COMPUTER ENHANCED LEARNING FOR MATHEMATICS IN MALAWI

by

Matthews A. Ngwale

A Master's thesis

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Supervisor: Professor A.C. Bajpai
Director of CAMET and Head of
Department of Engineering Mathematics
Loughborough University of Technology

ABSTRACT

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by

M.A.NGWALE

C.A.M.E.T.

(Centre for Advancement of Mathematical Education in Technology)

Loughborough University of Technology

Mathematics is a dreaded subject all over the world more so in third world countries. Results in Malawian examination papers clearly show a higher failure rate in mathematics than other subjects. New teaching methods are needed to revolutionalise pupils' perspective of mathematical concepts and help them see mathematics as a doing subject independently or as a service discipline. The new teaching methods must be seen to make mathematical experience accessible to pupils which will in turn promote pupils' enjoyment of mathematics.

Lack of student active participation in present mathematics teaching methods and abstraction in some topics puts off weaker or slow learning students and develops in such students a sense of defeat and demotivation towards the subject. In Britain and other developed countries, syllabuses and teaching methods are

constantly under review. In some cases new syllabuses are adopted without prior training for teachers causing additional problems, e.g. the new GCSE syllabus in U.K. which is new in methodology, content and assessment methods.

This research, carried out for Malawi, particularly for the Polytechnic, looks at how this massive percentage of under achievement can be reduced. It also exposes the instructional ineffectiveness and inefficiency at learning tasks. The importance of in-service training for secondary and primary school mathematics teachers is also highlighted.

Computers can be a key to realising educational goals such as promoting pupil-directed inquiry, enhancing the development of scientific and mathematical concepts and addressing more efficiently the learning needs of individual children in mixed ability and overcrowded classrooms. An assessment of Computer Enhanced Learning for the improvement and reinforcement of present teaching methods is therefore made.

Finally, a set of recommendations for the improvement of mathematics education in Malawi is suggested to the Ministry of Education and Culture through the Polytechnic for implementation.

Key Words :motivational incentives, in-service training, computer enhanced learning, mixed ability, mathematical aptitude, slow learning, mathematical concepts.

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I also thank members of staff at Loughborough University of Technology's Department of Engineering Mathematics. I specifically would like to mention Mr P.K. Armstrong, Mr G. Bell, Mr. J.A. Fairley, Dr. D.N. Hunt, Mr. I. Downend and his colleagues, and the Secretary of the Department. I would like to also mention Mrs. L. Gondwe for making necessary corrections to the language.

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PREFACE

This is a thesis on Computer Enhanced Learning for Mathematics in Malawi. It utilises the experiences and projects carried out in Britain and other western countries. The theories are backed by the experimental lessons carried out at the Polytechnic (Malawi) between October and December 1986. The convictions of the author were strengthened through interaction and discussion with leading mathematical educationalists led by Professor A.C.Bajpai OBE and members of staff at Loughborough University of Technology; attendance of workshops with the Academic Staff Training and Development Programme (Loughborough University of Technology) in computer assisted learning; lectures in mathematics, statistics and computer programming; reading background literature on the subject and visiting schools with such programmes in the United Kingdom.

Chapter one covers the educational background of Malawi and also gives the historical background of the Polytechnic to which this thesis is aimed.

In chapter two, problems in mathematical education in Malawi are discussed. These cover mathematical teaching problems in the primary and secondary schools and more specifically mathematical problems at the Polytechnic's Department of Mathematics and Science of which the author is a member of staff.

Chapter three is a review of background literature on computers and their role in education. A computer enhanced lesson is briefly described based on the author's experiences as discussed in the following chapter. Some aspects of courseware production are also discussed. Some of the discussions in this chapter form a basis for the ideas developed in chapter five.

Chapter four is a report of the Computer Enhanced Learning Project at the Polytechnic in Malawi. Results are statistically analysed and a treatment of the questionnaire given to students involved in the experiment led to the author making the concluding remarks given at the end of this chapter.

A proposal for a Teachers' Centre at the Malawi Polytechnic to help in the coordination of secondary school teachers and their activities is discussed in chapter five. The contribution that this project will make to the Teachers' Centre is also pointed out adding that production of courseware locally will easily be achieved by a combination of the experience of secondary school teaching staff, computer programming staff of the Polytechnic and other interested members. The Teachers' Centre will provide an ideal atmosphere for such cooperation.

