. In previous experiences in Fiji the author adopted the mode of moving hardware from school to school.

Software Requirements

The course is designed using Atari ST Basic Language which comes bundled with the Atari ST. A list of Graphic commands in Atari ST Basic is given in the Teachers Handbook.

In addition to the hardware and software detailed above the course materials consist of a set of 22 Worksheets and the Teacher's Handbook. A copy of the Worksheets and the Teacher's Handbook is attached.

INTRODUCTORY COURSE

AN INTRODUCTION TO PROGRAMMING

A GRAPHICS APPROACH

A COURSE FOR PRIMARY SCHOOLS IN FIJI

TEACHER'S HANDBOOK

This Handbook describes:

- (i) how the teacher should prepare the system for the pupils
- (ii) the relevant *graphic commands* of the Atari ST microcomputer
- (iii) solutions of the Worksheets.

The Worksheets are designed to investigate some of the graphics commands of the Atari ST Basic Language. Many mathematical concepts are involved in the application of computer graphics and some of them will be manipulated while investigating graphics on the Atari ST.

Lesson

Previous Knowledge

It would be useful if the pupil is shown how to:

- i terminate a line by the RETURN key,
- ii erase a character or word by the BACKSPACE key,
- iii clear the windows with the CLEARW Command.

To avoid frustration and boredom it is best to give students one Worksheet at a time and see they complete it with corrections before they go on to the next one. Ten minutes on the keyboard per student is quite ample. They will need to work out first on paper what they should input and have it ready when they come to the keyboard. Ensure that pencil and paper is available at the keyboard.

Prepare the computer system by going through the following procedure, which could be taught to the pupils when they have had some experience with the hardware.

Getting Ready

- 1 Load the Basic Language Disk into the disk drive.
- 2 Switch both the screen and the microcomputer on, FIGURE 1a should display.
- 3 Using the mouse click on Options. A drop down menu should display.
- 4 Click on SET OPTIONS in the drop down menu. This should display another set

INTRODUCTORY COURSE

of options - LOW, MEDIUM, HIGH

- 5 Click on MEDIUM . The screen should now switch to Medium resolution. A sharper image of FIGURE 1a should display.
- 6 Open Floppy Disk A by double clicking in quick succession on it. FIGURE 1b should display.
- 7 Double click on BASIC.PRG to run the Basic Language Program. FIGURE 1c should result.
FIGURE 1c shows three windows headed LIST, OUTPUT, and COMMAND. The fourth window headed EDIT is concealed under the three visible windows.
- 8 Close the LIST and EDIT windows by clicking in the top left hand corner of each of the windows.
- 9 Manipulate and resize the COMMAND and OUTPUT windows to display as shown in FIGURE 2. It is important that the two windows meet as shown in FIGURE 2, a good guide is the letter 'u' in the word Debug at the top of the windows. FIGURE 2 should be on the screen when the pupils come to work on the Worksheet.

RETURN key

Remind the student to press the key marked 'RETURN' after typing each line.

CLEARW

After pressing (return) at the end of a line, the Command CLEARW can be used to clear the Output window or the Command window.

CLEARW 3 will clear the Command window.

CLEARW 2 will clear the Output window.

Desk File View Options

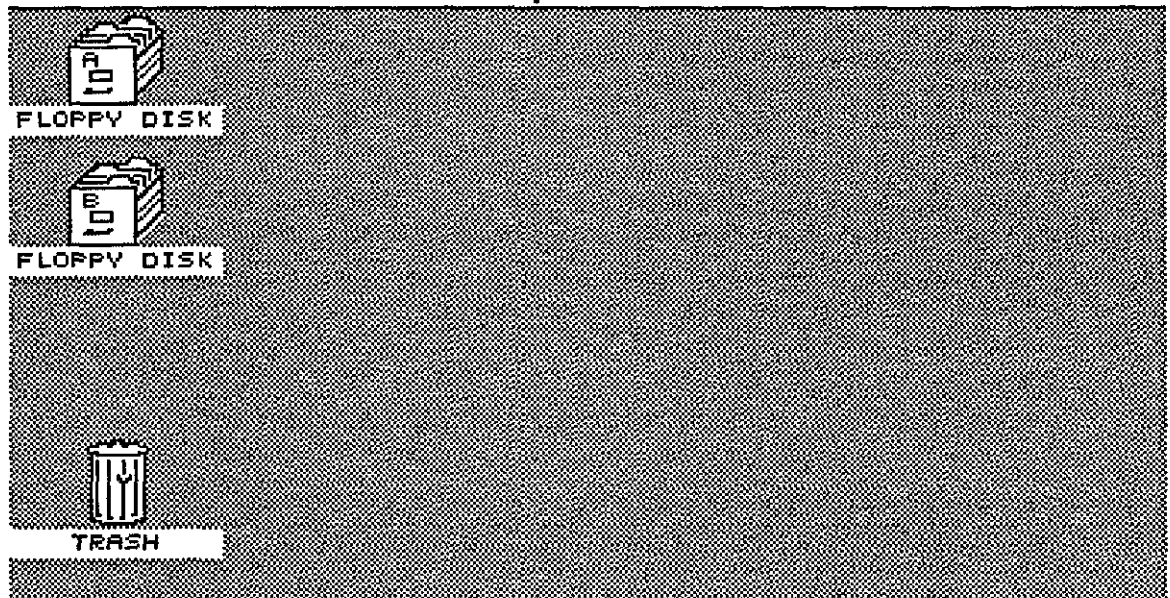


FIGURE 1a

Desk File View Options

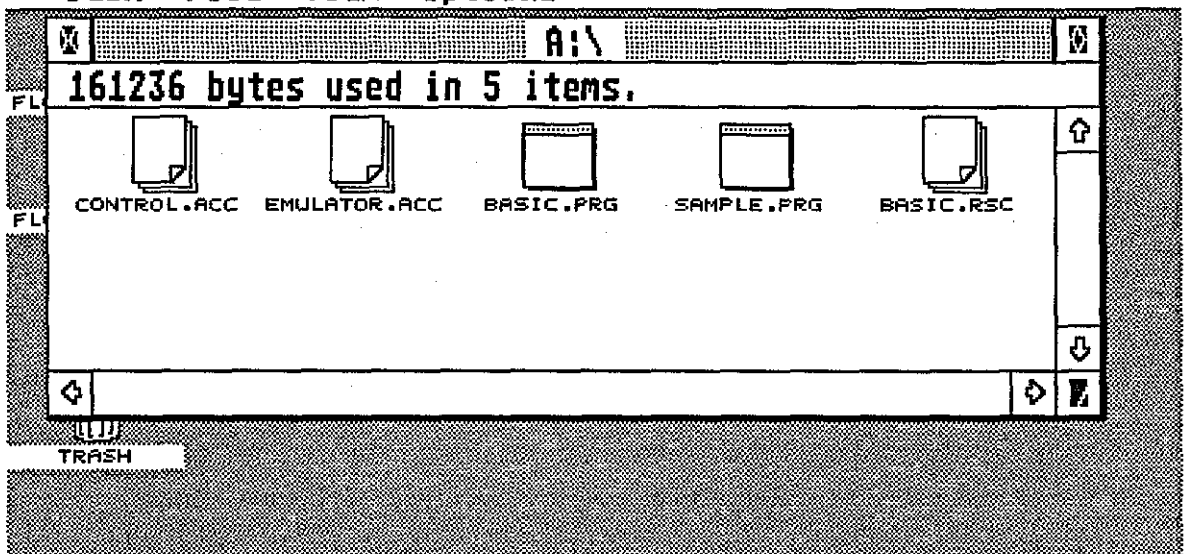


FIGURE 1b

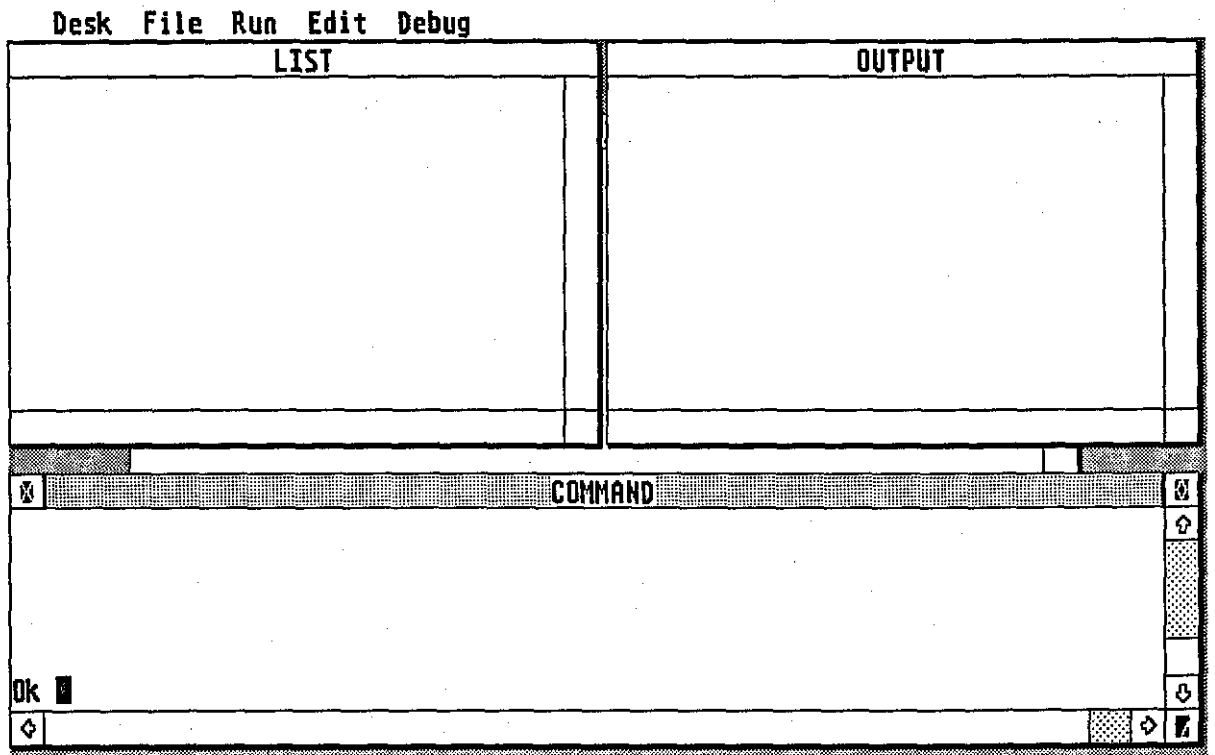


FIGURE 1c

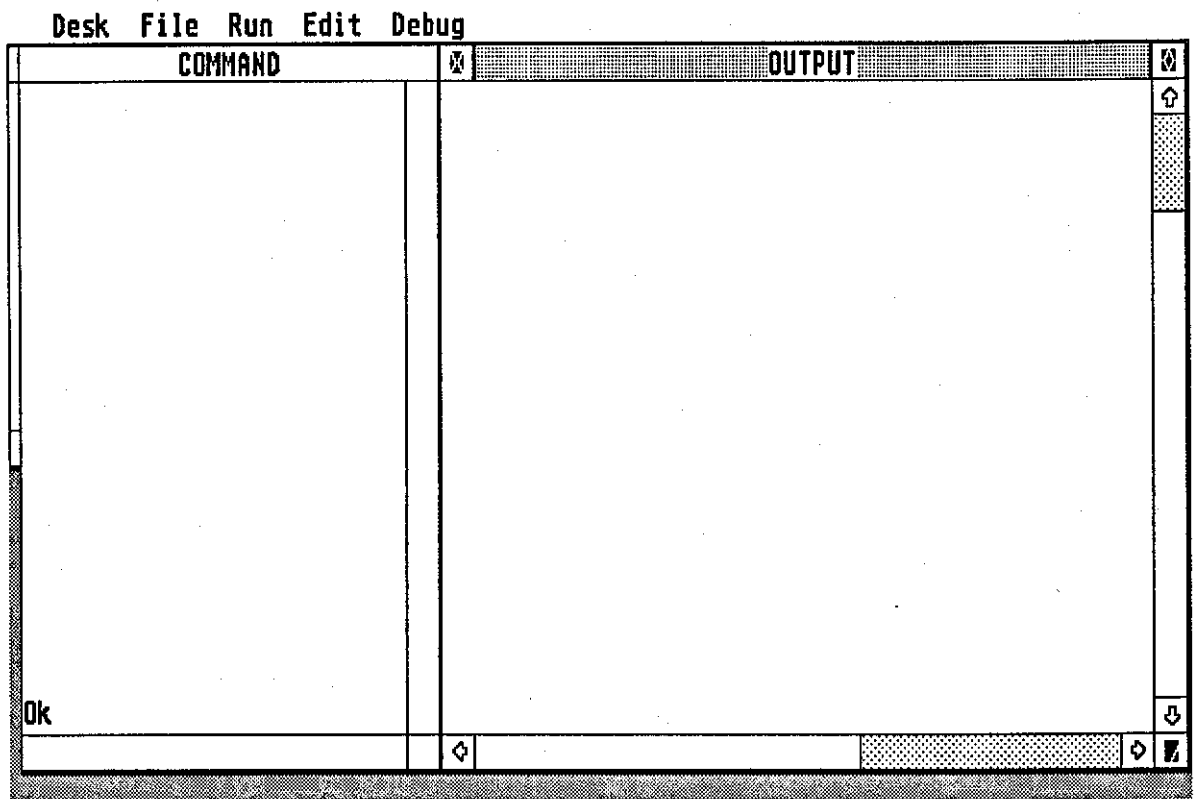


FIGURE 2

INTRODUCTORY COURSE

A list of Graphic commands in Atari ST Basic is given here:

CLEARW x

This clears the screen windows

CLEARW 0

clears the Edit window

CLEARW 1 - clears the List window

CLEARW 2 - clears the Output window

CLEARW 3 - clears the Command window.

FULLW x

This makes the designated(x) window full size.

COLOR x,y,z

x - is the colour of the next character to be printed

y - is the colour used for filling shapes

z - is the color of lines drawn.

FILL x,y

This allows a shape to be filled with colour or pattern. The x,y parameters define the coordinates of the point where to start filling.

CIRCLE x,y,r

This draws a circle with centre at point (x,y) and radius r.

CIRCLE x,y,r,s,f

This draws part of a circle centre (x,y), radius r, starting at s degrees and finishing at f degrees. Zero degrees is to the right and increases in anticlockwise direction.

PCIRCLE x,y,r,s,f

INTRODUCTORY COURSE

This draws a filled circle or part of a circle.

ELLIPSE x,y,h,v

This draws an ellipse centred at point (x,y) with horizontal radius h, and vertical radius v.

PELLIPSE

This fills the ellipse.

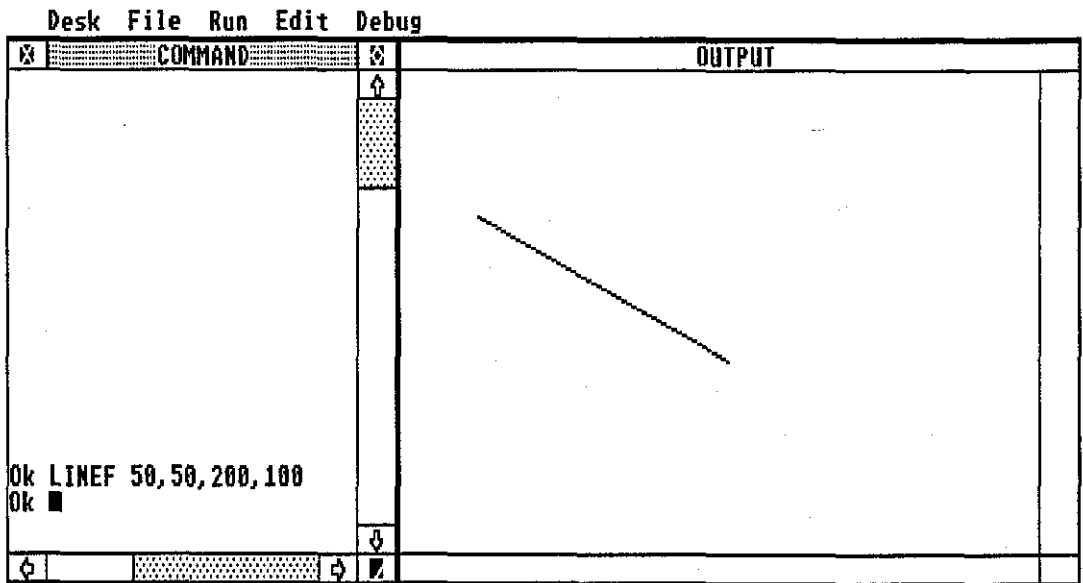
LINEF x1,y1,x2,y2

This draws a line from point (x1,y1) to point (x2,y2).

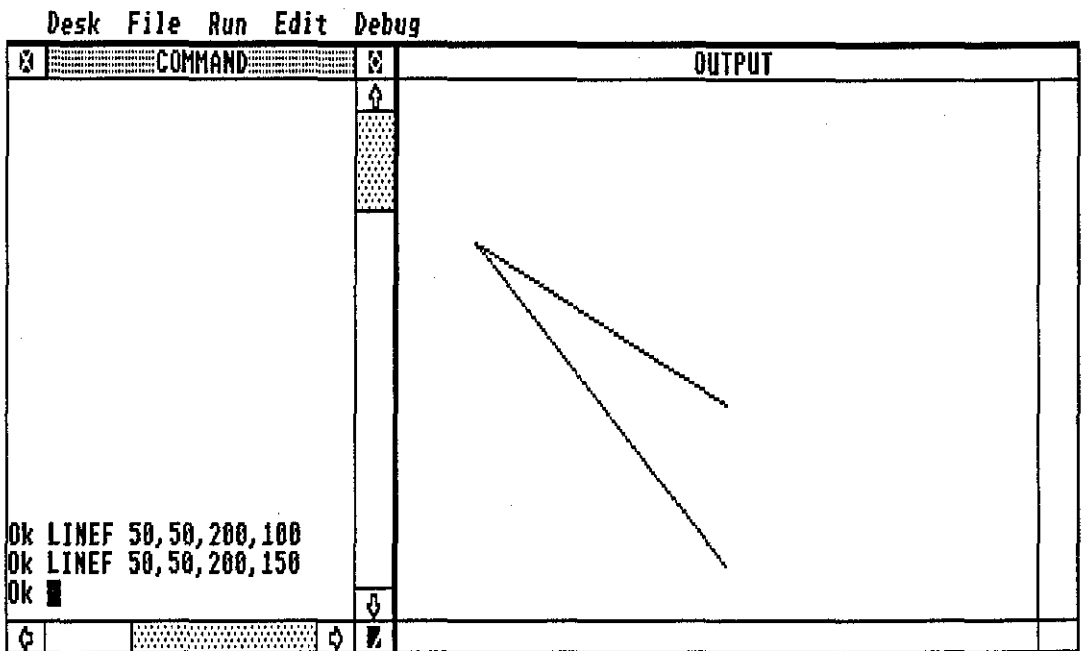
The rest of this Handbook describes the results of the Worksheets.

BECAUSE OF DIFFICULTIES IN PRODUCING SCREEN DUMPS
THE COMMAND CIRCLE DRAWS A CIRCLE ON THE SCREEN
BUT THE SCREEN DUMP TURNS OUT TO BE ELLIPTICAL.