Lastly, chapter six includes conclusions, implications and necessary recommendations made to the authorities for the improvement of mathematics teaching and learning. Future research directions are briefly given at the end of this chapter.

The thesis ends with a list of references, appendices and bibliography.

CONTENTS

CHAPTER 1

BACKGROUND INFORMATION

CHAPTER 1

BACKGROUND INFORMATION

1.1 LOCATION

The Republic of Malawi is situated in Southern Africa and is bordered by Mozambique to the south, Zambia to the west and Tanzania to the north. The location of Malawi is between 10 and 17 degrees south; and between 33 and 36 degrees east(see fig.1.1)

The surface area of Malawi is 115 895 square kilometres, approximately one third of which is covered by water i.e. Lake Malawi, Lake Chilwa, Lake Malombe, Lake Chiuta and Lake Kazuni. Lake Malawi is the third largest lake in Africa and the eighth largest in the world. It is 588 Km long, 60 - 80 km wide and 474 metres above sea level. Lake Malawi is one of the major tourist attractions in Malawi. The rest of the lakes are comparatively small.

The altitude varies from 474m at Lake Malawi to 3000m at Sapitwa peak on Mount Mulanje, another tourist attraction in southern Malawi. Other interesting mountains and plateaus are Zomba (2087m), Vipya (1954m), Nyika (2606m) and Dedza.

Malawi's present population is approximately 7.08 million (Government of Malawi National Statistics, 1984) and is calculated to be increasing at rate 4.2% per annum. It is projected that the population will be approximately 10.06 million in 1995 and to reach 14 million by the year 2007. Malawi is an agricultural country i.e. its economy is highly dependent