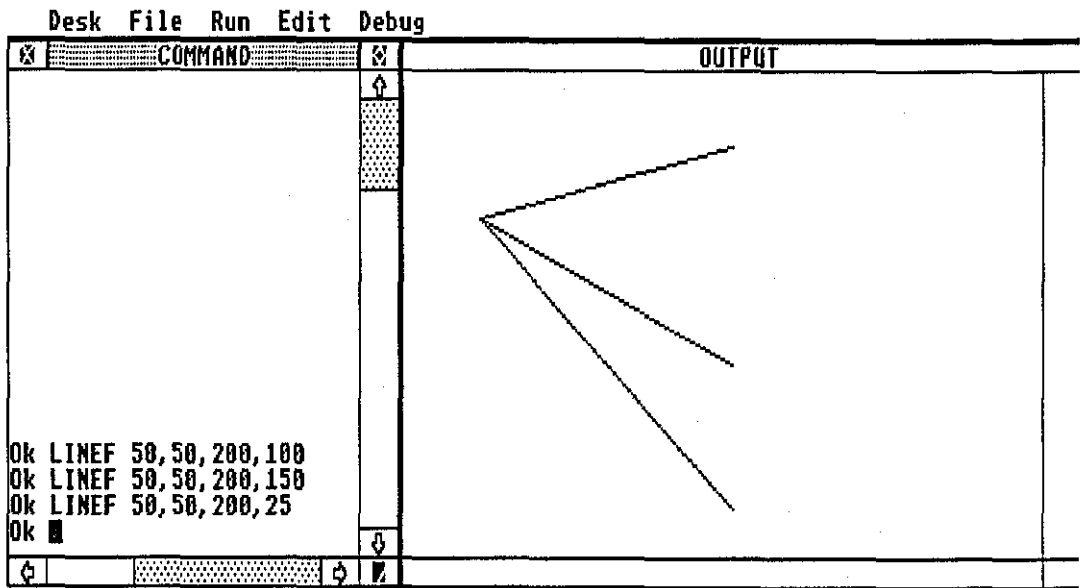
Worksheet 1 Activity 1



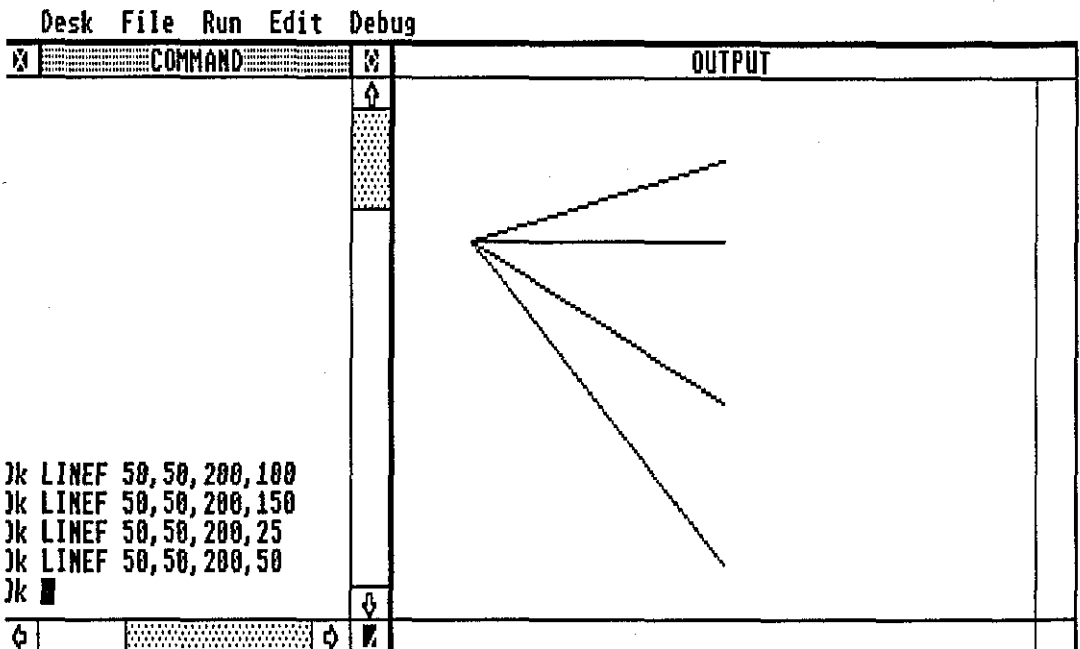
Worksheet 1 Activity 2



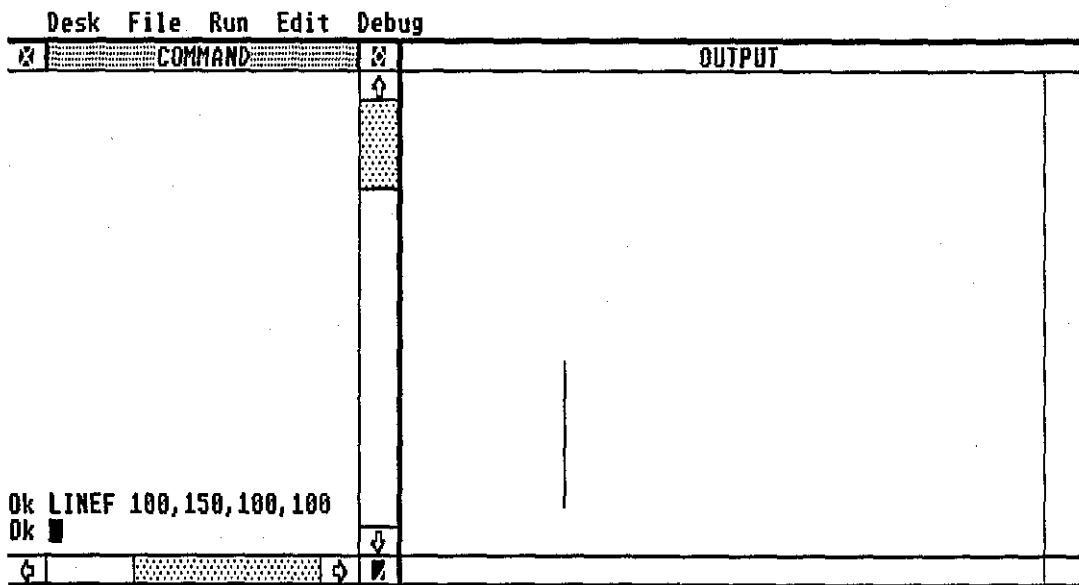
Worksheet 1 Activity 3



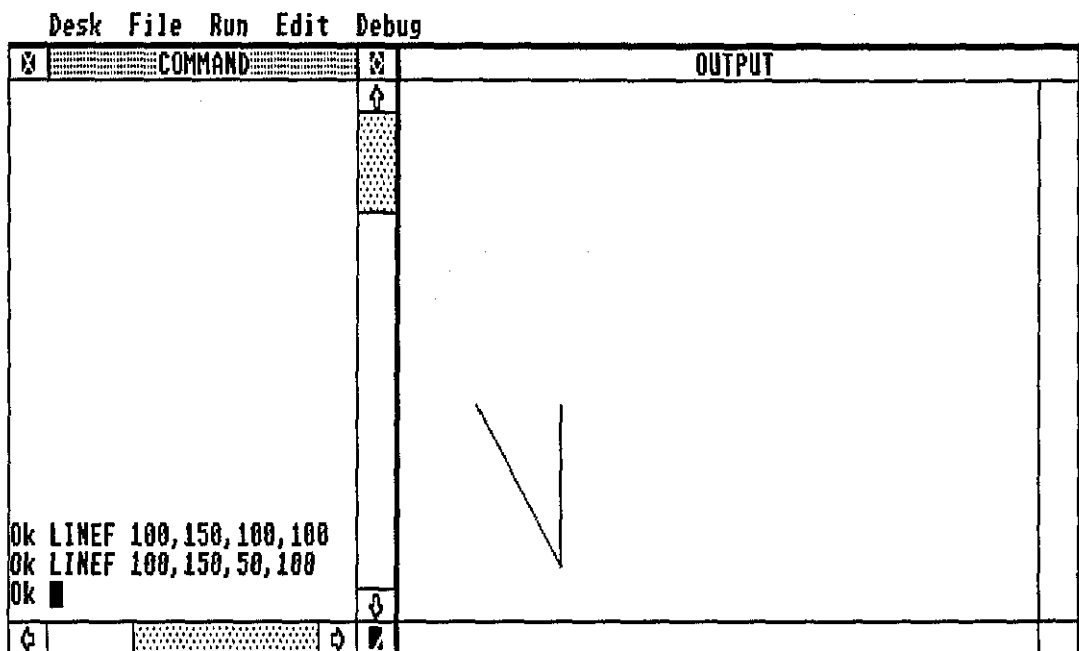
Worksheet 1 Activity 4



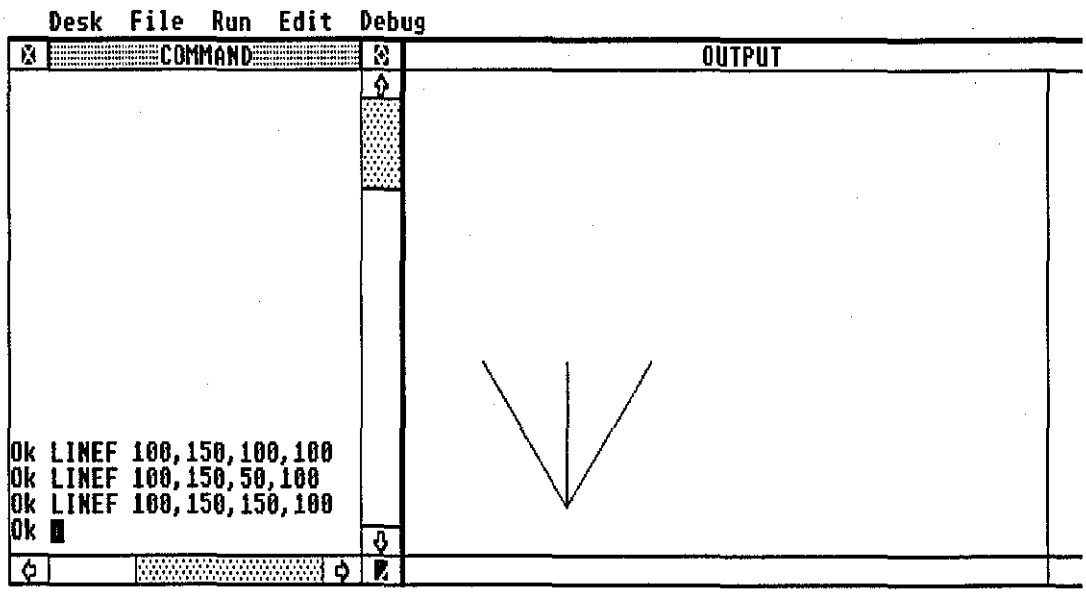
Worksheet 2 Activity 1



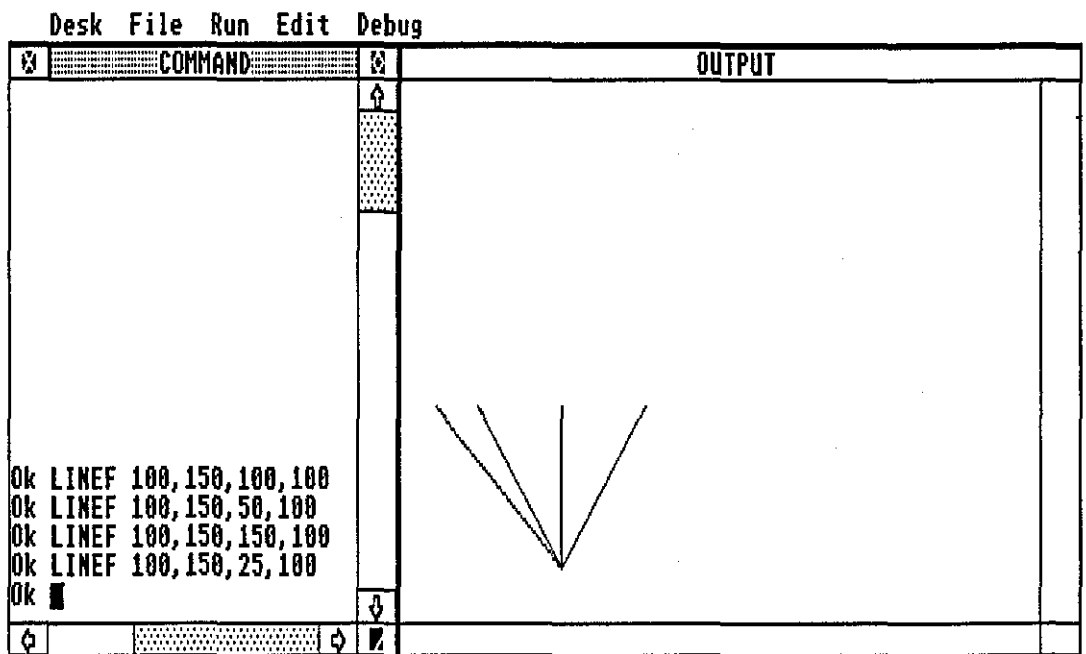
Worksheet 2 Activity 2



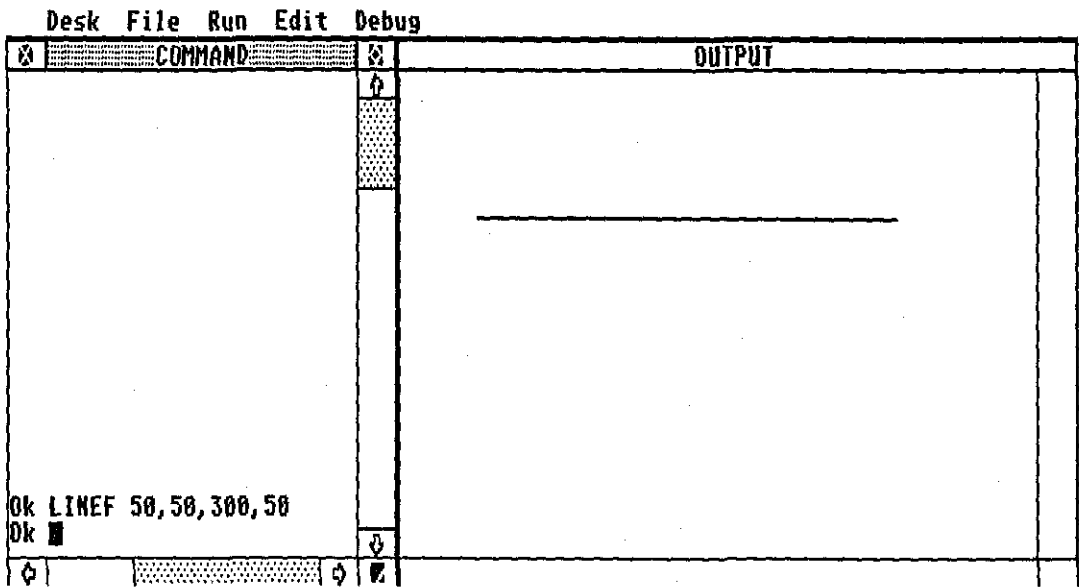
Worksheet 2 Activity 3



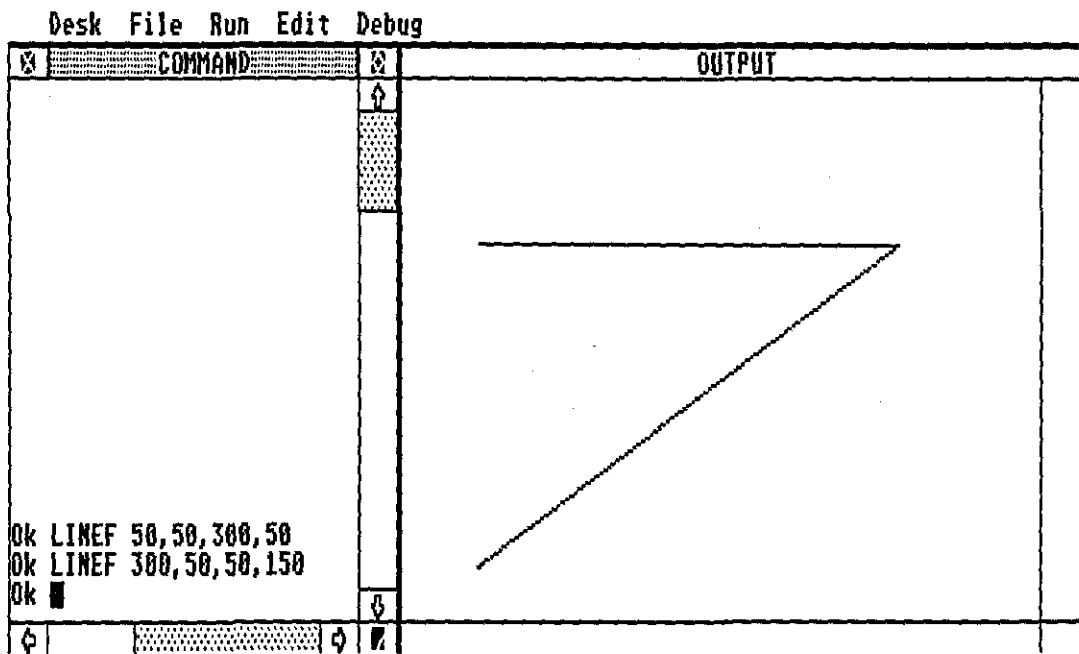
Worksheet 2 Activity 4



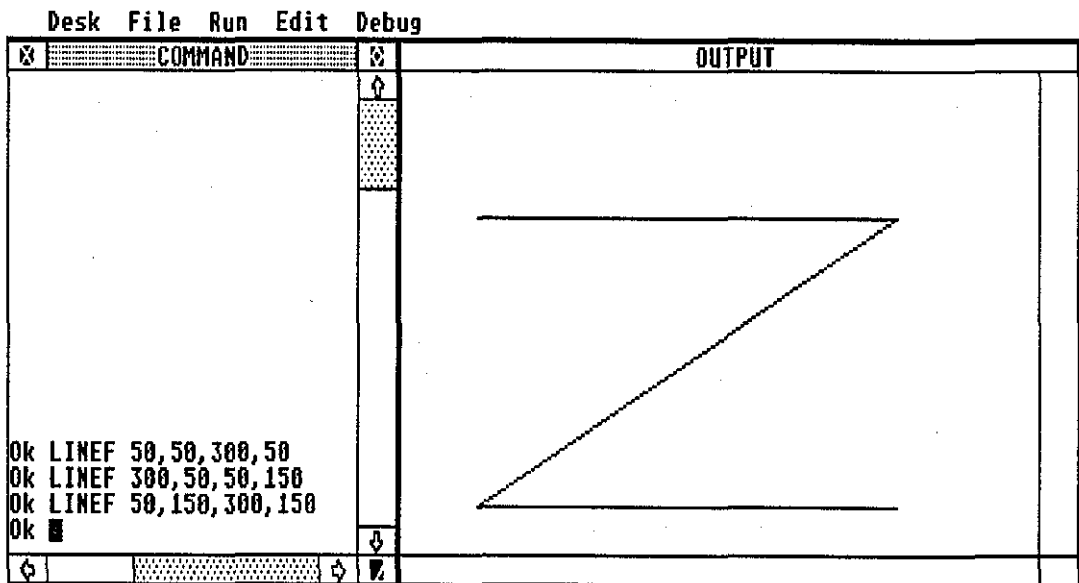
Worksheet 3 Activity 1



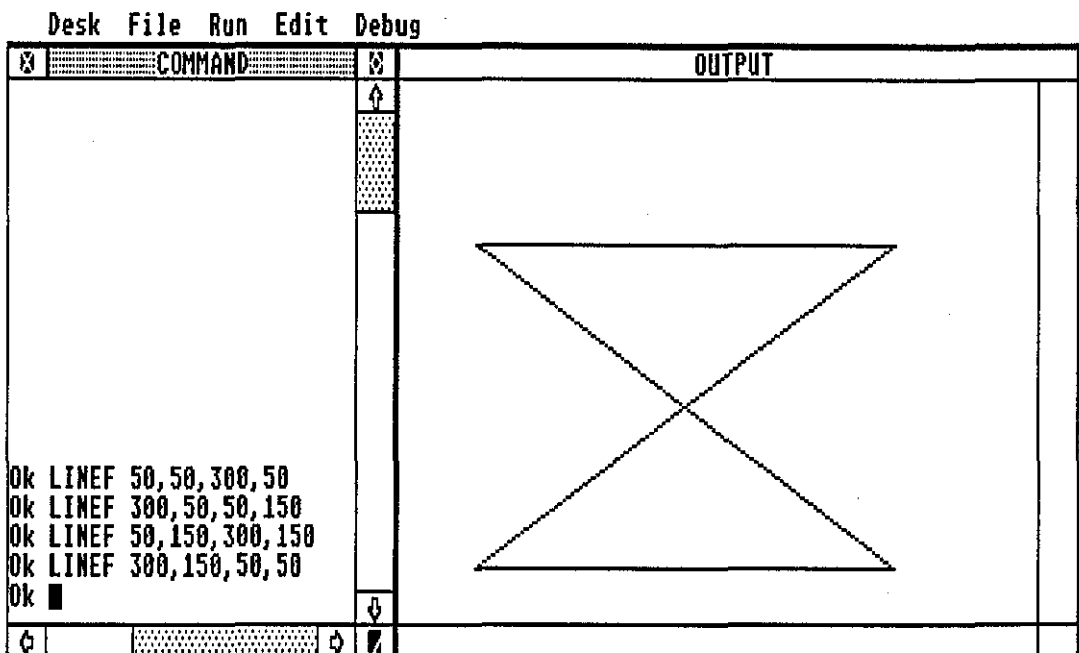
Worksheet 3 Activity 2



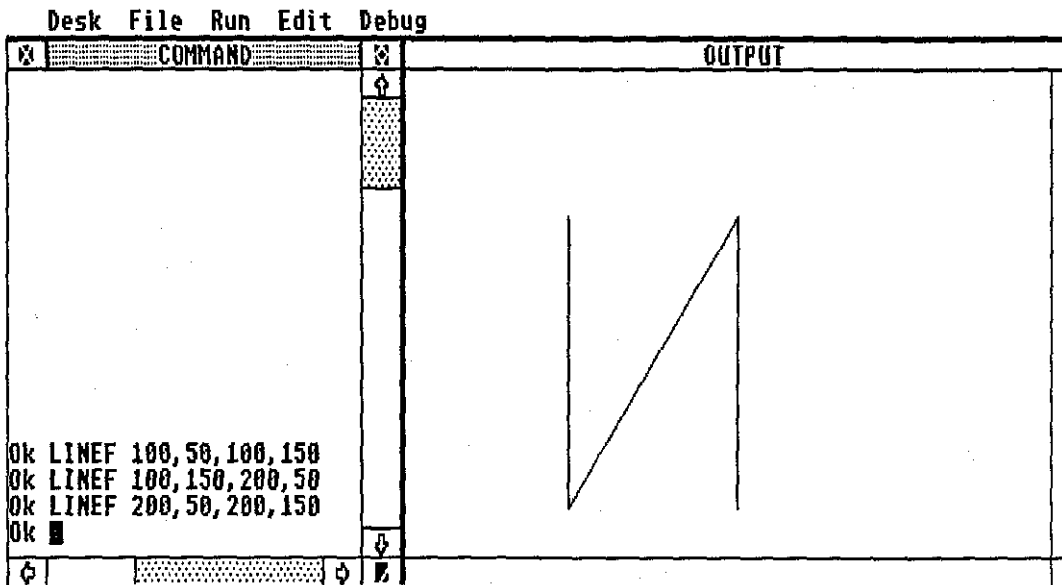
Worksheet Activity 3



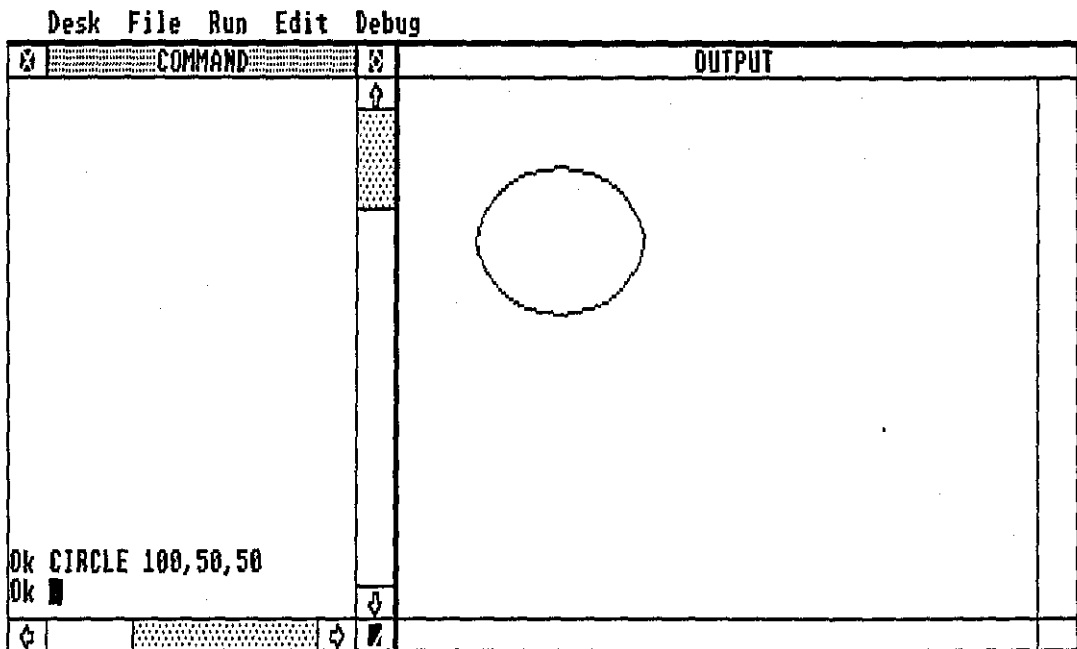
Worksheet 3 Activity 4



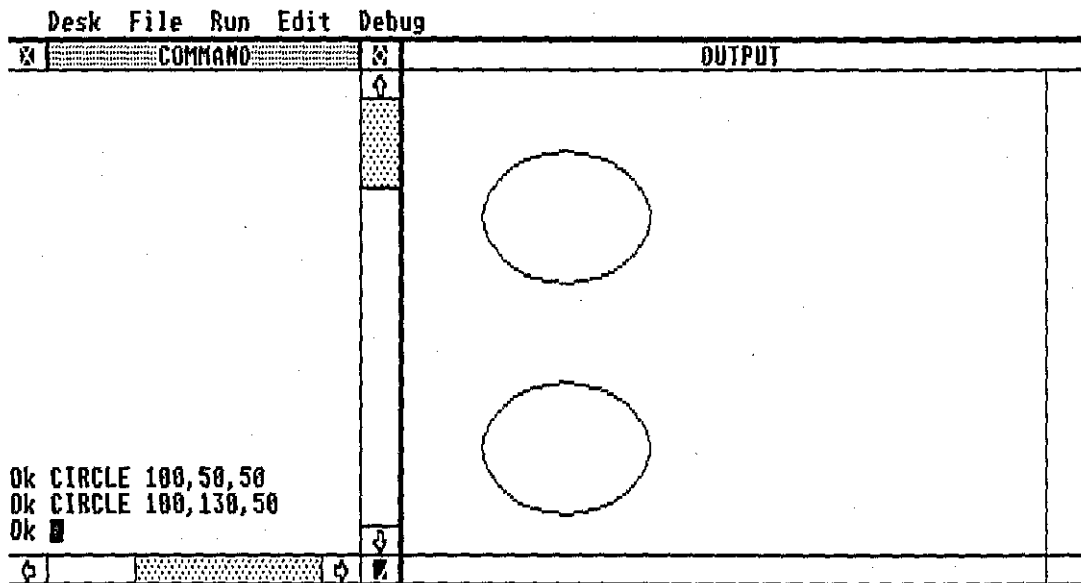
Worksheet 4 Activity 1



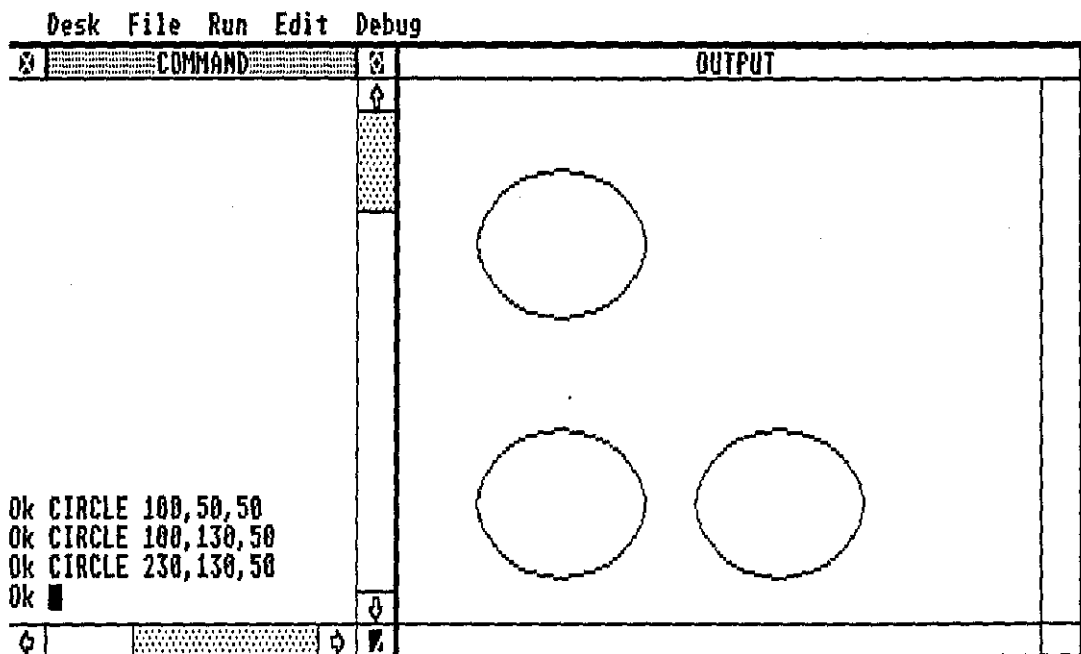
Worksheet 5 Activity 1



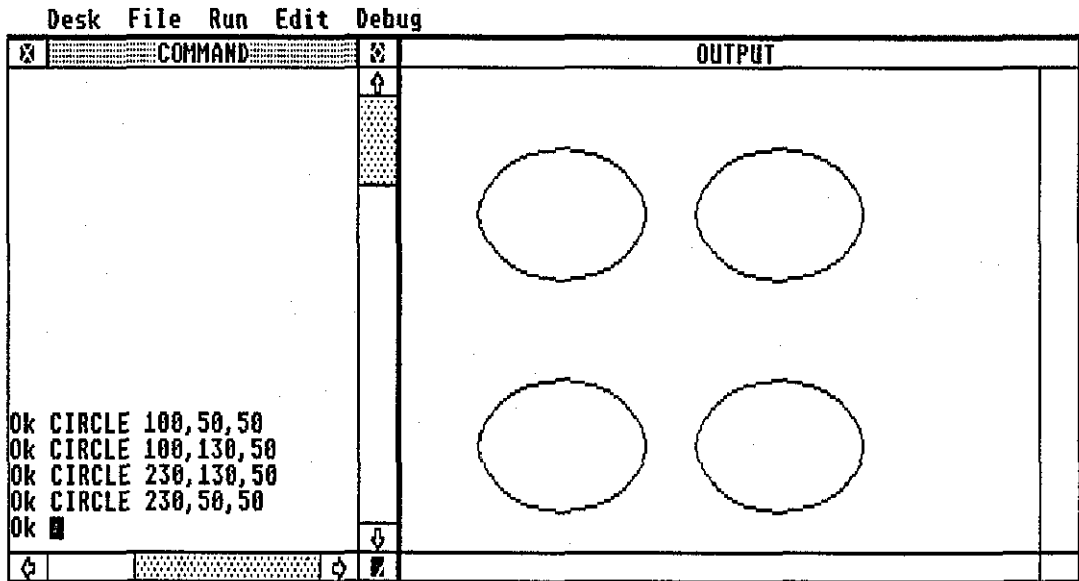
Worksheet 5 Activity 2



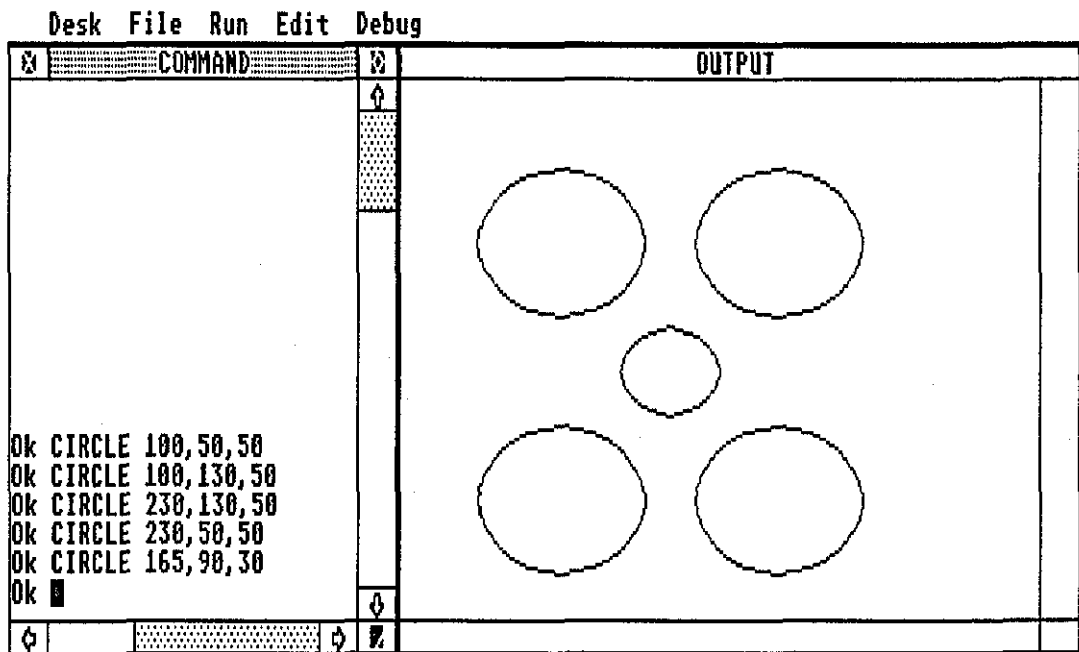
Worksheet 5 Activity 3



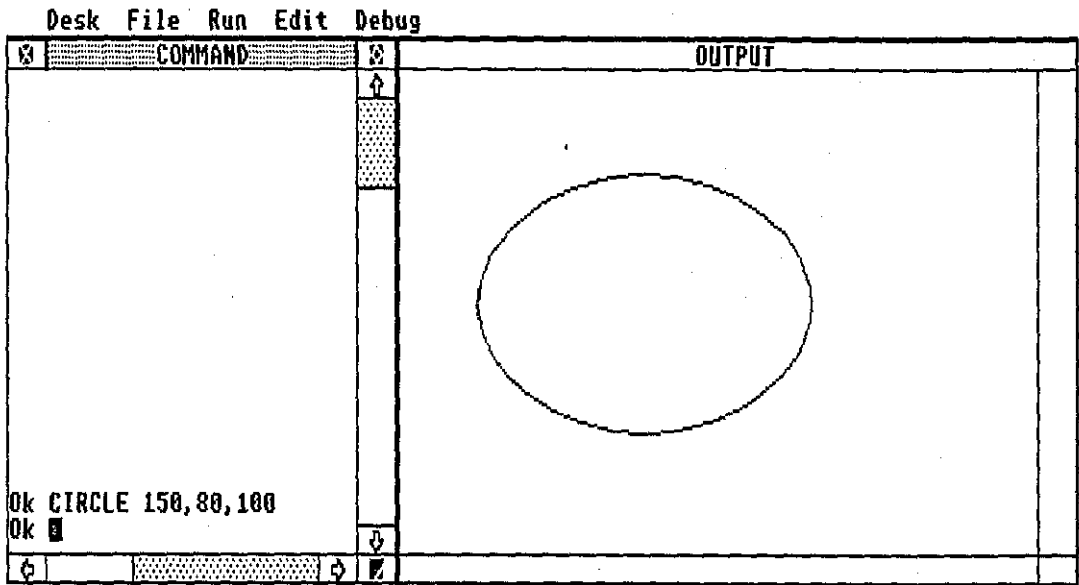
Worksheet 5 Activity



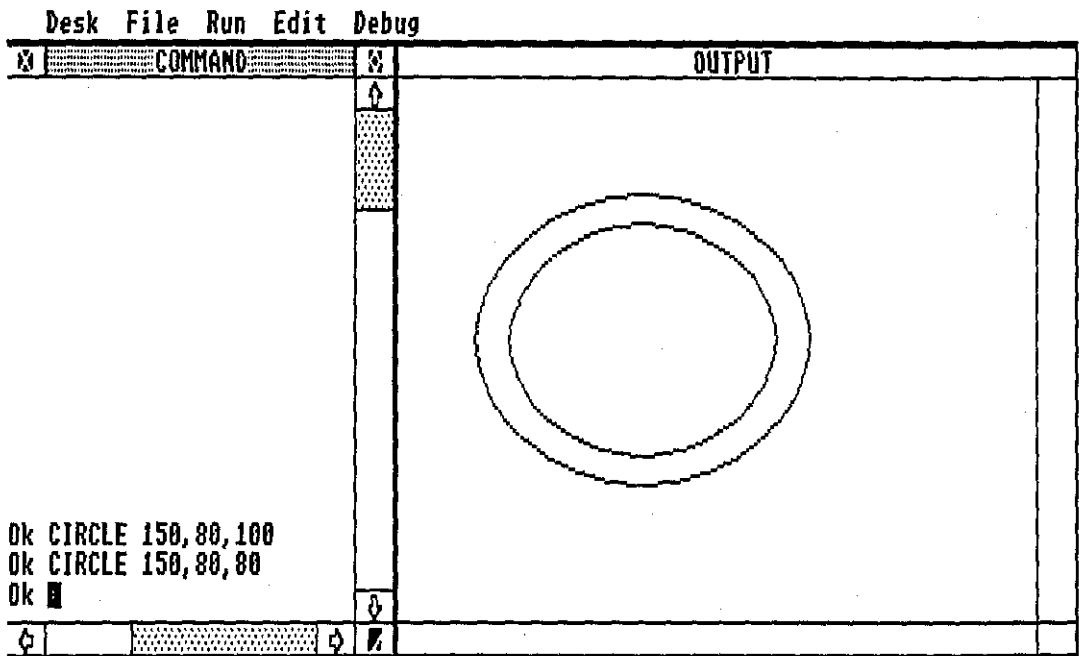
Worksheet 5 Activity 5



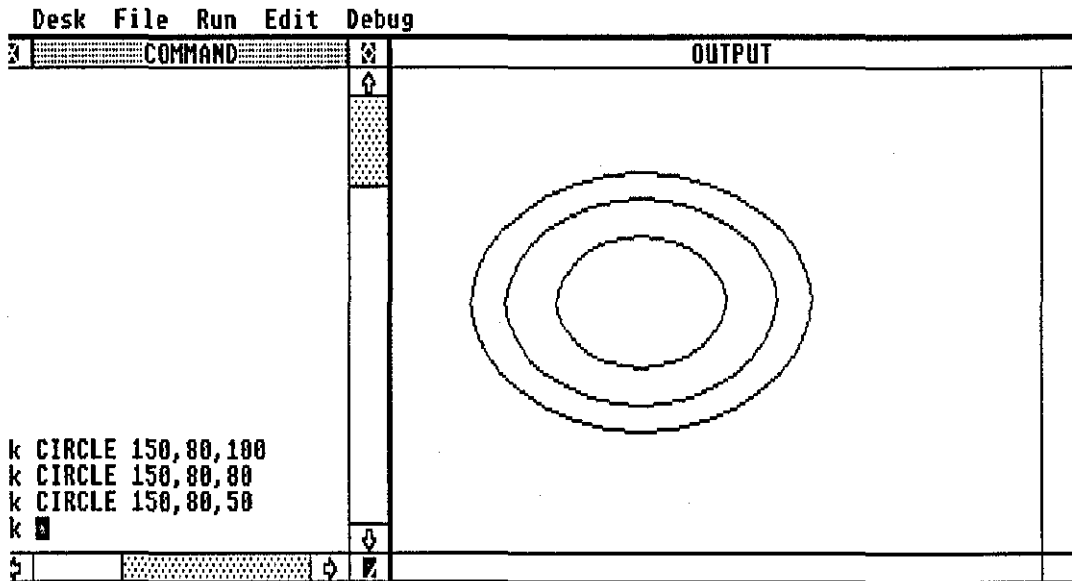
Worksheet 6 Activity 1



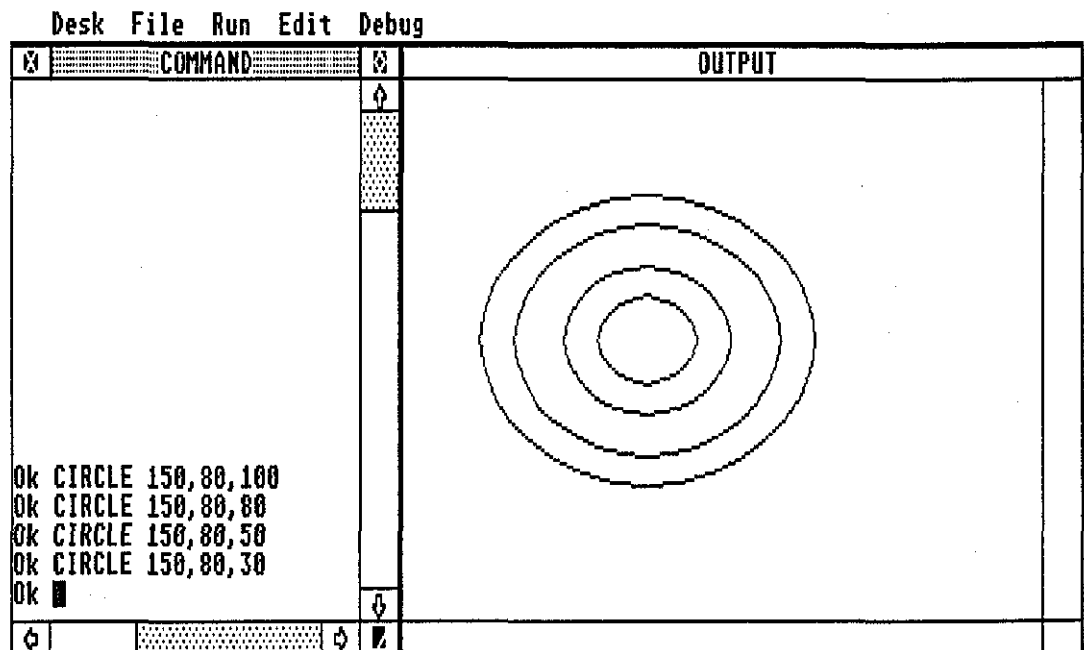
Worksheet 6 Activity 2



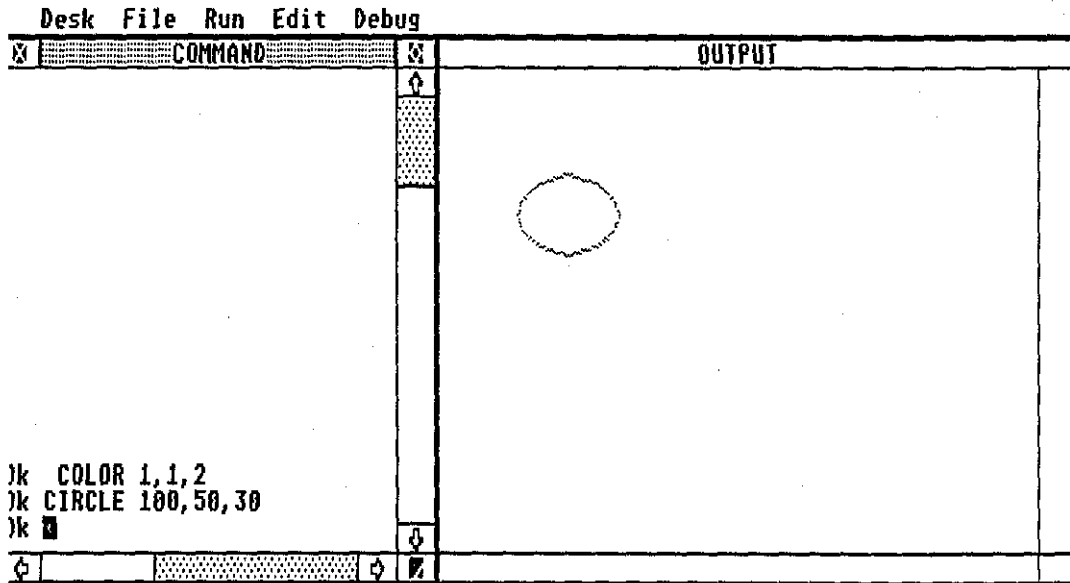
Worksheet 6 Activity 3



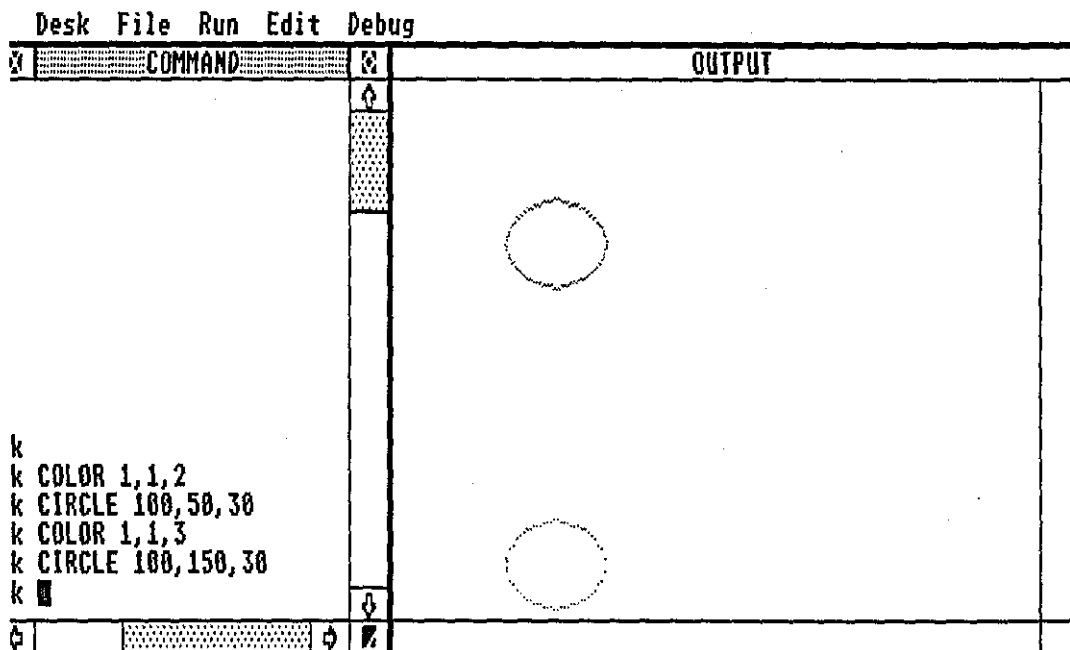
Worksheet 6 Activity 4



Worksheet 7 Activity 1



Worksheet 7 Activity 2



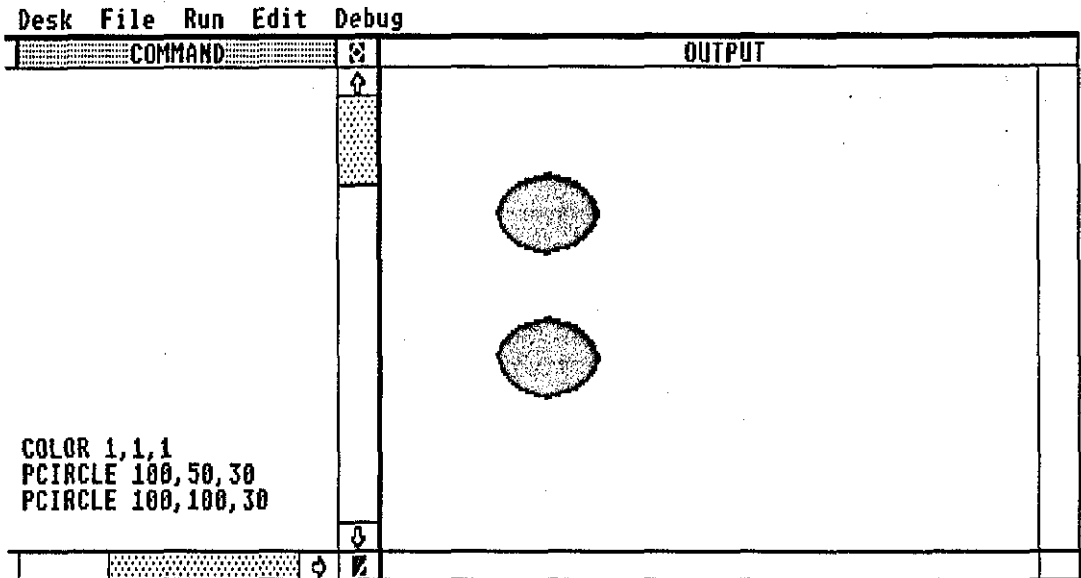
Worksheet 7 Activity 3

Desk File Run Edit Debug		OUTPUT
COMMAND		
Dk		
Dk COLOR 1,1,2		
Dk CIRCLE 100,50,30		
Dk COLOR 1,1,3		
Dk CIRCLE 100,150,30		
Dk COLOR 1,1,1		
Dk CIRCLE 200,150,30		
Dk █		