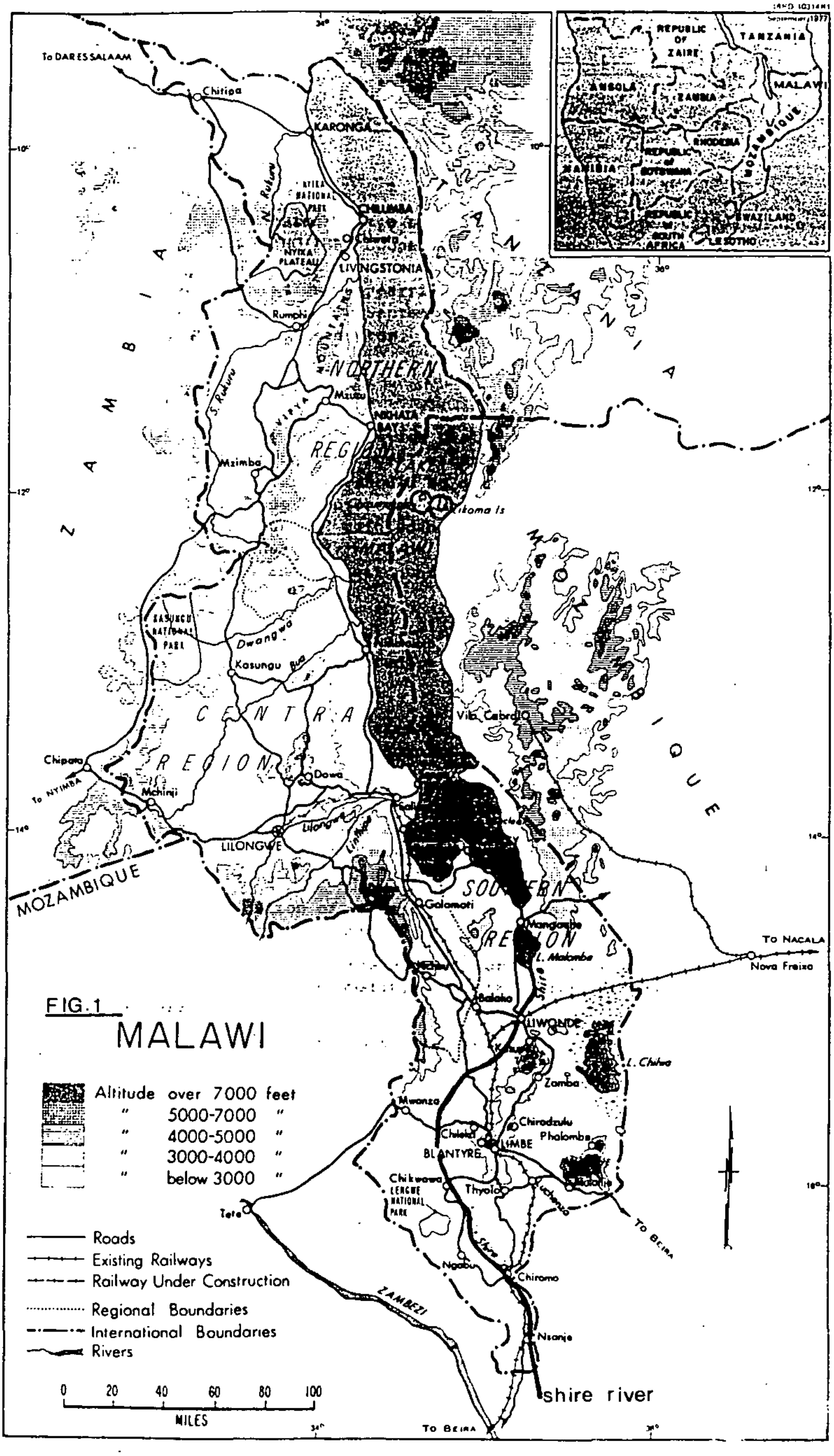


FIG. 1
MALAWI
Altitude over 7000 feet
" 5000-7000 "
" 4000-5000 "
" 3000-4000 "
" below 3000 "
Roads
Existing Railways
Railway Under Construction
Regional Boundaries
International Boundaries
Rivers
0 20 40 60 80 100
MILES
To DAR ES SALAAM
Chitipa
KARONGA
NYIKA NATIONAL PARK
NYIKA PLATEAU
LIVINGSTONIA
Rumphi
NORTHERN
REGION
Mzuzu
Mzimba
NKHATA BAY
Likoma Is
KASUNGU NATIONAL PARK
Dwangwa
Kasungu
CENTRAL
REGION
Chipata
To NYIMBA
Mchinji
Dowa
Salima
LILONGWE
Lilongwe
MOZAMBIQUE
ZAMBIA
TANZANIA
MOZAMBIQUE
Vila Cabral
Golomoti
SOUTHERN
REGION
Mangochi
L. Malombe
Balaka
LIWONDE
L. Chilwa
Zomba
Mwanza
Chiradzulu
Chileka
LIMBE
BLANTYRE
Phalombe
Chikwawa
LENGWE NATIONAL PARK
Thyolo
Mulanje
To BEIRA
Tete
ZAMBEZI
Ngabu
Chiromo
Nsanje
shire river
To BEIRA
To NACALA
Nova Freixo
REPUBLIC OF ZAIRE
TANZANIA
ANGOLA
ZAMBIA
MALAWI
RHODESIA
NAMIBIA
REPUBLIC OF BOTSWANA
MOZAMBIQUE
REPUBLIC OF SOUTH AFRICA
SWAZILAND
LESOTHO

on agriculture. This being the case, 90% of the population live in rural areas engaged in farming. Only 10% of the population live in the cities of Blantyre in the south, the biggest industrial and commercial city in Malawi; Lilongwe in the central region, the capital city of Malawi and Mzuzu in the north.