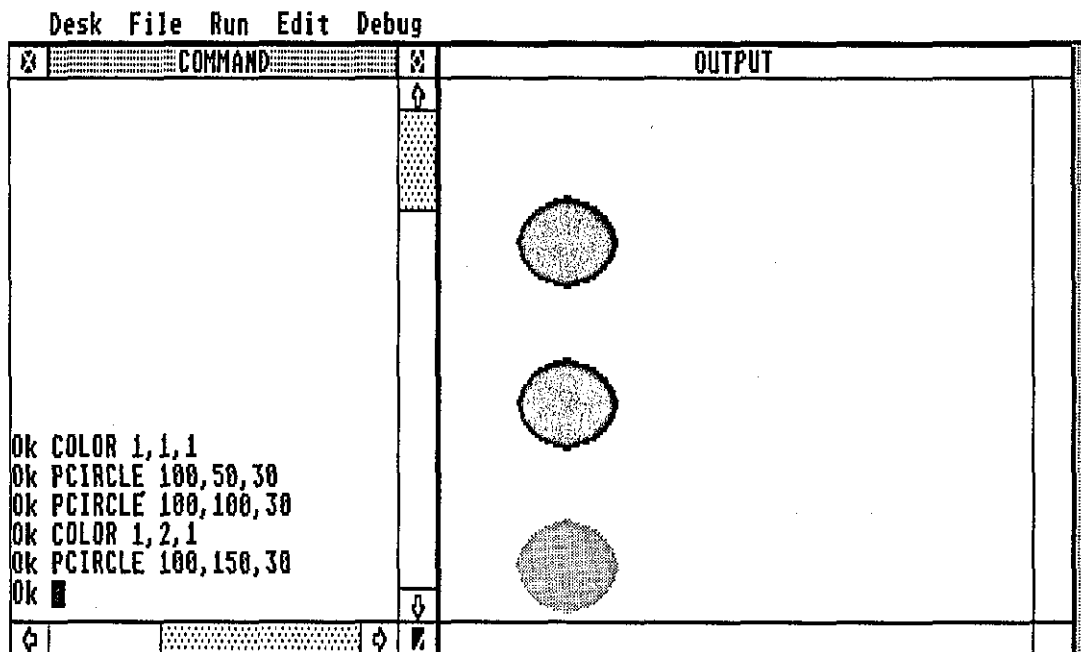
Worksheet 8 Activity 1

Desk File Run Edit Debug		OUTPUT
COMMAND		
k		
k COLOR 1,1,1		
k PCIRCLE 100,50,30		
k █		