1.2 EDUCATIONAL SYSTEM AND OPPORTUNITIES IN MALAWI.

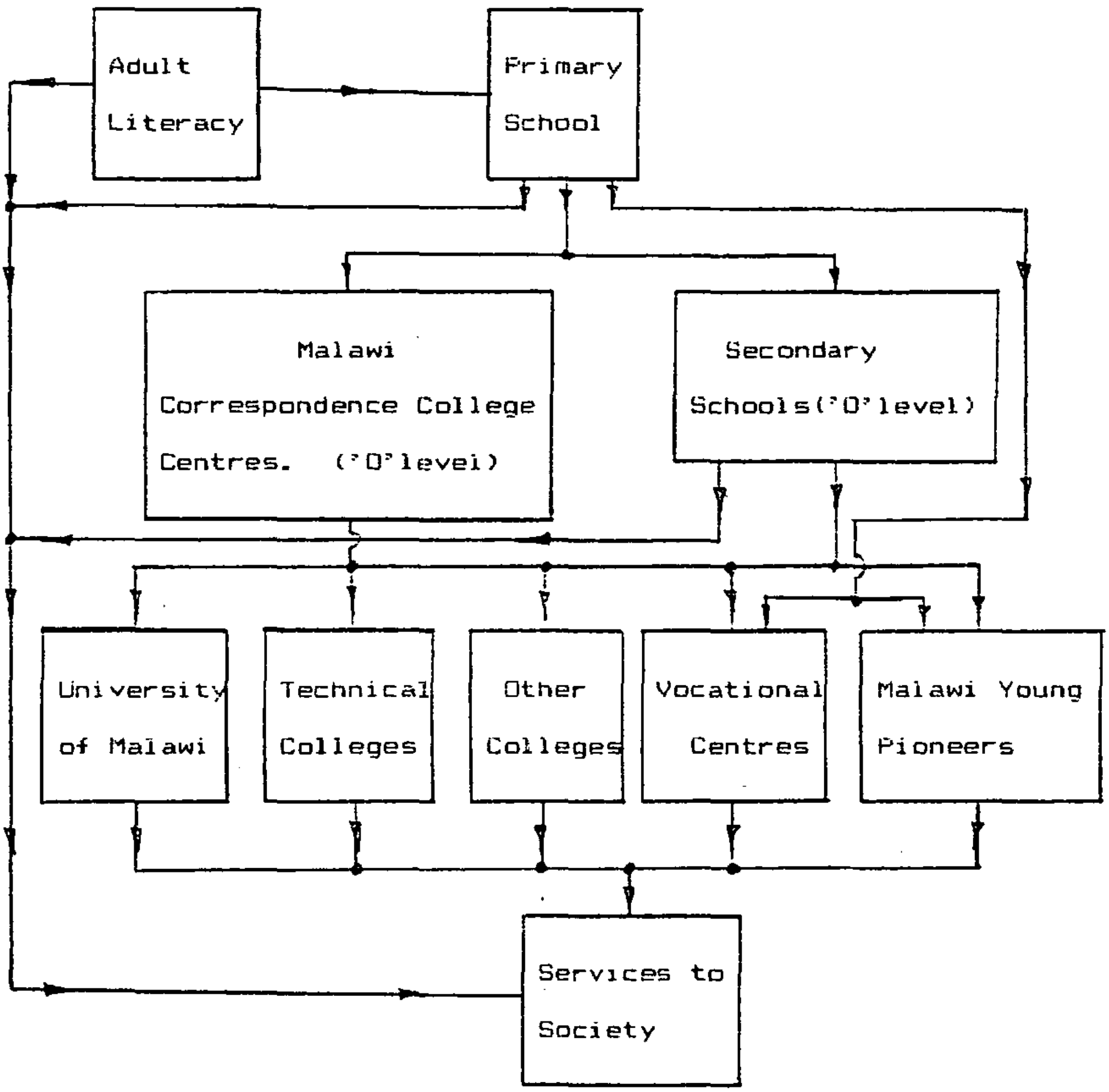


Figure 1.2

The Malawian educational system may be summarised as in the figure 1.2 above. Unlike the United Kingdom, where at primary and secondary level age is the major determinant for the level of education, Malawi's educational system has always been systematically modelled as above. Students of varying ages may be attending the same class. As more and more people appreciate the value of school and the education it provides, literacy levels are rising, and the range of different ages within the same class is reducing.

The adult literacy programme was launched by the Malawi government to combat ignorance. The basic aim was to help those elderly people who did not have the opportunity to attend school when they were young. The programme therefore helped them become better citizens by communicating and serving the society more efficiently. Some who were keen to continue with education could do so by correspondence courses for primary education.

Primary school in Malawi is for eight years. After the first five years, pupils sit a national examination. Another national examination, the Primary School leaving Certificate Examinations, comes at the end of the eight years. There are presently 2470 primary schools in Malawi whose enrolment is 900 000 pupils. Of these, 88 500 are in standard eight (the final year in primary school). The pass rate is presently put at 70% i.e. 61 900 pupils passed the standard eight exams (1985/86 academic year).

There are only 74 secondary schools in Malawi hence out of the 61 900 pupils, only 5627 of them are selected for form one in secondary school. Secondary education lasts four years. After the first two years, students write the junior certificate examinations. The total secondary school enrolment (1985/86) was 24 000. Of these, 5082 students were in form four (the final class in secondary school) ready to write their MSCE (Malawi School Certificate of Education) examinations ('O' level). 65% of them passed the 1986 exams i.e. 3315 students. Of these, only 539 students were selected to the University of Malawi. Apart from the 539 students, the university also recruited 79 mature entry students (students with diplomas in industry, who did not have a chance at their time because degree courses were not available), 23 'A' level students (with at least 3 passes) and 5 overseas students. The total intake for the university was therefore 646.