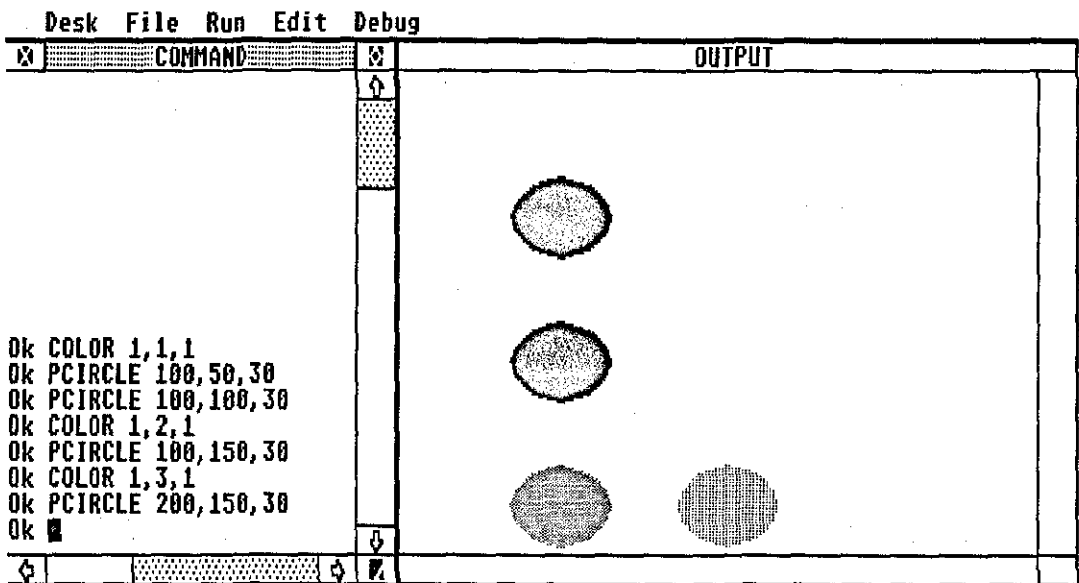
Worksheet 8 Activity 2



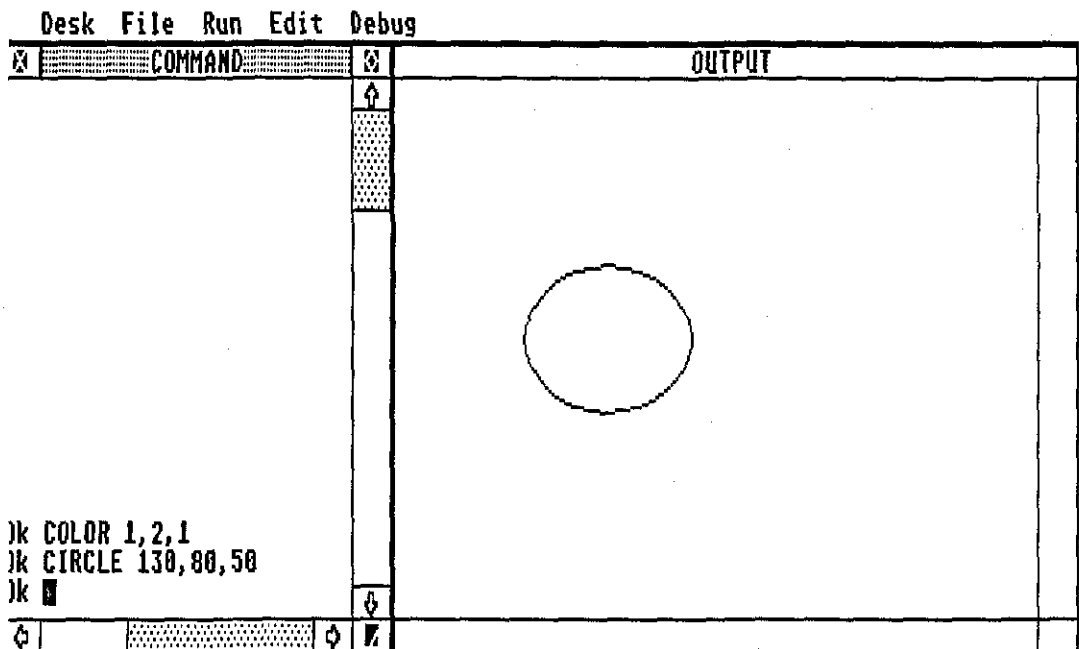
Worksheet 8 Activity 3



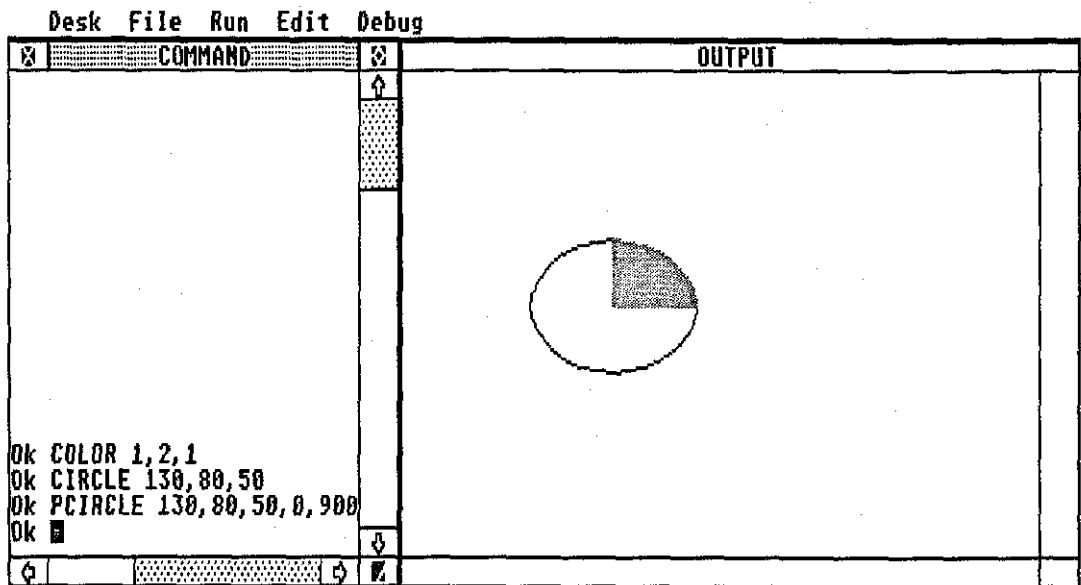
Worksheet 8 Activity 4



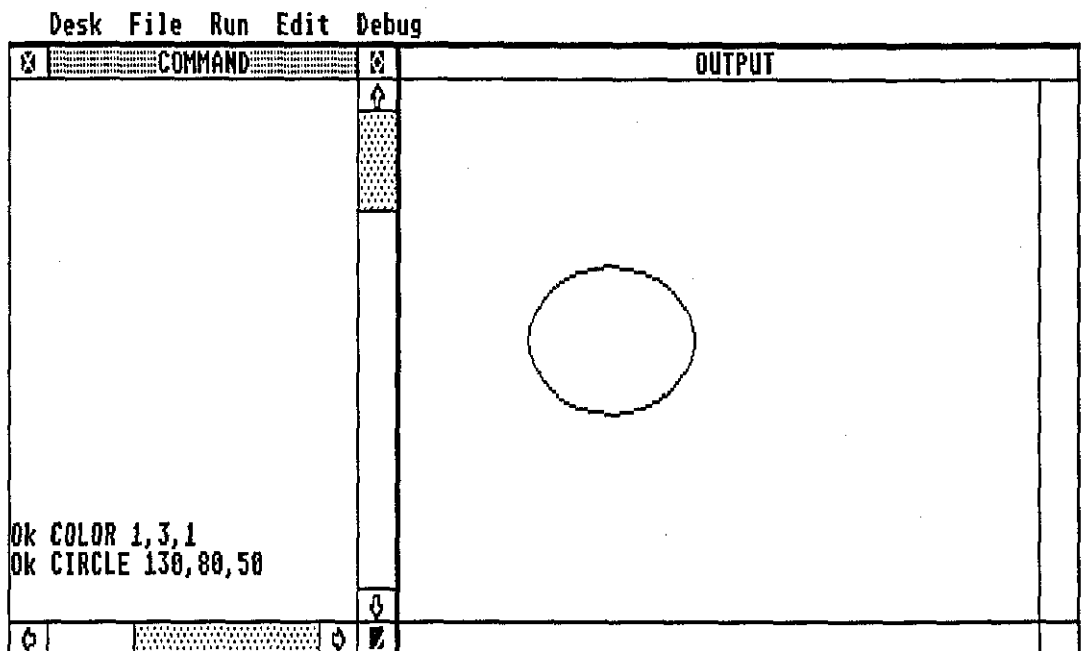
Worksheet 9 Activity 1



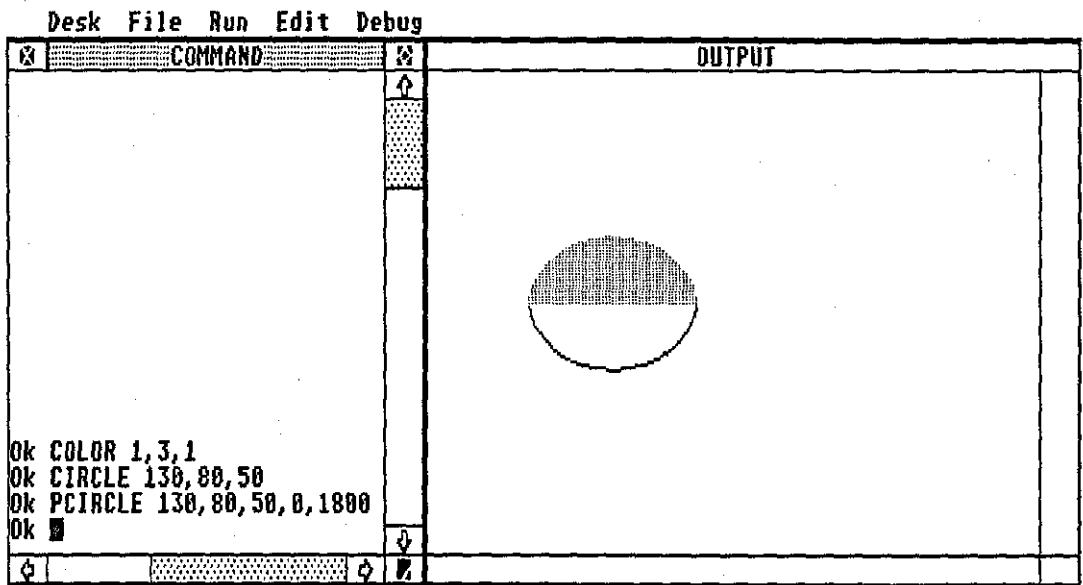
Worksheet 9 Activity 2



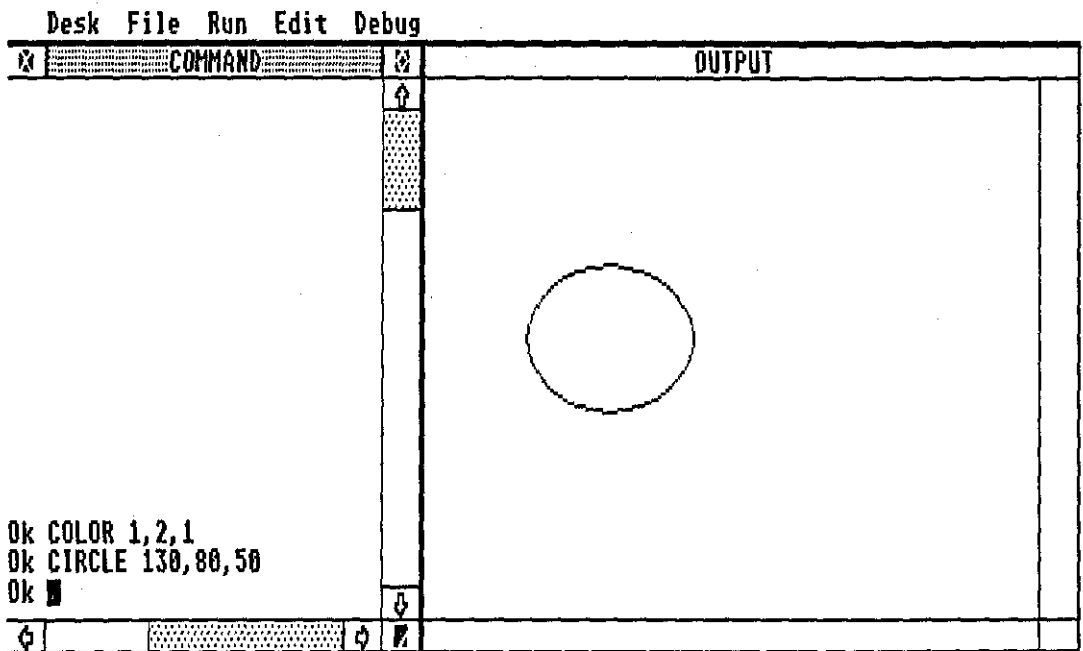
Worksheet 10 Activity 1



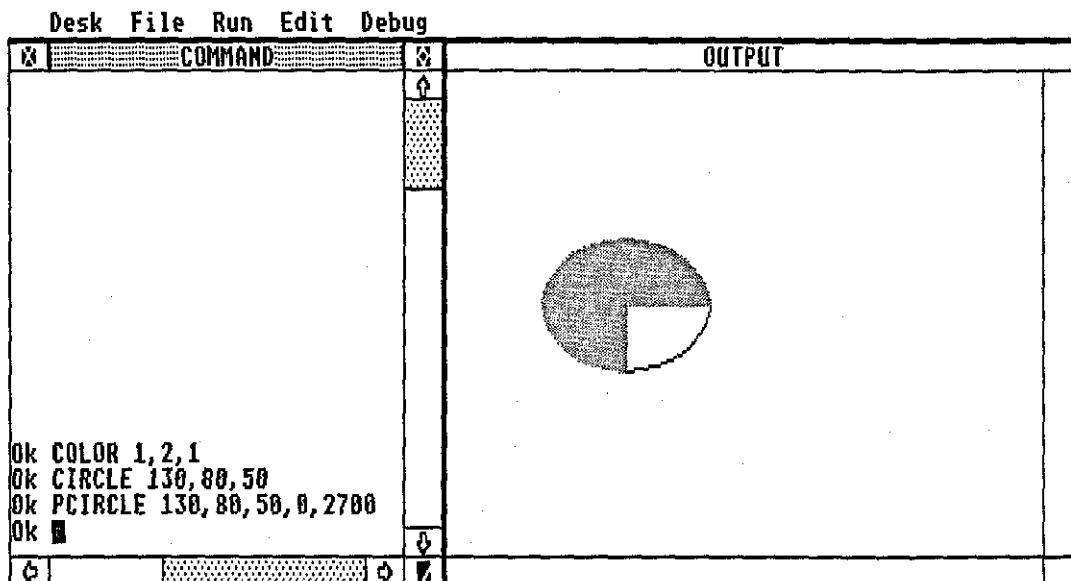
Worksheet 10 Activity 2



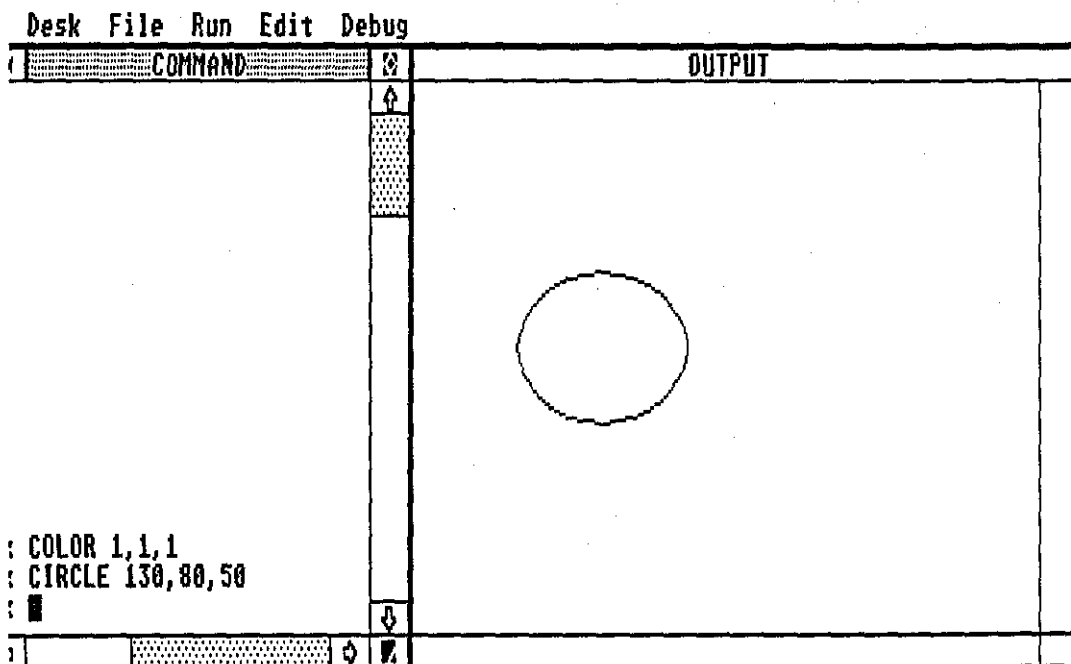
Worksheet 11 Activity 1



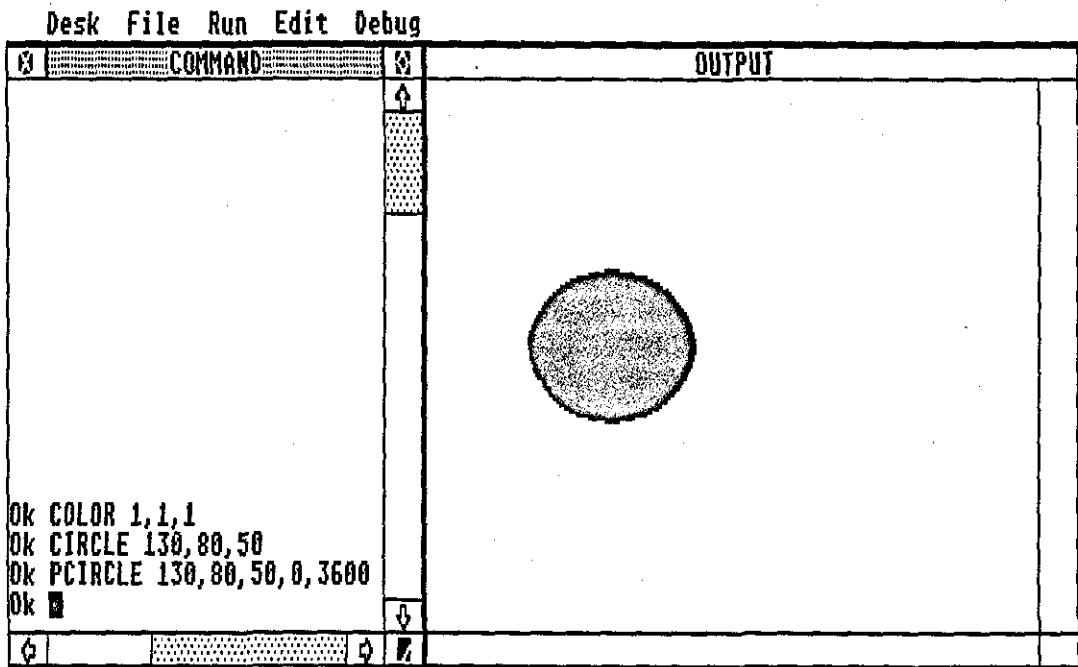
Worksheet 11 Activity 2



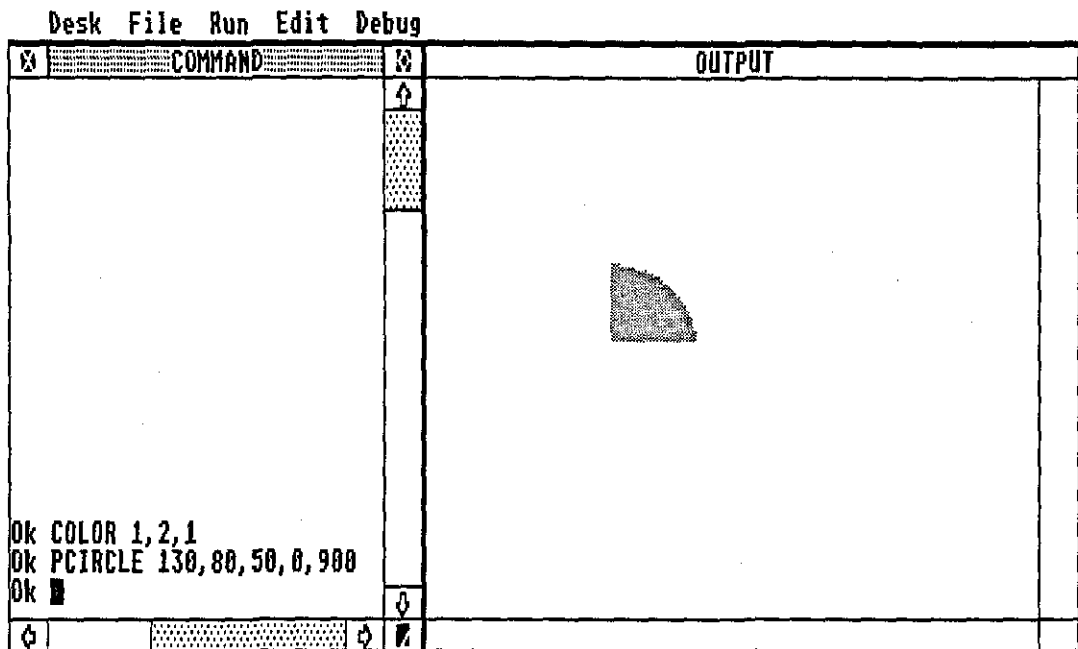
Worksheet 12 Activity 1



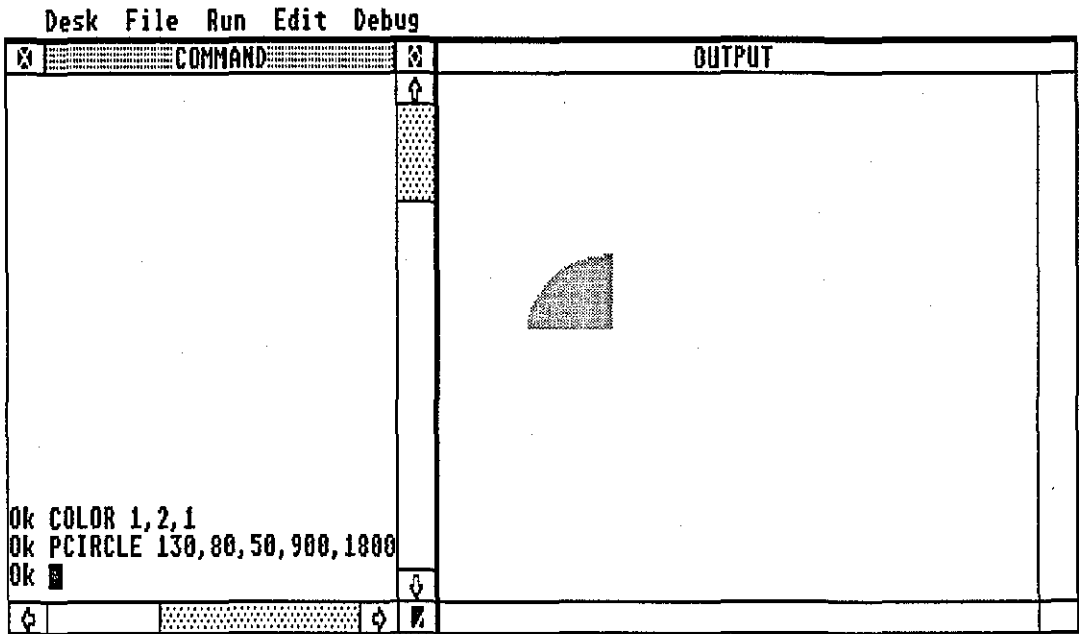
Worksheet 12 Activity 2



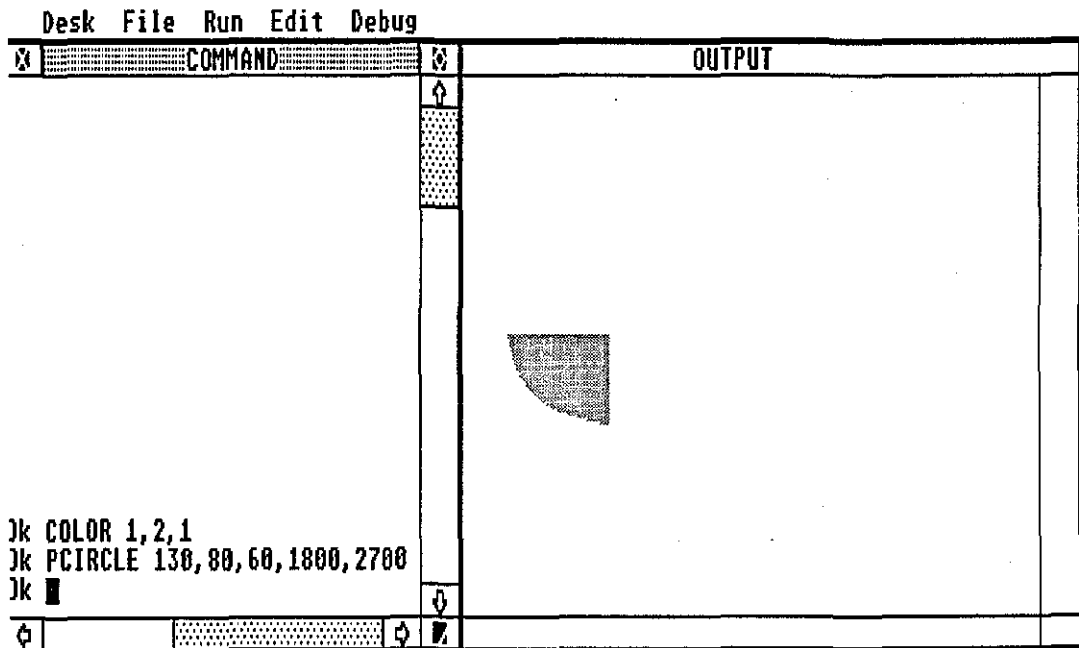
Worksheet 13 Activity 1



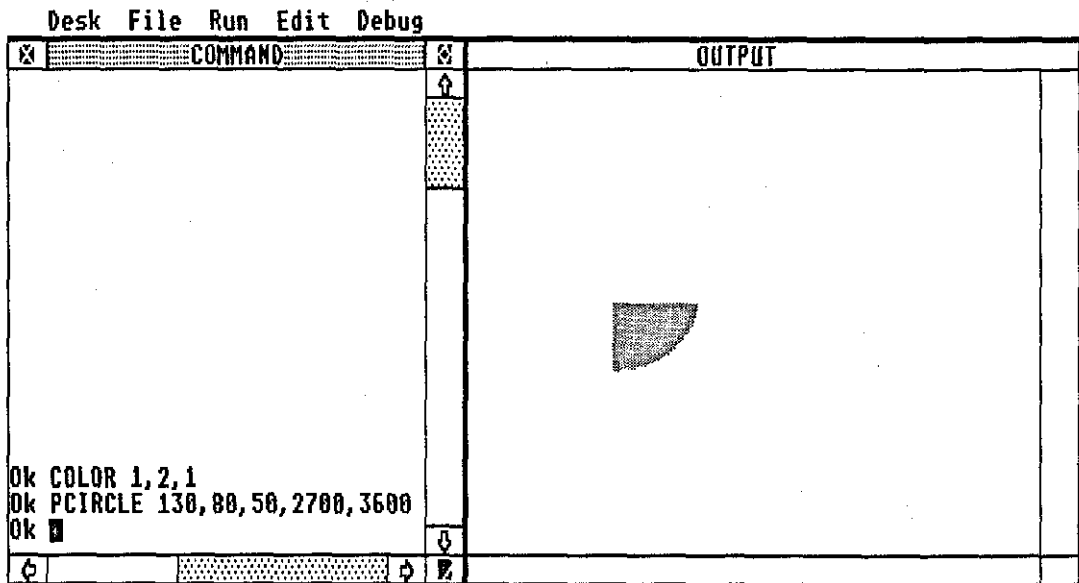
Worksheet 14 Activity 1



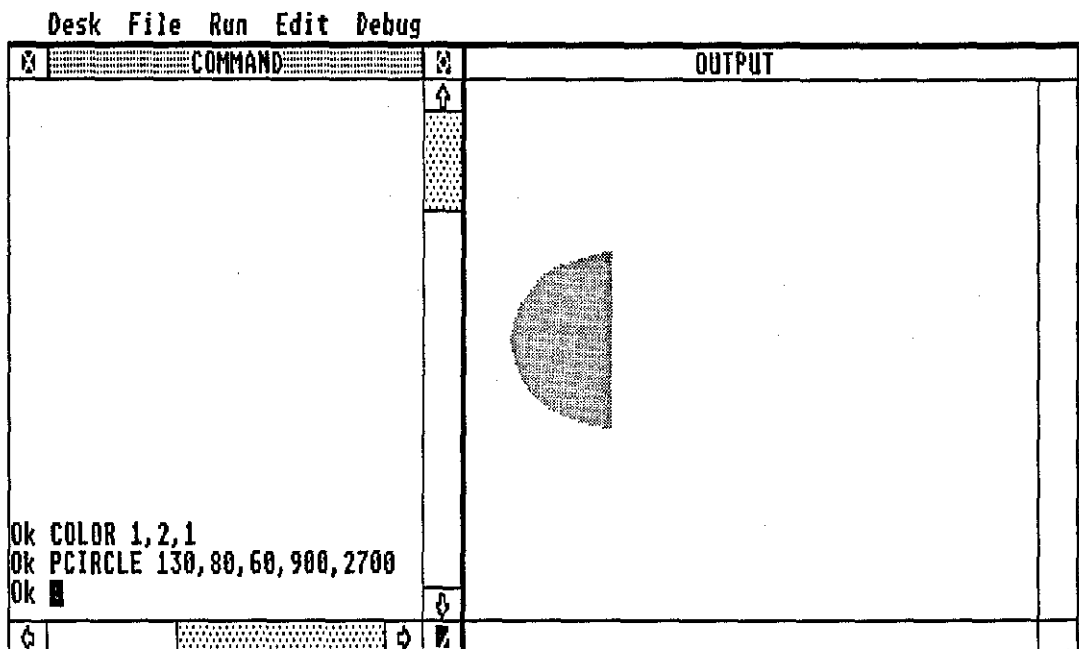
Worksheet 15 Activity 1



Worksheet 16 Activity 1




Worksheet 17 Activity 1



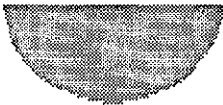
WORKSHEET 17 ACTIVITY 1

Desk File Run Edit Debug

COMMAND	OUTPUT
<pre>Ok COLOR 1,2,1 Ok PCIRCLE 130,80,60,*,*█</pre>	

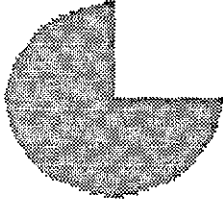
WORKSHEET 18 ACTIVITY 1

Desk File Run Edit Debug

COMMAND	OUTPUT
<pre>Ok COLOR 1,2,1 Ok PCIRCLE 130,80,60,*,*█</pre>	

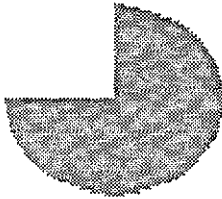
WORKSHEET 19 ACTIVITY 1

Desk File Run Edit Debug

COMMAND	OUTPUT
<pre>Ok COLOR 1,2,1 Ok PCIRCLE 130,80,60,*,*█</pre>	

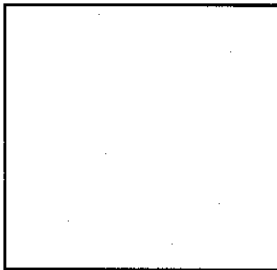
WORKSHEET 20 ACTIVITY 1

Desk File Run Edit Debug

COMMAND	OUTPUT
<pre>Ok COLOR 1,2,1 Ok PCIRCLE 130,80,60,*,*█</pre>	


WORKSHEET 21 ACTIVITY 1

Desk File Run Edit Debug

COMMAND		OUTPUT
Ok LINEF 50,50,200,50		
Ok LINEF 200,50,200,150		
Ok LINEF 200,150,50,150		
Ok LINEF *,*,*,* █		

WORKSHEET 22 ACTIVITY 1

Desk File Run Edit Debug

COMMAND		OUTPUT
Ok LINEF 70,30,150,30		
Ok LINEF 70,120,150,120		
Ok LINEF 70,30,70,120		
Ok LINEF *,*,*,* █		

INTRODUCTORY

COURSE

BI/37

INTRODUCTORY COURSE

AN INTRODUCTION TO PROGRAMMING

A GRAPHICS APPROACH

A COURSE FOR PRIMARY SCHOOLS IN FIJI

STUDENT'S WORKSHEETS

INTRODUCTORY COURSE

WORKSHEET 1

DRAWING LINES USING

LINEF (1)

ACTIVITY 1

Type *LINEF 50,50,200,100* (return)

Copy the line in the space provided below. Label the left end of the line O and the right end A.

ACTIVITY 2

Type *LINEF 50,50,200,150* (return)

Copy the line and label it OB.

ACTIVITY 3

Type *LINEF 50,50,200,25* (return)

Copy the line and label it OC.

ACTIVITY 4

Type *LINEF 50,50,200,50* (return)

Copy the line and label it OD.

Describe any changes in Activities and Lines.

INTRODUCTORY COURSE

WORKSHEET 2

LINEF (2)

Type each Activity and Copy each diagram.

ACTIVITY 1 LINEF 100,150,100,100 (return)

ACTIVITY 2 LINEF 100,150,50,100 (return)

ACTIVITY 3 LINEF 100,150,150,100 (return)

ACTIVITY 4 LINEF 100,150,25,100 (return)

Describe the effect of changing the numbers in the commands.

INTRODUCTORY COURSE

WORKSHEET 3

LINEF (3)

Type each Activity and Copy each diagram.

ACTIVITY 1 LINEF 50,50,300,50 (return)

ACTIVITY 2 LINEF 300,50,50,150 (return)

ACTIVITY 3 LINEF 50,150,300,150(return)

ACTIVITY 4 LINEF 300,150,50,50 (return)

Describe the changes in the numbers and lines.

INTRODUCTORY COURSE

WORKSHEET 4

LINEF (4)

ACTIVITY 1

Use the Command LINEF with numbers of your choice to copy the shape, FIGURE 4, on to the screen.

ACTIVITY 2

Copy the Commands with the numbers you used to draw the shape.

INTRODUCTORY COURSE

WORKSHEET 5

CIRCLE (1)

Type the Commands for each Activity. Copy the Commands in the Command space provided and the Diagrams in the Output space provided.

ACTIVITY 1 CIRCLE 100,50,50 (return)

ACTIVITY 2 CIRCLE 100,130,50 (return)

ACTIVITY 3 CIRCLE 230,130,50 (return)

ACTIVITY 4 CIRCLE 230,50,50 (return)

ACTIVITY 5 CIRCLE 165,90,30 (return)

INTRODUCTORY COURSE

WORKSHEET 6

CIRCLE (2)

Type and Copy Commands and Diagrams.

ACTIVITY 1 CIRCLE 150,80,100 (return)

ACTIVITY 2 CIRCLE 80,80,80 (return)

ACTIVITY 3 CIRCLE 150,80,50 (return)

ACTIVITY 4 CIRCLE 150,80,30 (return)

WORKSHEET 7

COLOR, CIRCLE

Type and Copy the Commands and Diagrams. Note the spelling of the Command 'COLOR'.

ACTIVITY 1 COLOR 1,1,2 (return)

CIRCLE 100,50,30 (return)

ACTIVITY 2 COLOR 1,1,3 (return)

CIRCLE 100,150,30(return)

ACTIVITY 3 COLOR 1,1,1 (return)

CIRCLE 200,150,30(return)

INTRODUCTORY COURSE

WORKSHEET 8

COLOR, PCIRCLE

Type and Copy Commands and Diagrams.

ACTIVITY 1 COLOR 1,1,1 (return)

PCIRCLE 100,50,30 (return)

ACTIVITY 2 PCIRCLE 100,100,30 (return)

ACTIVITY 3 COLOR 1,2,1 (return)

PCIRCLE 100,150,30(return)

ACTIVITY 4 COLOR 1,3,1 (return)

PCIRCLE 200,150,30 (return)

INTRODUCTORY COURSE

WORKSHEET 9

COLOR, CIRCLE, PCIRCLE (1)

Note that PCIRCLE has three five numbers with it, before it had only three numbers with it.

Type and copy the Commands and diagram.

ACTIVITY 1 COLOR 1,2,1 (return)

CIRCLE 130,80,50 (return)

ACTIVITY 2 PCIRCLE 130,80,50,0,900 (return)

INTRODUCTORY COURSE

WORKSHEET 10

COLOR, CIRCLE, PCIRCLE (2)

ACTIVITY 1 COLOR 1,3,1 (return)

CIRCLE 130,80,50 (return)

ACTIVITY 2 PCIRCLE 130,80,50,0,1800 (return)

INTRODUCTORY COURSE

WORKSHEET 11

COLOR, CIRCLE, PCIRCLE (3)

Type and copy the Commands and the Diagrams.

ACTIVITY 1 COLOR 1,2,1 (return)

CIRCLE 130,80,50 (return)

ACTIVITY 2 PCIRCLE 130,80,50,0,2700 (return)

INTRODUCTORY COURSE

WORKSHEET 12

COLOR, CIRCLE, PCIRCLE (4)

Type and copy Commands and Diagrams.

ACTIVITY 1 COLOR 1,1,1 (return)

CIRCLE 130,80,50 (return)

ACTIVITY 2 PCIRCLE 130,80,50,0,3600 (return)

INTRODUCTORY COURSE

WORKSHEETS 13 - 22

The Commands given with each of the Diagram in Worksheets 13 to 22, are incomplete.

One or two of the numbers are missing, and there are stars (*) in their places.

For each Worksheet find the number or numbers to replace the star to draw the given diagram.

If you make a mistake, you can clear the screen with the Commands:


CLEARW 3(return)

CLEARW 2(return)

Remember when typing the Commands to draw the Diagram, press the (return) key after each Command.


WORKSHEET 13 ACTIVITY 1

Desk File Run Edit Debug

COMMAND		OUTPUT
<pre> : COLOR 1,2,1 : PCIRCLE 130,80,50,*,900 </pre>		

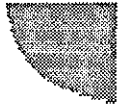
WORKSHEET 14 ACTIVITY 1

Desk File Run Edit Debug

COMMAND		OUTPUT
<pre> Ok COLOR 1,2,1 Ok PCIRCLE 130,80,50,*,1800 </pre>		

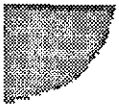
WORKSHEET 15 ACTIVITY 1

Desk File Run Edit Debug

COMMAND	OUTPUT
Ok COLOR 1,2,1 Ok PCIRCLE 130,80,60,1800,*	
⏪	⏩


WORKSHEET 16 ACTIVITY 1

Desk File Run Edit Debug

COMMAND	OUTPUT
Ok COLOR 1,2,1 Ok PCIRCLE 130,80,60,*,3600	
⏪	⏩

WORKSHEET 17 ACTIVITY 1

Desk File Run Edit Debug

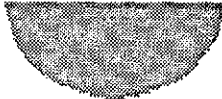
COMMAND	OUTPUT
<pre>Ok COLOR 1,2,1 Ok PCIRCLE 130,80,60,*,*█</pre>	

↑

↓

WORKSHEET 18 ACTIVITY 1

Desk File Run Edit Debug

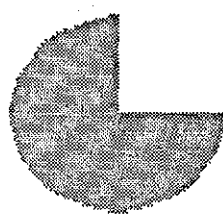
COMMAND	OUTPUT
<pre>Ok COLOR 1,2,1 Ok PCIRCLE 130,80,60,*,*█</pre>	

↑

↓

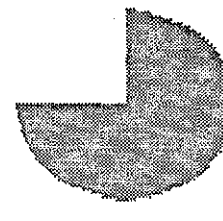
WORKSHEET 19 ACTIVITY 1

Desk File Run Edit Debug

COMMAND	OUTPUT
<pre>Ok COLOR 1,2,1 Ok PCIRCLE 130,80,60,*,*█</pre>	

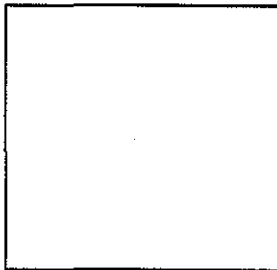
WORKSHEET 20 ACTIVITY 1

Desk File Run Edit Debug

COMMAND	OUTPUT
<pre>Ok COLOR 1,2,1 Ok PCIRCLE 130,80,60,*,*█</pre>	

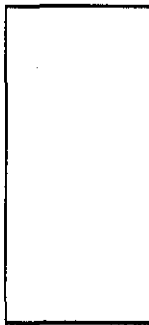
WORKSHEET 21 ACTIVITY 1

Desk File Run Edit Debug

COMMAND		OUTPUT	
Ok LINEF 50,50,200,50 Ok LINEF 200,50,200,150 Ok LINEF 200,150,50,150 Ok LINEF *,*,*,* █			

WORKSHEET 22 ACTIVITY 1

Desk File Run Edit Debug

COMMAND		OUTPUT	
Ok LINEF 70,30,150,30 Ok LINEF 70,120,150,120 Ok LINEF 70,30,70,120 Ok LINEF *,*,*,* █			

APPENDIX C

COMPUTERS IN SCHOOLS CONFERENCE/WORKSHOP

Introduction

The first Computers in Schools Conference/Workshop (CSCW) was held one school year after the official declaration of government support of the technology and its supply of hardware to some selected schools. The aim of this first CSCW was to address some problems that arose in the first year of computers in schools. The nature of these problems was such that it was clear there was a definite lack of staff in schools with knowledge about computers. The workshop part of the CSCW was an attempt to respond to this problem. Experience has shown that one should not try to bombard practitioners with new technology, but to expose them to it little by little, hence the one day workshop tacked on after the conference during CSCW. Time and finance did not allow any more time for the conference either, so that the whole exercise took two days.

Conference

Speakers at the conference were from the Ministry of Education, teachers in schools, and academics from USP with one overseas speaker from Armidale College of Education in Australia. Their topics ranged from emerging technologies in education to computer uses in the classroom and its associated problems.

The conference highlighted several areas of computers in schools that needed looking into. Most of the problems at this stage stemmed from the lack of preparation by the schools to receive the microcomputers. Teachers felt they were being pushed in at the deep end and told to get on with it.

With schools that are used to operating in a restrictive mode, with directives from the Ministry at most levels of decision making, the initial response by the staff was rather chaotic. They had expected some definite directive from the

Ministry of Education but instead there was a total lack of instructions and ignorance of the problems involved.

Problems raised at the conference included lack of physical amenities to cater for the microcomputers, lack of knowledge on the part of the teachers, lack of software for the microcomputers and a total lack of appreciation of problems by the Ministry of Education. Teachers had tackled the problems mostly themselves in their own way.

A questionnaire put to the teachers who attended the conference showed that:

- (i) 75% of them had taught themselves programming
- (ii) 35% were teaching their students computing
- (iii) 50% had attended computing courses of some sort
- (iv) 80% wanted a follow up conference on a higher level
- (v) all attendants agreed the conference should be at least an annual event.

The above indicates the willingness of teachers in Fiji to respond to the challenges presented by the introduction of computers as a teaching aid.

It is noteworthy that the majority of teachers who attended the conference were maths and/or science teachers.

Workshop

The workshop was an attempt to respond to the lack of basic knowledge of computers as indicated by enquiries from schools during the previous school year.

Due to the lack of software teachers were teaching pupils in schools computer programming, and they were encountering problems due to their lack of computer basics and because of their self taught sketchy knowledge of computer programming principles. A teacher had indicated that tutors who ran the two week familiarisation course at the beginning of the year were not fully familiar

themselves. The two week familiarisation course was organised by the Ministry of Education as preparation for the placing of microcomputers in schools.

As a result the workshop concentrated on programming in Basic and running some prepared programs.

In the closing discussion it was indicated that the workshop had helped to overcome some of their frustrations and had solved a few of their problems.

The questionnaire showed :

- (i) all participants gained something
- (ii) 50% cleared up some misconceptions
- (iii) all agreed to the success of the exercise.

Conclusions

From general comments it was obvious that different levels of understanding of micros existed.

- (i) It was suggested that the next CSCW should be held at two levels, 'beginners' and 'advanced'.
- (ii) A need for a proper in-service computing course for teachers was identified as urgent.
- (iii) There is a place for a regular publication of an informative nature to inform teachers and interested parties on what is happening and what is available in the way of software, hardware and other relevant developments in Fiji.
- (iv) The use of micros across the curriculum was to be encouraged.
- (v) It was the norm to find computers in the science and maths department in schools. Computers were absent from other subject areas and this was by no means pre-planned.

It was suggested that the next conference theme be 'computers across the curriculum'.

It was also agreed at the closing session that the Chairman, Prof. Phythian of the Maths Dept., USP write to the Ministry of Education suggesting amongst other things that:

- (i) a body be set up to coordinate computing activities in education
- (ii) the Ministry seek funds from outside to fund the next CSCW
- (iii) changes in the school curriculum needed to involve computers.

The author wishes to point out here that any correspondence, including the one above, with the Ministry of Education on the subject of computing activities in education did not receive due or favourable attention. This reluctance of some people in office to confer on matters of public interest has been a stumbling block in the development of computers in education in Fiji. It is important for Fiji to utilise whatever resources are available. An open mind and a willingness to allow people to participate can only benefit the nation. Hopefully more discussion and exchange of ideas on computing in education will take place in the future.

APPENDIX D

SURVEY ON THE USE OF MICROCOMPUTERS IN SCHOOLS

The survey was conducted in November 1984, one school year after the introduction of microcomputers in Fiji schools. It was carried out mainly as an exploratory exercise to gain an insight into how the new technology fared in its first year in schools in Fiji.

As the author had organised the first class in computer awareness at the USP all enquiries from school teachers were directed to his office. It was on the basis of these enquiries that the author carried out the survey and organised the conference, see Appendix C.

The survey was carried out in two government secondary schools and one church secondary school.

When the first batch of government issue of microcomputers were available in January 1984 the two government secondary schools in this survey were amongst the recipients. The church school had provided theirs from other sources. Not all secondary schools in the country received microcomputers at this time.

The three schools in the survey had had microcomputers for at least one school year and no more than two for the church school.

This time scale has to be borne in mind when looking at the implications of the results of the survey.

One of the government schools and the church school offer some boarding facilities while the other government school does not have boarding facilities for its students. The government school with boarding facility takes students in at Forms 5 and 6 while the other two schools in the survey take in students from Form 1.

The three schools are in the locality of Suva, the largest town in Fiji, the furthest one from Suva being no more than ten miles. The proximity of a

school to Suva has a bearing on the students who attend the school. Students who live near Suva will have a better chance of updating their experience on new technology than those students who attend schools further away from Suva in the rural districts.

The survey in the form of a questionnaire was carried out in 1984 and the intention was to repeat it again in 1987 but circumstances relating to the political situation in Fiji (beyond the author's control) prevented the second survey.

A copy of the questionnaire is given below with the 1984 responses. Figures given are percentages of total number of 300 questionnaires returned.

Where percentages in a question exceed 100, some students have made more than the appropriate number of choices. Where total percentages do not add up 100, some students have not made any choices.

Comments and conclusions of the survey are discussed in Chapter 3.

SURVEY QUESTIONNAIRE 1984

QUESTION 1

WHEN DID YOU FIRST USE A MICROCOMPUTER ?

THIS YEAR	88%
LAST YEAR	6%
TWO YEARS AGO	0%
MORE THAN TWO YEARS AGO	6%

QUESTION 2

WHAT BRANDS OF MICROCOMPUTERS HAVE YOU USED ?

APPLE	6%
ATARI	5%
COMMODORE	100%
OTHERS	0%

QUESTION 3

WHAT HAVE YOU USED A MICROCOMPUTER FOR ?

PHYSICS	6%	LANGUAGES	20%
MATHS	96%	GEOGRAPHY	0%
BIOLOGY	1%	HISTORY	0%
CHEMISTRY	4%	OTHERS	0%

QUESTION 4

IN WHICH SUBJECT AREA HAVE YOU FOUND MICROCOMPUTERS MOST USEFUL ?

PHYSICS	6%	LANGUAGES	20%
MATHS	96%	GEOGRAPHY	0%
BIOLOGY	1%	HISTORY	0%
CHEMISTRY	4%	OTHERS	0%

QUESTION 5

HOW MANY HOURS A WEEK ARE YOU TIMETABLED FOR THE MICROCOMPUTER ?

< 0.5 HOUR	28%
0.5 - 1 HOUR	39%
1 - 1.5 HOURS	7%
1.5 - 2 HOURS	1%
> 2 HOURS	3%

QUESTION 6

DO YOU OWN A MICROCOMPUTER ?

YES	0%	NO	100%
-----	----	----	------

QUESTION 7

WOULD YOU LIKE TO SPEND MORE TIME ON MICROCOMPUTERS EVEN IF IT MEANS AFTER NORMAL WORKING HOURS ?

YES	100%	NO	0%
-----	------	----	----

QUESTION 8

WHICH ADJECTIVES BEST TYPIFIES YOUR ATTITUDE TO
COMPUTER LEARNING AS YOU HAVE EXPERIENCED IT ?

WASTE OF TIME	0%	USEFUL	32%
MOST UNHELPFUL	0%	VERY USEFUL	62%
SOMETIMES USEFUL	6%		

QUESTION 9

HOW DO YOU RATE THE FOLLOWING MICROCOMPUTER FACILITIES?

	VERY USEFUL	SOME USE	LITTLE USE	NO USE
G	33%	32%	7%	0%
S	24%	40%	28%	3%
SP	82%	7%	6%	0%
A	95%	5%	0%	0%
C	42%	33%	15%	3%

G - graphics; S - sound; SP - speed; A - accuracy;

C - colour.

QUESTION 10

IF YOU HAVE EXPERIENCED COMPUTER ANIMATION WITH MICROCOMPUTERS IN THE CLASSROOM, DID YOU FIND IT ?

VERY USEFUL	43%
SOME USE	31%
LITTLE USE	1%
NO USE	0%

QUESTION 11

YOU HAVE THE CHOICE TO JOIN ONE OF 5 CLASSES. EACH CLASS USES ONE OF THE FOLLOWING AIDS: CHARTS, SLIDES, FILMS, MICROCOMPUTERS, MODELS

INDICATE WHICH CLASS YOU WOULD JOIN.

CHARTS	5%	MICROCOMPUTERS	75%
SLIDES	0%	MODELS	10%
FILMS	10%		

QUESTION 12

DO YOU THINK THE MICROCOMPUTER DISPLAY SCREEN IS ?

BETTER THEN THE BLACKBOARD	47%
AS GOOD AS THE BLACKBOARD	43%
NOT AS GOOD	6%
NOT GOOD AT ALL	0%

QUESTION 13

WHEN USING THE MICROCOMPUTER FOR LEARNING, DO YOU LIKE TO ?

WORK ON YOUR OWN	54%
WORK IN TWO'S	39%
WORK IN GROUPS > 2	1%
LET TEACHER OPERATE IT	6%

QUESTION 14

IF YOU HAD TO CHOOSE BETWEEN HAVING A TEACHER OR A MICROCOMPUTER FOR SOME CLASSES WHICH WOULD YOU CHOOSE ?

MICROCOMPUTER ALL OF THE TIME	1%
MICROCOMPUTER MORE OF THE TIME	7%
50 - 50	74%
TEACHER MORE OF THE TIME	10%
TEACHER ALL THE TIME	0%

QUESTION 15

HOW DO YOU RATE THE USEFULNESS OF THE MICROCOMPUTER IN THESE SUBJECTS ?

	VERY USEFUL	SOME USE	LITTLE USE	NO USE
M	85%	11%	1%	1%
S	44%	40%	7%	1%
G	11%	35%	15%	8%
A	10%	17%	24%	15%
MU	17%	19%	28%	7%
TS	15%	21%	14%	11%
L	39%	25%	10%	4%

M - mathematics; S - science; G - geography;
A - arts; MU - music; TS - technical studies;
L - language.

QUESTION 16

WHICH SUBJECTS DO YOU TAKE AT SCHOOL ?

MATHS	97%	HISTORY	21%
PHYSICS	65%	ARTS	29%
BIOLOGY	85%	MUSIC	39%
CHEMISTRY	54%	TECH STUDY	10%
GEOGRAPHY	42%	LANGUAGE	74%

QUESTION 17

WHICH 5 SUBJECTS WOULD YOU TAKE IF GIVEN THE CHANCE ?

MATHS	84%	PHYSICS	61%
BIOLOGY	32%	CHEMISTRY	8%
GEOGRAPHY	8%	HISTORY	15%
ARTS	1%	MUSIC	7%

QUESTION 18

SHOULD THERE BE A COMPUTING SUBJECT AT SCHOOL AT?

FORM 3 LEVEL	50%	FORM 6 LEVEL	45%
FORM 5 LEVEL	51%	FORM 7 LEVEL	20%

QUESTION 19

SHOULD SCHOOLS TEACH SOMETHING ABOUT COMPUTER HARDWARE?

YES	77%	A LITTLE	22%	NO	1%
-----	-----	----------	-----	----	----

QUESTION 20

THE MICROCOMPUTER HAS A VERY FAST RESPONSE TIME, DO YOU FIND THIS ?

VERY USEFUL	90%	OF LITTLE USE	0%
OF SOME USE	10%	OF NO USE	0%

QUESTION 21

DO YOU PREFER THE MICROCOMPUTER TO ?

ONLY EXPLAIN FACTS	3%
EXPLAIN FACTS AND ASK QUESTIONS	7%
EXPLAIN, ASK AND RESPOND TO YOUR ANSWERS	90%

QUESTION 22

THE USE OF MICROCOMPUTERS HAS HELPED MY UNDERSTANDING OF MATHEMATICS.

STRONGLY AGREE	46%	DISAGREE	7%
AGREE	44%	STRONGLY DISAGREE	0%

QUESTION 23

FIJI SHOULD SPEND MORE MONEY ON MICROCOMPUTERS.

STRONGLY AGREE	46%	DISAGREE	7%
AGREE	47%	STRONGLY DISAGREE	0%

QUESTION 24

GRANTED COMPUTER HARDWARE AND SOFTWARE IS EXPENSIVE,
WHICH SCHOOLS IN FIJI SHOULD HAVE MICROCOMPUTERS ?

ALL SECONDARY SCHOOLS ONLY (3 OR 4 IN EACH)	42%
ALL SECONDARY (1 EACH)	14%
SECONDARY & JUNIOR SECONDARY	44%
PRIMARY SCHOOLS	7%
A FEW SECONDARY SCHOOLS	11%

QUESTION 25

DO YOU THINK MORE OR FEWER JOBS WILL BE CREATED BY
COMPUTERS ?

MORE JOBS	47%	A FEW JOBS	26%
NO MORE	1%	FEWER JOBS	25%

QUESTION 26

WOULD YOU LIKE A JOB INVOLVING COMPUTERS WHEN YOU ARE
QUALIFIED ?

DIRECTLY INVOLVING COMPUTERS	88%
INDIRECTLY INVOLVING COMPUTERS	10%
NOT INVOLVING COMPUTERS	2%

APPENDIX E

COMPUTER USAGE IN THE SOUTH PACIFIC

The list given here is not complete but gives an idea of the kind and extent of computers installed in the South Pacific up until 1985, and the range is increasing all the time.

Fiji Islands

NCR V8450	3	Data Processing Bureau
NCR Tower	6	Data Processing Teaching
ICL 2903/4	2	Data Processing Teaching
ME 29	9	Banks mainly
DRS 20/50	8	Data Processing
PRIME 550	5	Data Processing
HONEYWELL	6	Data Processing
WANG VS45	3	Data Processing Bureau
APPLE LISA	3	
MICRODATA	3	
CANNON AS100	3	
IBM PC	25	Data Processing Statistical Word Processing
COMMODORE	250	
RADIO SHACK	10	
OLIVETTI	4	

School Micros

Commodore	100
Atari	10
BBC Model B	10
Apples	10

VANUATU

NCR 8200	1	Statistics and Word Processing
NCR 9200	1	Finance - Accounts and Payroll
Apricot + 10MB HD	4	Electoral List, Manpower Planning Scholarships
BBC	2	Teaching Awareness
Apple II	6	Teaching and Training
Apple IIe	2	Teaching and Training
IBM 34	1	Electricity Board

KIRIBATI

HP 85	1	Fisheries Data Analysis
NCR 9010	2	Finance with support from Suva, Fiji
IBM PC	2	Statistics
BBC Model B	1	Teaching Accounting and Statistics

NAURU

ICL 2903	2	
----------	---	--

soon to change to IBM

SOLOMON ISLANDS

NCR 8271	1	National Provident Fund
NCR 8270	1	Government Accounts
Apple	3	Statistics
NCR 9300	1	National Bank
NCR	1	Development bank

Most islands plan to expand their use of computers in the near future. The current level and intention to expand show a commitment to computers and emphasise the need for an extensive computer education programme for the region of the South Pacific.

APPENDIX F

PROBLEM SOLVING USING SPREADSHEET AND BASIC LANGUAGE: A COMPARISON

A group of fourth year secondary students in a girls' school were given a project to compare two methods of solving a pair of simultaneous equations:

- (i) Using a spreadsheet
- (ii) Using a Basic program.

Hardware

Hardware used were the BBC (British Broadcasting Corporation) microcomputers in a network employing Econet with eight machines sharing a disk drive and a printer.

Software

BBC Basic was used for writing programs and Viewsheet was the spreadsheet available on the BBC microcomputer.

Preparing Students

The group consisted of twenty fourth year students, who had studied Basic programming on the same network during the previous year in the third form.

To prepare them for the project, 4 periods of 35 mins were spent on revising Basic programming.

The students were already familiar with the general network setup.

By the time the group started on the project they were able to use the following commands:

INPUT, LET, PRINT, IF.....THEN, GOTO

The spreadsheet Viewsheet was on the network server and students were instructed on:

- (i) how to load the program from the file server
- (ii) a general description of what the Viewsheet displayed on loading. With Viewsheet two screens are available.
- (iii) how to move the cursor with the arrow keys and make entries in the slots
- (iv) how to read the content of a slot from the slot content indicator at the top left hand corner of Viewsheet
- (v) what can be entered in the slots:
 - numerical value
 - labels
 - formulae
- (vi) how to formulate formulae using slot locations as variables
- (vii) the ability of the spreadsheet to automatically evaluate formulae and display values.

Exercises on data entry and using a simple spreadsheet to solve a linear equation gave the students an opportunity to see a spreadsheet in action.

The exercise given to the students was the solution of the linear equation:

$$ax + b = c \text{ where } a, b, c \text{ are constants,}$$

$$\text{and the solution is } x = (c-b)/a$$

Entries for the above equation are:

SLOT	ENTRY
A1	value of a
B1	value of b
C1	value of c
B2	type 'x ='
C2	type formula '(C1-B1)/A1'

The students were given the above entries and some linear equations to solve first without the spreadsheet, and then checked with the spreadsheet.

The instruction on Viewsheet took up 6x35 minute lessons before they embarked on the project. In the project the students were asked to write a program in Basic to solve a pair of simultaneous equations, and also to set up the spreadsheet to solve simultaneous equations. A Basic program and a spreadsheet template to solve simultaneous equations was available on the network for those students who were unable to produce their own. The project was tackled with enthusiasm by most students with very encouraging results. Two samples of projects done by the students are attached.

Comments on the Project

Mathematical activities including oral expressions of mathematical concepts were very much in evidence.

Clarification of the roles of variables in formulae was demanded to enable a better understanding of the use of spreadsheets. Values in a spreadsheet can be referred to by their cell locations. It is readily accepted that a cell location, equivalent to a variable, represents a value because one can see the contents of the particular cell.

Clarification of the method of solution of simultaneous equations was also required. To write the Basic program or set up the spreadsheet to solve the simultaneous equations a thorough understanding of the method of solution is necessary. Students had already studied the solution of simultaneous equations in their maths lesson before they did the project. Consolidation of previous knowledge was made and this gave the students some satisfaction.