As very few people can be accommodated in the formal educational system, the competition for places is very high indeed. As can be seen from the high figure in standard eight classes, only one in eleven are selected for secondary education. Alternative channels were therefore found necessary to take care of dropouts defined later. The government therefore introduced the Malawi Correspondence College centres (M.C.C. centres) all over the country. Students in these centres do their secondary education by following programmed notes prepared by experienced teachers for the M.C.C. Part-time teachers are recruited to lecture to students in such centres. The quality and level of secondary education so obtained is comparable with that obtained in secondary schools. Up to 1986, the pass rate in the centres is generally low due to student and staff attitudes i.e. some people had a feeling that centres were for failures or rejects. Lack of qualified teachers to teach in these schools is another reason for the high failure rate. As the number of students is increasing with increasing population, the government is doing all it can to improve the situation.

Some of the dropouts at standard eight join the Malawi Young Pioneers training bases, where they learn a trade, others enter employment in industry, join the army etc. Secondary school dropouts (i.e. those not selected to university) have several alternatives. They may join technical colleges, vocational centres, Malawi Young Pioneers bases, agricultural colleges, nursing, forestry, fisheries, social workers' colleges etc.

Presently in Malawi, we do not educate for the individual but for the society i.e. the courses offered by the university and other colleges reflect the needs of the society and not necessarily the choice of students taking those courses. Hence training is application based. The courses offered may not be as extensive as in western countries but are geared for particular needs of the society.

The entry requirements for the University of Malawi is a full MSCE certificate or any 'O' level equivalent with at least five credits which should include English. Most courses require a good pass in mathematics as well. Holders of at least three 'A' level passes are admitted into the second year of a course of their choice.

Unlike many countries in the west where primary and secondary education is free, in Malawi, these presently have to be paid for. This has the effect of denying some poorer people their chance for education. If education was free however, the present facilities could not handle it. There are unfounded rumours that plans are under way to make primary education free in the near future. There is need for cautious preparation before this is done, considering seriously the resources available i.e. number of teachers, schools and extra money for maintenance. University education has always been government sponsored, until 1984 when students were for the first time asked to pay a contribution of K200 (£1 is approximately K3.74, (1987))

1.3 EDUCATIONAL OPPORTUNITIES

Some of the educational opportunities are highlighted in the earlier section. These are in terms of educational alternatives and career prospects. In this section we discuss opportunities in terms of statistics i.e. how many people have the opportunities discussed in 1.2 and how many do not. Appendix 1 shows the population figures for Malawi in 1977 by age and sex. The formal education ages can be assumed to be between the ages of 5 and 25. Primary school is for 8 years, secondary school for 4 years and university a maximum of 6 years. Allowing a school starting age of six years, one would be expected to finish their education with a first degree at the age of 24. From Appendix 1, people between the ages of 5 - 24 totalled 2 389 677. The Malawi population total was 5 547 460. This means that 43% of the population were in the formal education age. Appendix 2 shows enrolment in primary and secondary schools, technical colleges and university for the past 10 years in Malawi. It can be noticed from this table that for the 1977/78 academic year, the total number of people in primary, secondary, technical colleges and university totalled 692 947 people. This was 12% of the population. The expected percentage of people in schools and colleges for that year (1977/78) was 43% and the observed proportion was 12% which is considerably very low. What happened to the 31%? It is possible that some of the people in the 31% never went to school at all due to several other reasons e.g. fees etc. Some might have dropped out of the system due to a small number of secondary schools, university and colleges.

1.4 THE POLYTECHNIC - BACKGROUND

The Polytechnic is a constituent college of the University of Malawi. Being a technological institution, it was decided that it should be situated at a busy location (Blantyre) where students could easily go for industrial visits and vocational training could easily be arranged. Communication between industry and the Polytechnic is greatly enhanced by the proximity. It was established in 1965 through an aid package to the newly independent Malawi (independence from Britain in 1964) and was offering certificate courses in motor vehicle technology, woodwork, building technology and commerce. The University of Malawi became responsible for the diploma courses and the college administration in 1967. In the same year, the Malawi Polytechnic Board of Governors was established as a body responsible for the certificate courses mentioned above. The Board still runs these courses to the present day and the number of courses offered has increased to include electrical technology, general fitting, mechanical engineering technology, printing, welding, diesel fitting, automotive-electrical technology, telecommunications and land and quantity surveying. These are four year courses taking the form of one full year in college followed by one term block-release in each of the second, third and fourth years. Throughout the years, students sit the City and Guilds of London examinations in their respective subjects and improve their grades by obtaining certificates indicating the part satisfied.