Mathematical activities outside the bounds of simultaneous equations were experienced by the students. Accuracy of numbers was discussed at length, as well as the error display when a division by zero was encountered by the

program. The use of brackets in algebraic expressions and formulae and the order of mathematical operations were thoroughly reviewed.

There seemed to be a general concensus amongst the students that it was easier and simpler to solve equations with the spreadsheet. This view was perhaps influenced by the length of time spent on writing the Basic program. With the spreadsheet, once the solution formula was derived the entry of the equations did not present any problem. A preference for the spreadsheet was also due to the well-laid out display of the screen which was difficult to achieve in Basic, especially with the students' limited knowledge of Basic programming.

Some students were unsure of the meaning of the many values on display in the spreadsheet whereas in the Basic program it was possible to end up with only the solution on display.

The students enjoyed the exercise and in some way believed that the computer did solve the problem for them, even though they derived the formula for the solution in both cases, Basic and spreadsheet, just as they would working without computers,

In conclusion the students agreed that they now had a better understanding of the method of solving simultaneous equations and also of the power of the spreadsheet.

In effect they gained some mathematics and some knowledge of the computer application package spreadsheet. The rest of this Appendix contains two samples of the students' work.

CONTENTS:

1. Introduction
2. Method of solving simultaneous equations
3. BASIC
4. Spread Sheets
5. Flow Charts

7

*** Econet ** Station 2 ***

	A	B	C	D
.....1	3	2	9	
.....2				
.....3	2	1	7	
.....4				
.....5				
.....6				
.....7	3	2	9	
.....8				
.....9	4	2	14	
.....10				
.....11				
.....12	1	X=	5	
.....13				
.....14		Y=	-3	
.....15				
.....16				
.....17	(THIS IS A VIEW SPREAD SHEET)			
.....18				
.....19				

Writing statement

** Econet **		Station	2	**
		A	B	C
.....1		[REDACTED]	2	9
.....2		[REDACTED]		
.....3		2	1	[REDACTED]
.....4				
.....5				
.....6				
.....7		[REDACTED]	2	9
.....8				
.....9		4	2	[REDACTED]
.....10				
.....11				
.....12		[REDACTED]	X=	[REDACTED]
.....13				
.....14			Y=	[REDACTED]
.....15				
.....16				
.....17				
.....18				
.....19				

using mae comple
digits.

** Econet **		Station	2	**
		A	B	C
.....1		①	2	9
.....2				
.....3		0	2	0.456
.....4				
.....5				
.....6				
.....7		0	4	18
.....8				
.....9		0	4	0.912
.....10				
.....11				
.....12		0	=	-17.088
.....13				
.....14			Y=	[REDACTED]
.....15				
.....16				
.....17				
.....18				
.....19				

values = 0 ∴ y
not be, wated or
therefore = ? Error.

E1:

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

A

B

C

D

E

F

G

(LOTUS 1, 2, 3)

3

2

9

2

1

7

3

2

9

4

2

14

1

5

= x

5

-3

= y

 = Cell formulae.

**** Econet ** Station 2 ****

	A	B	C	D
.....1	3	2	9	
.....2				
.....3	2	1	7	
.....4				
.....5				
.....6				
.....7	3	2	9	
.....8				
.....9	0	2	14	
.....10				
.....11				
.....12	1	X=	5	
.....13				
.....14		Y=	-3	
.....15				
.....16				
.....17				
.....18				
.....19				

using positive values.

**** Econet ** Station 2 ****

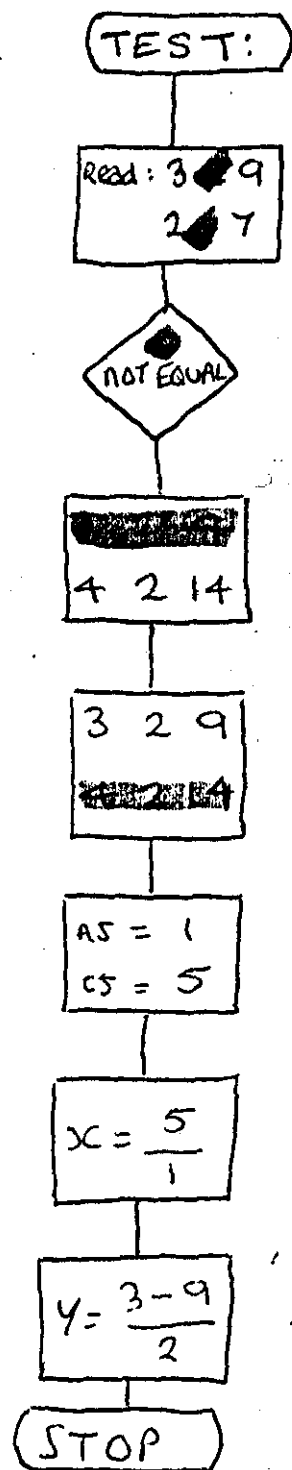
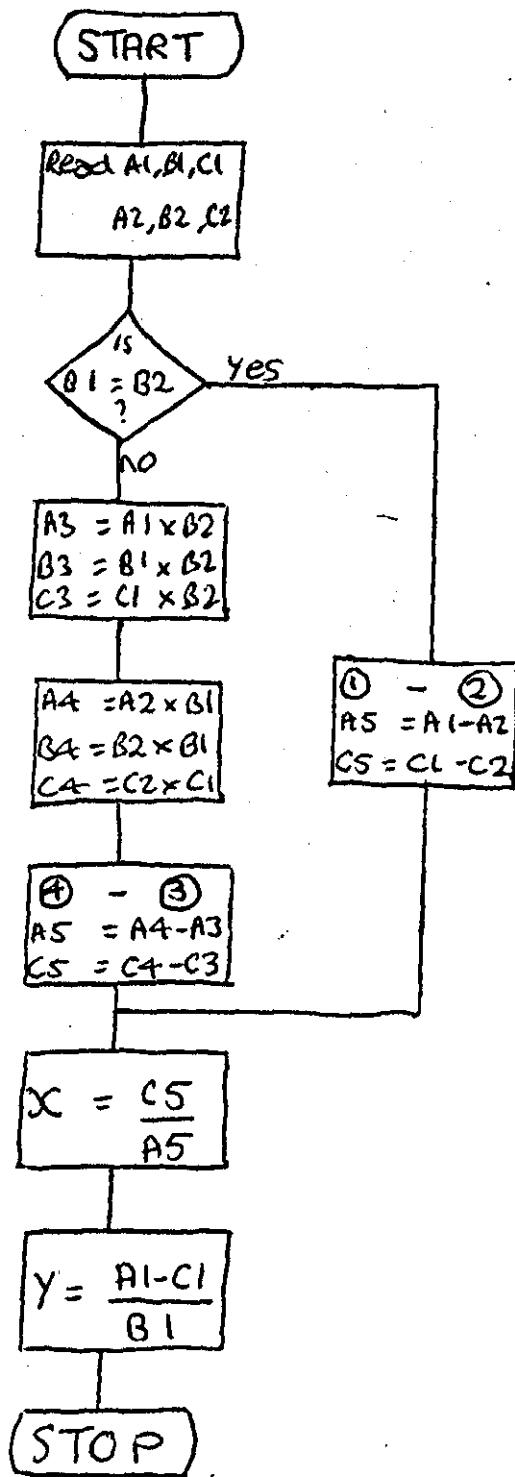
	A	B	C	D
.....1	-3	2	9	
.....2				
.....3	2	1	7	
.....4				
.....5				
.....6				
.....7	-3	2	9	
.....8				
.....9	4	2	14	
.....10				
.....11				
.....12	7	X=	5	
.....13				
.....14		Y=	-33	
.....15				
.....16				
.....17				
.....18				
.....19				

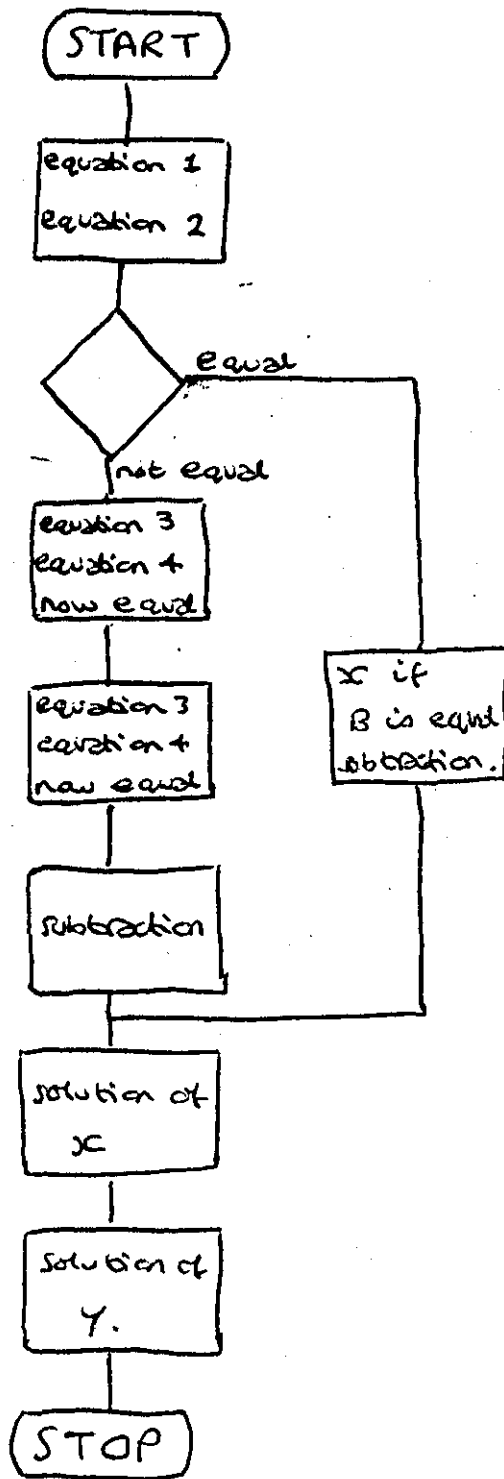
using negative values.

A20:

	A	B	C	D
1	8	-2	12	
2	'ax	'b	'= c	
3	6	1	24	
4				
5				
6	8	-2	12	
7	'a1*b2	'b1*b2	'c1*b2	
8				
9	-12	-2	-48	
10	'a2*b1	'b2*b1	'c2*b1	
11				
12	-20		-60	
13	'a8-a5		'c8-c5	
14				
15	3			
16	'c11/a11			
17				
18	24		12	
19	'a1*a14		'c1	
20				

EXERCISE TO SHOW
THE SOLUTION OF
SIMULTANEOUS EQUATIONS
BY CELL FORMULAS IN A
SPREADSHEET





PROJECT CONTAINS .

- (1) INTRODUCTION AND AIMS OF THE PROJECT.
- (2) THE SIMULTANEOUS EQUATION.
- (3) THE BASIC PROGRAM.
- (4) PROS AND CONS OF THE SPREADSHEET AND BASIC PROGRAM.
- (5) BIBLIOGRAPHY AND THANKS!

INTRODUCTION AND AIMS

OF THE PROJECT.

The purpose of this project was to solve a pair of Simultaneous Equations using the general formular and the elimination method, and then to transfer this knowledge onto the computer and use the computer to solve ANY Simultaneous Equation using a Basic Program and then progress and use a Spreadsheet.

This project had a lot of scope and a few limitations as well.

Firstly you had to borrow a maths book and read up all about how to solve them. Then you had to adapt this to suit a Basic Program. There was a limit, on the writing of a Basic Program, because if you didn't know a lot about programme making or the Basic language, then you could have quite a problem. This wasn't a problem for me because I had done some programming before .

However I had never used a Spreadsheet before and this was a problem. However with a bit of time and patience, that to was solved, and the project continued.....!

I set about this project by first learning (or should I say refreshing my memory) about Simultaneous Equations, the general formular and the Elimination method.

I have written how to solve a pair of Simultaneous Equations on the next page, after which I shall continue with the main aims of this, my second G.C.S.E Computer Project.

THE

SIMULTANEOUS EQUATION.

To solve a pair of Simultaneous Equations, you need a general formular:

The general formular is:

$$ax+by=c$$

$$dx+ey=f$$

a,b,c,d,e,f are all constants.

x and y are the variables.

The method I used to solve a pair of Simultaneous Equations was the Elimination method. The method behind this method is best explained by showing how to solve two equations by various examples.

eg 1. $2x+y=1$ equation 1.
 $3x+y=1$ equation 2.

Firstly you look at the y values and see if they are balanced. In the above examples they are equal. Then you just go straight ahead and take equation 1 away from equation 2 to find the x values.

$$2x+y=1$$

$$3x+y=1$$

$$x=0$$

If you then want to carry on and find the y values you take your answer, your x value and say;

$$2*0=0$$

You then need to add 0 to something (y) to find the answer 1. Therefore the y value in the equations is 1.

So the answer for this equation is;

$$x=0 \text{ and } y=1.$$

If however the y values are uneven, then before progressing to solve the equations you need to balance the y values.

eg 2. $2x+y=1$ equation 1.
 $2x+2y=1$ equation 2.

To balance the y values in equation 1 you times everything in the 1st equation by 2y

$$4x+2y=2 \quad \text{equation 3 (a new equation made by using both of the first equations.)}$$

Then you find the y value in equation 2 by timesing everything in the 2nd equation by y.

$$2x+2y=1 \quad \text{equation 4 (another new equation made by using both of the original equations.)}$$

Then when you have balanced the y values in both equations you continue as before to find the x and y values.

$$2x=1$$

$$x=.5$$

$$y=0$$

And there you have your answer; $x=.5$ and $y=0$.

But now we must progress and transfer this knowledge to a Spreadsheet and a Basic Program. But of course we must first find out something about these two new computer calculators.

THE BASIC PROGRAM .

The Basic Program.

```

10 REM PROGRAM TO SOLVE A PAIR OF SIMULTANEOUS EQUATIONS.
20 REM Ax+B=C
30 INPUT A1,B1,C1
40 INPUT A2,B2,C2
50 IF B1=B2 THEN GOTO 150
60 A3=A1*B2 : B3=B1*B2 : C3=C1*B2
70 A4=A2*B1 : B4=B2*B1 : C4=C2*B1
80 A5=A3-A4
90 C5=C3-C4
100  x=(C3-C4)/(A3-A4)
110  y=(C1-A1*x)/B1
120 PRINT "x= "x
130 PRINT "y= "y
140 END
150A3=(A1-A2)
160 C3=(C1-C2)
170  x=(C1-C2)/(A1-A2)
180 GOTO 110
190 END

```

Above is a program to solve a pair of Simultaneous Equations. There are many other ways to write a program which will solve a pair of Simultaneous Equations, BECAUSE THE BASIC LANGUAGE IS VERY LARGE AND SO YOU CAN USE VARIOUS OTHER METHODS.

This program took me quite a long time to write although I had used the language before. I tried various programs out and at last I made one out which worked. I had quite a lot of help, however, from my maths teacher and also my computer teacher.

The program doesn't set out the answers to the equations very clearly, but it is quite able to solve a pair of Simultaneous Equations. You could store this program on a Disc and keep it for use in the future when you next come to solving this type of equation.

I think the other drawbacks to this sort of programming, apart from the language side, is if you didn't keep the program but decided some time latter to use this sort of program, then it takes quite a long time to write it in.

However, for this type of programming you just need to type in "RUN" and the program will run again. But, with the Spreadsheet you need to change all the values on the sheet at the top. This can take time, and for the beginner it can be confusing how to input numbers, values, and formulas into the Spreadsheet.

The first two lines have REM in them, and this means that although the computer knows there there, the computer would never print them on the screen. It is a good place to put things you want to remember but which will not be printed on the screen unless you use the list command.

The next two lines are asking you to input the numbers you want worked out.

Line 50 is saying that if your B values are equal then you go to line 150, because there is no need for that equation to go through the middle of the program.

Line 60 and 70 are balancing the two B values.

Line 80 and 90 are subtracting the two new equations to get the x and y values.

(Line 100 and 110 are just the workings out of the last lines.

120 and 130 are just presenting the x and y values in some sort of decent form.

140 is ending that section .

150A3=A1-A2
160 C3=C1-C2
170 x=(C1-C2)/(A1-A2)
180 GOTO 110
190 END

THE

SPREADSHEET.

WHAT IS A SPREADSHEET?

The Spreadsheet is one of those amazingly useful ideas which is so simple in principle that we all wish we had thought of it first.

Imagine a huge chart composed entirely of rectangular pigeon-holes - in Viewsheet (the BBC computers Spreadsheet service) there are as many as 255 by 255.

These pigeon-holes (we call them "slots") may be filled with any of the following:

- A number.
- A formula (for example, to multiply the value in another slot by 55).
- A "label" (for example: TOTAL).

Any slot may be linked with any other slot, so that slots may interact with each other across the length and breadth of the sheet.

Once a sheet is set up, any new amounts entered in it can automatically be related to what is recorded already. Calculations that would be very repetitive if carried out by hand or other conventional means, are achieved at no greater effort than that of entering the data on which they are based.

On the next page is an illustration of a Spreadsheet and what each bit means. Then, below that are the ideas of how to enter the values etc, that you may wish to use. Then we will go on and use a Spreadsheet expressly for the purpose of solving Simultaneous Equations.

A SPREADSHEET.

SLOT A1

CONTENTS = *BLANK*

	A.....	B.....	C.....	D.....
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				

Above is a copy of a Spreadsheet. If you move the cursor across the screen using the function keys at the side of the computer, then the letters at the top of the page will change, and become E.....F.....G.....H. Only four letters will fit on the screen at a time.

If you move the cursor downwards, again using the function keys, then the numbers will change and nineteen following numbers will come onto the screen.

Below is a copy of the Spreadsheets I made on the computer to solve a pair of Simultaneous Equations.

** Econet ** Station 3 **				** Econet ** Station 3 **					
	A.....	B.....	C.....	D.....		A.....	B.....	C.....	D.....
.....1	2	1	1		.....1	5	3	9	
.....2	2	2	1		.....2	7	7	10	
.....3					.....3				
.....4	4	2	2		.....4	15	9	27	
.....5	2	2	1		.....5	21	9	30	
.....6					.....6				
.....7	-2		-1		.....7	5		3	
.....8	2X=		1		.....8	2X=		1	
.....9	X=		0.5		.....9	X=		0.5	
.....10					.....10				
.....11	Y=		0		.....11	Y=		2.16667	
.....12					.....12				
.....13					.....13				
.....14					.....14				
.....15					.....15				
.....16					.....16				
.....17					.....17				
.....18					.....18				
.....19					.....19				


```

** Econet ** Station 3 **
.....A.....B.....C.....D
.....1      E      T      9
.....2      7      3      10
.....3
.....4      0      0      27
.....5      0      0      0
.....6
.....7      0              -27
.....8      2X=      ?Error
.....9      X=      ?Error
.....10
.....11     Y=      ?Error
.....12
.....13
.....14
.....15
.....16
.....17
.....18
.....19

```

```

** Econet ** Station 3 **
.....A.....B.....C.....D
.....1      2      1      1
.....2      3      1      1
.....3
.....4      2      1      1
.....5      3      1      1
.....6
.....7      1              0
.....8      2X=      0
.....9      X=      0
.....10
.....11     Y=      1
.....12
.....13
.....14
.....15
.....16
.....17
.....18
.....19

```

I've deliberately put in a copy of a Spreadsheet with an "Error?" statement in it, to show what a Spreadsheet looks like with this such command in it. The Spreadsheet has got this command in it, not because of the two letters in instead of numbers, but because I only programmed this Spreadsheet to find what 2x was by multiplying x by 2. In this case this cannot be done because we haven't got an x to multiply 2 with, therefore the computer shows up the "Error?" statement.

NB. On the BBC Computer network, to get a Spreadsheet printed out you:

- (1) Pressed "ESCARE".
- (2) Then you type in
*FX5,4
- (3) Then you pressed the "RETURN" key.
- (4) Then you typed in
*FX6,0
- (5) Then finally you typed in the "PRINT" command and away you'd go!

On the next page is another typed Spreadsheet, this time showing exactly what commands I put into my Spreadsheet To get my solved Simultaneous Equations.

SLOT A1

CONTENTS = *A1*

	A.....	B.....	C.....	D.....
1	A1	B1	C1	
2	A2	B2	C2	
3				
4	A1*B2	B1*B2	C1*B2	
5	A2*B1	B2*B1	C2*B1	
6				
7	A5-A4		C5-C4	
8	2x=		((C4-C5)/(A4-A5))*2	
9	x=		(C4-C5)/(A4-A5)	
10				
11	y=		(C1-A1*C9)/B1	
12				
13				
14				
15				
16				
17				
18				
19				

There are, of course, other ways to solve these Equations. BUT YOU MUST ALWAYS REMEMBER AND USE THE GENERAL RULE:-

$$\frac{ax+b=c}{\quad}$$

PROS AND CONS OF

THE SPREADSHEET AND BASIC

PROGRAM.

The Cons Of The Spreadsheet.

- (1) You have to have a Disc-Drive and of course a Disc program. This might mean additional expense to a user.
- (2) For the first time user entering the values etc. and taking out any wrongly put in values could be difficult. This is because, or at least on Viewsheet, to enter values etc. you have to make sure that the cursor is in the right place, then write your value in and then press "RETURN" to get the value onto the sheet. If your cursor hasn't been moved to the right spot, by using the function keys, then your value could go into a spot that you didn't want it to go into, so causing more confusion. This is also similar for the removal of values which have been wrongly entered.

The Pros Of The Spreadsheet.

- (1) Once you have placed the right formulas in the right places then all you have to do to work out another sum of the same sort then all you do is to change your variable values at the top the screen and the computer will work out the answer to your sum using the formulas still in the Spreadsheet slots.
- (2) It is quicker than the Basic Program because as you enter your different values, the Spreadsheet is already working out the answer using the new variables.
- (3) To print out while using the Spreadsheet is easier than printing out while using a Basic Program.
- (4) The Spreadsheet is clearer and is neater, lay-out wise. Therefore you can read your answers easier and quicker and, therefore, more efficiently.

The Cons Of The Basic Program.