On the commercial side, the Board of Governors runs a two year secretarial course. Apart from this major course, there are several three-month in-service or upgrading courses for secretaries drawn from industry and other institutions.

The University of Malawi still runs the diploma courses at the Polytechnic and most of them have been extended to degree level in engineering, commerce and technical education. A new two year diploma course in management was introduced to help those in industry with management needs. There are plans in the pipeline for more degree courses in public health and business administration.

Since 1965, the Polytechnic has seen a lot of expansion. New laboratories, with modern equipment for more effective experiments, were built for the departments of Mathematics and Science, Electrical and Civil engineering. A new lecture theatre with a seating capacity of more than 800 has just been completed.

A new library capable of holding 90 000 books and a seating capacity of 420 has also been built. Student's welfare has also seen major leaps. New spacious hostels were built in 1982 such that almost all students are accommodated on campus. Kitchen facilities were greatly improved in the new cafeteria built in 1983. There are plans for a new students' union and expansion of hostels. As a result of all these developments, the student intake levels have seen a sharp rise from 1153 in 1977/78 academic year to 2073 in the 1986/87 academic year. There is a high probability that these figures will continue to rise as new courses are being introduced and the national population grows.

CHAPTER 2

SCOPE OF PROBLEMS IN MATHEMATICAL EDUCATION IN MALAWI

CHAPTER 2

2.1 PRIMARY MATHEMATICS

Malawian children grow up in a mathematical enviroment without actually realising it. The different tribal languages are provided with number systems which the chidren learn early in their childhood. Traditionally, each and every household will have domestic animals of some sort e.g. chicken, cattle, goats etc. These are usually a symbol of status hence everyone tries to have them in large numbers. Local languages therefore had to have a way of accepting number concepts, mensuration, proportion and money. Distances for example were given in terms of how many rivers away a place was, or how many 'walking days' it would take to reach a place. Estimation of the sun's position was and still is a way of telling time for most Malawians. To give an example, a quotation of what is generally common talk in the village would be something like;

"How far away is Blantyre from here?"

Answers to this question could be, "It is two rivers away." where 'river' is a concept of distance which almost everyone holds constant.

Another answer could be "it is a day's journey." again a constant speed is assumed between those discussing. These answers are not numerical but they carry a lot of mathematical concepts in them.

The number of cattle or goats one had, had to be counted numerically although these could not necessarily be written. The author remembers herding cattle before he went to school and it was always necessary to make sure that all the cattle were there before going back home in the evenings, all herd boys had to count them.

If someone committed a crime, the seriousness of the crime could be measured in terms of how many chickens or goats he had to pay as compensation. The number concept is again demonstrated in this example. There are numerous such examples which show that African children like any other child in the world are born in an atmosphere where mathematical thinking is the order of the day.

The argument being raised here is actually to put across the message that the Malawian child is prepared to take mathematical concepts easily since these are exposed to him very early in his childhood not as an academic endeavour but as a way of life. This is one side of the argument.

On the other hand is the evidence that mathematics is the most dreaded subject in Malawi. The general acceptance that anything mathematical is difficult has also affected the performance of pupils in other mathematically oriented subjects like Physical Science, Chemistry, Computing etc. Added to this is the other fact that Malawian girls or women dread mathematics much more than boys. Evidence of this may be found in any national exam results in Malawi where mathematics is part of the curricula. For example, in a class where the author was a member at Malamulo Secondary School, out of 14 girls, only 2 passed mathematics in 1979. Out of the 2 girls only one passed with a grade six the other was a marginal pass.