- (1) You have to have some knowledge of the Basic language. If you don't have this knowledge, then you have to be prepared to look up any relevant information about programming and the language which you are using.
- (2) You also have to be prepared to have to write your program out quite a few times as it is only for the experienced to get a program right first time. Dry-runs, flow-charts and objective lists are all good ideas to use when trying to write a program.
- (3) As well as this time consuming element, your program might not always carry out every task which you had hoped it might. Therefore, it is back to the drawing board, as it were!
- (4) Unless specially written into the program, the results to your program might not be very well set out.

The Pros Of The Basic Program.

- (1) Once of course, and presuming that you have of course got a computer, you do not need to buy a special program, like that of the Spreadsheet. This is very convenient, of course.
- (2) All you have to do when you want to enter some new values is to press or type in the "RUN" command and the program is quicker to be re-run than the Spreadsheet, because you only have to type in the one command, and not have to alter a whole couple of lines of figures, as on the Spreadsheet.

MY OPINION AND PREFERENCE OF THE TWO.

For mathematical problems there is no doubt that I prefer the Spreadsheet, for both its clearness of display, its ability to solve problems quickly and clearly, and the way the formulae in the slot where the cursor is is shown on the screen.

However, having said that I also enjoy using the Basic Program. I find it very intriguing the way you have to get exactly the order and combination of words before the program will work properly. I think therefore that the Basic language and program might be more beneficial to a person designing Graphics, because while working on one program to illustrate one thing, in an error he might come across a new and better idea to illustrate the same thing.

However as each persons point of view I shall leave you to think over your own thoughts on this matter, and hope that the work contained in this project might be of some assistance.

BIBLIOGRAPHY AND

THANKS !

BOOKS USED.

Page 17

Work Out Computer Studies 'O' Level And G.C.S.E

by

Maomillan Master Series (G.Taylor)

AcornSoft Viewsheet

by

Acorn

Also

Various maths text books.

PEOPLE WHO HELPED ME THROUGHOUT THE PROJECT.

My Computer Teacher

And

My Maths Teacher

And

Emma Ginns (School friend and class-mate.)

APPENDIX G

DATA REPRESENTATION IN COMPUTERS

The availability of high powered low cost computers will alter the school curriculum. Computers will introduce new ways of doing traditional school tasks and also introduce new tasks for the school curriculum to cope with. A whole new world has opened up with the new discipline in computer studies. It adds variety to the school curriculum and relates theory to practice in a variety of ways.

Computers can offer mathematics a rich source of topics. Computers use number systems other than base 10 extensively. The various number systems employed and the method of storing and representing data can be a source of mathematical activities in an integrated computer studies package.

Binary System

Digital computers are designed to carry one of two possible signals, either a high or low voltage, which can be adequately represented by the digits 1 and 0. Memory exists as the state of a device known as a 'flip-flop'. The flip-flop can be in one of two states, flipped or flopped, depending on the last voltage received, high or low. Programs are at one level nothing more than a sequence of signals made up of high and low voltages, or 1's and 0's. A string of 1's and 0's called BITS (Binary DigiTS) can be very confusing so they are treated in groups.

Four bits make one NIBBLE and two nibbles make a BYTE.

4 BITS = 1 NIBBLE

2 NIBBLES = 1 BYTE

8 BITS = 1 BYTE

Byte

Most personal computers are designed with the smallest addressable unit of memory capable of storing eight bits(= 1 byte). A byte can represent quite different things, depending on what the computer expects at a particular location. A byte can be used to represent a number, a character, a logical value or to name a location in memory. It can also represent operations.

Numbers

Computers do arithmetic in the binary system. Numbers entered are translated into binary form before being processed. To make life a little easier other systems are employed by different types of computers. Other systems include base 8 (octal system) and base 16 (hexadecimal system). Numbers written in octal form are prefixed with &, and hexadecimal numbers are prefixed with H e.g. the decimal number 17 is written as &21 in octal system and H11 in hexadecimal. The hexadecimal system uses the alphabet letters A,B,C,D,E and F to represent values 10,11,12,13,14 and 15. The digits available are 1,2,3,4,5,6,7,8,9,A,B,C,D,E,F.

Characters

Letters, punctuation marks and other symbols like those representing numbers are also represented by bytes. There is no natural meaning attached to each digit in the binary representations of these characters.

An industry-wide standard code for characters has been agreed and developed by the American National Standards Institute (ANSI). The code, the American Standard Code for Information Interchange (ASCII), uses seven digits of a byte, and the eighth is used as a check digit. TABLE G.1 (see page G.5) shows the characters and their ASCII codes given in Hexadecimal and Decimal form.

Locations in Memory

Memory is rated in bytes which hold a single character code. Since computers have large memories, the unit commonly referred to is the Kilobyte which is

exactly 1024 bytes approximated to 1000 bytes. Memory is divided into cells each holding a piece of information. Each cell is identified by a number. In the BBC (British Broadcasting Corporation) microcomputer, the operating system resides in locations starting at hexadecimal FF00 up to hexadecimal FFFF and the basic language interpreter resides in locations hexadecimal 0 to hexadecimal 6F.

The Atari 800XL has memory locations labelled from number 1 to 65536 (=FFFF in hex). The Atari 800XL is marketed as a 64K machine, i.e. $64 \times 1024 = 65536$ bytes.

Operations

The 6502 Processor, employed by Apple II, Atari 800 and the Commodore Pet microcomputers, has an operation binary code of '1000 1101'. When the 6502 processor encounters the code '1000 1101' it takes a value from a special memory location called the 'accumulator' and copies it into another designated memory location. Numerical codes like '1000 1101' make up the machine language of a computer. The operation code '1000 1101' can be simplified by converting it into hexadecimal form which will be 8D.

Computer Instruction Format

Memory, data and operations are converted from decimal to hexadecimal in an attempt to make reading and understanding easier. Consider the instruction:

'Place a copy of the contents of memory location 35CF (hex) into the accumulator'

In hex this is : AD CF35

in binary : 10101101 1100111100110101

Machine code programming is written in hex, which can be simplified further by using an Assembler, where the above instructions will read LDA \$35CF.

The two parts of a typical computer instruction are:

- (i) The Operation Code which informs the machine what to do.
- (ii) The Data Code which informs the machine where the data to be operated on is to be found. This is normally given as the memory location of the data.

The two instructions AD CF35 and LDA \$35CF discussed above are equivalent.

Mathematical Activities

Some mathematical activities can be derived from the codes used in the storage and representation of data in computer memory. The translation of numbers into different number systems can provide exercises in basic number operations. The use of number, character, location and operation codes can be useful in logic exercises. Problem solving of coded messages is an entertaining mathematical pastime. The use of computer related mathematical activities will to a certain degree introduce computers to students who may not get a chance to experience exposure to computer hardware. For those students who will be more involved with computers it will provide some background knowledge of computers while learning mathematics. Suggestions for computer mathematics without computer hardware are dealt with in more detail in Appendix H, Computer Mathematics Without Access To Computer Hardware.

TABLE G.1

DECIMAL	BINARY	OCTAL	HEXADECIMAL	CHR
32	100000	40	20	
33	100001	41	21	!
34	100010	42	22	"
35	100011	43	23	#
36	100100	44	24	\$
37	100101	45	25	%
38	100110	46	26	&
39	100111	47	27	'
40	101000	50	28	(
41	101001	51	29)
42	101010	52	2A	*
43	101011	53	2B	+
44	101100	54	2C	,
45	101101	55	2D	-
46	101110	56	2E	.
47	101111	57	2F	/
48	110000	60	30	0
49	110001	61	31	1
50	110010	62	32	2
51	110011	63	33	3
52	110100	64	34	4
53	110101	65	35	5
54	110110	66	36	6
55	110111	67	37	7
56	111000	70	38	8
57	111001	71	39	9
58	111010	72	3A	:
59	111011	73	3B	;
60	111100	74	3C	<
61	111101	75	3D	=
62	111110	76	3E	>
63	111111	77	3F	?
64	1000000	100	40	@
65	1000001	101	41	A
66	1000010	102	42	B
67	1000011	103	43	C
68	1000100	104	44	D
69	1000101	105	45	E
70	1000110	106	46	F
71	1000111	107	47	G
72	1001000	110	48	H
73	1001001	111	49	I
74	1001010	112	4A	J
75	1001011	113	4B	K
76	1001100	114	4C	L
77	1001101	115	4D	M
78	1001110	116	4E	N
79	1001111	117	4F	O
80	1010000	120	50	P
81	1010001	121	51	Q
82	1010010	122	52	R
83	1010011	123	53	S
84	1010100	124	54	T
85	1010101	125	55	U
86	1010110	126	56	V
87	1010111	127	57	W
88	1011000	130	58	X
89	1011001	131	59	Y

TABLE G.1 (Continued)

DECIMAL	BINARY	OCTAL	HEXADECIMAL	CHR
90	1011010	132	5A	Z
91	1011011	133	5B	[
92	1011100	134	5C	\
93	1011101	135	5D]
94	1011110	136	5E	^
95	1011111	137	5F	~
96	1100000	140	60	·
97	1100001	141	61	¸
98	1100010	142	62	a
99	1100011	143	63	b
100	1100100	144	64	c
101	1100101	145	65	d
102	1100110	146	66	e
103	1100111	147	67	f
104	1101000	150	68	g
105	1101001	151	69	h
106	1101010	152	6A	i
107	1101011	153	6B	j
108	1101100	154	6C	k
109	1101101	155	6D	l
110	1101110	156	6E	m
111	1101111	157	6F	n
112	1110000	160	70	o
113	1110001	161	71	p
114	1110010	162	72	q
115	1110011	163	73	r
116	1110100	164	74	s
117	1110101	165	75	t
118	1110110	166	76	u
119	1110111	167	77	v
120	1111000	170	78	w
121	1111001	171	79	x
122	1111010	172	7A	y
123	1111011	173	7B	z
124	1111100	174	7C	{
125	1111101	175	7D	|
126	1111110	176	7E	}
127	1111111	177	7F	~

APPENDIX H

COMPUTER MATHEMATICS WITHOUT ACCESS TO COMPUTER HARDWARE

Yoong-Ming and Peng-Yee [8] refer to the teaching of computational mathematics without access to computer facilities to emphasise the importance of numerical answers to practical problems. They defined computational mathematics as:

'the computational aspects of those branches of mathematics such as statistics, mathematical programming, combinatorics and in particular numerical analysis.'

This appendix deals with computer mathematics without access to computer hardware. Computer mathematics in this instance are those mathematics topics which have a practical application in the workings of computers. In teaching mathematics, reference can be made to its application in computer hardware, thus preparing students who will go on to study computing at a higher level. Some of the topics may already be taught in schools in Fiji but it is proposed here that a definite reference be made to their application to computers. For those students who do not intend to study computing at a higher level they will at least be made aware of the technology during computer mathematics lesson(s).

The appendix will suggest starting points for mathematics teachers to develop without the need to access computer hardware.

Number Systems

Binary, Octal and Hexadecimal systems should be given emphasis in the study of number systems because of their application in computer technology. Relevant exercises could include:

- (i) Sorting a string of 1's and 0's into groups of 4's or 8's
e.g Given 1100101100010101

(1) sort the string into groups of 4 digits

solution : 1100 1011 0001 0101

(2) sort the string into groups of 8 digits

solution : 11001011 00010101

(ii) Evaluation of binary digits and identification of the 'Most Significant Bit' (MSB), and the 'Least Significant Bit' (LSB) in a string of binary digits

MSB							LSB		
b7	b6	b5	b4	b3	b2	b1	b0	bits	
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	power of 2	
128	64	32	16	8	4	2	1	decimal value	

(iii) Investigation of the octal and hexadecimal system

decimal	binary	octal	hexadecimal
0	0	0	\$0
1	1	1	\$1
2	10	2	\$2
3	11	3	\$3
4	100	4	\$4
5	101	5	\$5
6	110	6	\$6
7	111	7	\$7
8	1000	10	\$8
9	1001	11	\$9
10	1010	12	\$A
11	1011	13	\$B
12	1100	14	\$C
13	1101	15	\$D

14	1110	16	\$E
15	1111	17	\$F

(iv) Conversion of a number from binary to octal

e.g. convert 1100 1010 1001 1111 1011 into Octal

solution: separate the string into groups of three bits

11 001 010 100 111 111 011

give decimal values (0-7) to each group:

3 1 2 4 7 7 3
11 001 010 100 111 111 011

answer 3124773 octal = 1100 1010 1001 1111 1011

(v) Conversion of binary to hexadecimal

e.g. convert 1000100110100011 into hexadecimal

solution: separate string into groups of four bits

1000 1001 1010 0011

look up in the table the hex values of the groups of four bits

1000 1001 1010 0011
\$8 \$9 \$A \$3

answer: 1000 1001 1010 0011 = \$89A3

(vi) What is the largest number that can be represented in four bits ?

solution 1111 = 15.

Investigate five, six, seven, eight, and n bits.

Alphanumerics - the data representation of characters and numerals.

(i) The difference between say, 0101 which represents the number 5 and 0011 0101 which stand for the notation '5'. The value 0011 0101 is the ASCII code for '5' as given in Table G.1 in Appendix G. All alphabets and numerals have an ASCII code.

The name Fiji can be coded in four different ways:

	F	i	j	i	
1.	70	105	106	105	decimal
2.	106	151	152	151	octal
3.	\$46	\$69	\$6A	\$69	hex
4.	1000110	1101001	1101010	1101001	binary

- (ii) The codes for the alphabets have seven bits, which is increased to eight bits by adding a zero at the front. The additional zero at the front does not make any difference to the alphabet the code represents. With eight bits, the alphabet is then represented by two groups of four bits:

F -	0100	0110	i -	0110	1001	j -	0110	1010
	\$4	\$6		\$6	\$9		\$6	\$A
	\$46			\$69			\$6A	

The hexadecimal is used to make reading easier. The computer actually reads the string of binary digits (bits), and treats each eight bits (=1 byte) as representing a character. The eight bit is broken into groups of four bits for ease of reading. When the computer encounters the byte 01000111 it prints the letter F.

- (iii) Sometimes the characters are printed in reverse on the screen (reverse video) i.e. white letter on a black background instead of black letter on white background. To tell the computer to print in reverse video the leading zero bit is changed to a 1.

To print Fiji in reverse video the codes for the letters will be:

F -	11000110	i -	11101001	j -	11101010			
	1100	0110		1110	1001		1110	1010
	\$C7			\$E9			\$EA	

Sample problem: What is printed on the screen and how is it printed when the code is \$C7 ?

Solution : \$C7 = 1100 0111 eight bits
 = 100 0111 seven bits
 = F (from Table G.1)

 printed in reverse because leading bit (b8) is 1.

Other topics are:

- (i) unsigned binary number representation - 8 bits (1 byte)
- (ii) signed binary number representation - 7 bits
- (iii) binary addition and subtraction
- (iv) logic operations
- (v) multiplication and division (shift operations).

The number of mathematical activities which can be derived from computer studies is enormous, and they can be tackled up to a certain level in schools without the access to hardware.

The exercises which can be developed by the starters given here should involve the class in talking about computers. It affords an opportunity to do some groundwork on computers and at the same time practise problem solving.

APPENDIX I

A PREPARATORY COURSE OUTLINE IN THE USE OF THE ELECTRONIC SPREADSHEET FOR MATHEMATICS LEARNING

This is a course outline to prepare students in Fiji in the use of the Electronic Spreadsheet for mathematics learning. It is assumed that students have no previous knowledge of the spreadsheet and the outline is the result of the author's experience in a secondary school in Leicestershire investigating the use of the spreadsheet. With previous experience in Fiji, the author recognises the different standards that exist between students in Leicestershire and students in Fiji. The lack of technical experience of the students in Fiji needs to be reflected in the level of materials in a first course of this kind. The outline is designed around the Atari ST microcomputer and the spreadsheet SwiftCalc.

Topics

1 Introduction

A physical description of the hardware and identification of the various functions is a necessity for a technical introduction. This will include things like connecting up the system, switching on of the display screen and keyboard, and what to expect if all is right. Safety precaution against electric shock and damage to equipment need to be emphasised.

2 Operating the Atari ST:

- loading a disk into the disk drive
- manipulating the mouse
- reading the desktop display of the screen
- closing and opening windows and files

loading programs.

3 Reading SwiftCalc Spreadsheet

Load the spreadsheet and identify the items on display.

4 Identification of Cells

This can be done quite satisfactorily with squared paper first before using the machine. Note the use of alphabets to label columns and numbers for rows. Cell locations are labelled with the column(alphabet) first then the row number e.g. B3, W12 etc.

5 Data entry

Examples from tables, shopping lists, class lists, etc can be entered into the spreadsheet. Names can be shortened to fit into the cell. Emphasise the difference between Labels and Numerals.

6 Formulating Formulas

Using cell locations as variables when making formulas is an important concept in working with the spreadsheet. The spreadsheet makes the concept of variable easier to grasp by displaying the value of the variable in its location. For example if $A3=4$, $A5=6$ and $A7=A3+A5$ the spreadsheet will display the values 4, 6 and 10 in their respective cell locations. When asked what is the value of $A3+A5$ the student can look in location A7, or look in locations A3 and A5 and do some mental arithmetic. The visual image of the value of variables is an advantage of the spreadsheet.

The above topics, which were found necessary during the work done at OLC school, should provide enough background to enable some beneficial use of the spreadsheet. Other advanced topics include Copying and Graphics. Other mathematical functions such as exponentials, square roots, minimum values are also available.

APPENDIX J

MICROBASED TEACHING METHODS PROJECT

The project was one of many responses to the many problems that resulted from the introduction of computers in schools in Fiji in 1984.

The basic idea behind the project was to explore how to begin to use the new technology that, as far as teachers were concerned, had been thrust upon them without any preparation or warning.

Teachers had shown an interest and acceptance of the new technology but there was a total lack of basic knowledge of the technology amongst teachers in general.

Based at USP and organised by the author, who realised the lack of any official coordinating body, a proposal was put to the United States Agency for International Development, which kindly agreed to fund the project.

Aims of Project

The aims of the project were twofold.

- (i) First was to raise the level of computer awareness of teachers in the 'pilot' group to help their respective schools to assess their requirements in computer education.
- (ii) Secondly, once a sufficient level of expertise had been reached a selection of computer based packages would be tested to determine their suitability for local conditions.

The results obtained may suggest modifications that could be made to existing material or could point to new packages which needed to be developed.

Project Equipment

The project purchased 4 units of microcomputer hardware each made up of:

- 1 Atari 800XL microcomputer

1 Video display unit

1 Disk Drive

A graphics printer was also purchased to supplement the 4 units.

The available hardware in Fiji at the time included Apple II's, Atari 800XL's and Commodore 64's. Atari was chosen mainly for its price and graphics capabilities. The Atari 800XL also has a video output which was compatible with the video input of the TV screen providing a sharper display of computer output.

Participating Schools

Three schools, two primary and one secondary, were involved in the project that began in late 1984 with one teacher from each of the participating schools attending a familiarisation course on the hardware held at the University of the South Pacific(USP) mathematics department. This was conducted three hours a week at times suitable to all involved. The one secondary school teacher in the group had some previous experience of computers, the two primary school teachers had no computing skills at all.

The Project

The familiarisation course was held during school term time and there were problems regarding the release of teachers from schools to come to USP to attend classes.

Computing was seen as non-examinable and headteachers were not keen to release teachers for activities that had no direct connection with the syllabus as laid down by the Ministry of Education.

The teachers involved were able to persuade the heads of their schools to let them go during their free periods. The project was initially intended to involve four schools but the problem of time off for teachers, discussed during preliminary talks, forced one of the schools to drop out.

The three schools in the project are all located near to USP and travelling did

not present any problem.

The familiarisation course topics included:

- (i) Hardware requirements for a basic system and their functions-
input/output units, central processing unit
- (ii) Connecting up the various components of the system and switching on
- (iii) System commands: load, run, list etc.
- (iv) Editing facilities
- (v) Disk Operating System
- (vi) Simple trouble shooting.

In December, when schools broke up for the long Christmas holidays, the teachers had gained enough knowledge of computers to enable them to operate the system.

The next activity was, given our limited knowledge, to consider the best way to use the microcomputer in class.

The two primary school teachers chose to use Logo in their first attempt in using the microcomputer in class.

The secondary school teacher opted for a tutorial chemistry program written in Basic for use on the BBC microcomputer.

The secondary teacher who was able to write programs in Basic decided to do the conversion of the program from BBC Basic to Atari Basic.

The chemistry program for the secondary school requires the user/ student to identify a chemical, after the program outputs the chemical reaction to a test input by the user/student. The student can input any number of tests before attempting to identify the chemical.

The primary school teachers decided to use Logo worksheet and found them of great value in their teaching and for their children.

The worksheets aim to teach pupils Turtle Graphics commands and in the process involve them in mathematical activities. The activities included verbalising, writing, sketching and thinking mathematical concepts.

The choice of using Logo with primary schools mathematics was an appropriate one due to the visual representation offered by the turtle. Primary school pupils could see something happening as a result of their inputs. They were not asked only to exercise their mental powers to appreciate the result of their inputs, their sense of vision also contributed to the motivation. This is important to encourage sustained efforts by the pupils.

The worksheets required pupils to 'think' mathematics, and allow them to express mathematics with words and diagrams.

In the worksheets they are asked to type in turtle commands and observe the results on the screen. The pupils then copy the diagram from screens on to their books.

The Logo language enables pupils to work in direct mode and immediately see the results of their inputs.

Learning by trial and error is intensified and problem solving exercises increase.

The Logo language encouraged investigations and discoveries and pupils' enjoyment was evident.

Conclusion

The first objective was achieved to a certain degree. The three teachers involved in the project were, at the end of 1985, in a better position than to assess their school's computing needs.

The second objective of testing computer packages was not successful in that there were no software packages to test. Instead the objective of producing computer material for use in the classroom was achieved.

As there were no packages available the project looked at the possibility of writing worksheets for use in schools. This was quite successful and more work in this area is anticipated.

The project was also successful in that it highlighted some problems that schools encounter during the early period of introducing computers in the curriculum. There is always opposition to new ideas but opposition encountered by the project was due to lack of official recognition. Even though government was in support of computers in schools it was not going far enough to allow time off for teachers to train in the new technology. The schools had to squeeze the use of computers in at the end of some extra curricula activities or during the lunch hour. It is hoped that government will remedy this state of affairs and make definite legislation on the role of computers in the classroom.