Some teachers and schools have done research in this area but not much has been done on a large scale and neither have any results been made public for the benefit of other schools. A project on this problem was underway at Malosa Secondary School (Zomba) in 1983. This is a mixed school (boys and girls) and girls' results in mathematics were observed to be significantly low. The mathematics department at the school decided to separate boys and girls when they went for mathematics. The idea behind the separation was to encourage girls to compete among themselves instead of shying off to the boys. The author was on teaching practice in 1983 when this was being tried out and was fortunate to be involved in the project by teaching the girl's class. The observed results then were positive in that there were more girls showing an interest in the subject, results with the boys' class were not significantly different. The attitude towards the subject had also positively changed compared to Malamulo where the author had learnt with girls who took mathematics as a "boys'" thing. It is worth mentioning here that the problem which girls have in coming to terms with mathematics is also recognised in western societies. The WISE (Women Into Science and Engineering) Programme of the Engineering Council, London and the Girls Into Mathematics Programme of the Open University are good examples of the work being undertaken in Britain on this subject. This is an area of research which ought to be looked into seriously if the image of mathematics is to be changed from the present stance.

The importance of mathematics cannot be overemphasized. It has a lot of influence on other subjects in the curriculum and society. It is required of mathematicians or mathematical educationists to ensure that the subject is well taught. Most experienced secondary school teachers in Malawi would agree that most pupils enter secondary school either already "destroyed" mathematically or well motivated to love the subject. Change of teaching methods and proper teaching does help motivate those who are neutral about the subject.

From the above argument, children at the input - from homes before joining the school system—are intrinsically unbiased about mathematics. On entering secondary school most pupils will have already developed a liking or hatred for the subject, this then makes us feel that part of the reasons for mathematical dislike in students is actually derived at primary school level. One can therefore say that there is need to start proper teaching of mathematics at primary school level where the basis of mathematical concepts are laid. A child badly taught at this stage may grow up to dislike mathematics for the rest of his/her life. The question then is, is mathematics well taught in Malawian primary schools? Is the fault elsewhere and not in the primary school? Suppose it was not well taught, what can be done to improve the situation? Is it the pupils' fault or the teachers' or could it be the "system's" fault?

As pointed out at the beginning of this section, most Malawian pupils enter school with either a neutral or a positive attitude towards mathematics. What then makes them enter secondary school with a negative attitude? There must be something to do with the way mathematics is communicated in primary school. Whatever it is, is carried over for a long time in the system. The author has then considered what this problem may be, having been in the system himself.

Firstly, looking at the mathematics syllabus for teacher training colleges from the Ministry of Education and Culture (1981) Appendix [3], about 95% of the topics covered in the syllabus are those topics which the students will have already done at 'O' level mathematics. It is rather difficult to imagine students enjoying mathematics if 95% of what they learn is a repetition of what they have already done. It may be argued that the same syllabus is used for those who only went up to junior certificate examinations and hence for them there wont be much repetition but in that case there isn't much done for 'O' level holders. It is necessary that teachers should be ahead of their students to allow for flexibility and confidence in their teaching.

Students at Chancellor College who are pursuing Bachelor of Education (B.Ed) and those at the Polytechnic pursuing the Bachelor of Science (Technical Education), are both meant to become secondary school teachers. Although they are to teach secondary school mathematics, they do not spend their two years in college reviewing or re-learning secondary school mathematics at all. They learn higher mathematics which improves their mathematical thinking and logic. After their course such students are in a better position to pursue further studies because they are well prepared for that. Primary school mathematics teachers following the above mentioned syllabus do not follow that theory. This syllabus does not take care of those who will go on in further education. In other words the mathematical capability of the Teacher Training College (TTC) graduate is no better than an 'O' level graduate mathematically. The only difference is item 9 for T3 and item 8 for T2 both of which positively introduce Statistics (data collection and presentation) for the T3 and up to probability concepts for the T2s. These students would feel more motivated if they were made to feel that going to the TTC is actually part of further education other than a mere grooming for teaching. The author's suggestion is that the topics listed in the syllabus be quickly revised just for recap, and then new material be introduced. A deeper and better treatment of statistics could be an idea. Topics like calculus, Simpson's Rule etc.,complex numbers, matrices, the exponential function, trigonometry waveforms, natural logarithms etc. could be among those considered for implementation. The author feels this will motivate students into learning and enjoying mathematics and give them a feeling that they can easily go into further education. Their mathematics background will be stronger as they go to teach. Considering also that these same primary school teachers are actually engaged in teaching Malawi Correspondence College Centres (MCC Centres) a change of this nature would improve mathematics and the passing rate in these MCC Centres whose results are presently disastrous. It must be realised that in western countries e.g. Britain, some university graduates go on to teach in primary school. Such teachers are confident and flexible in their approach to concept teaching.

The second point may appear sexist but is factually true. In most Malawian primary schools and some secondary schools, there is an increasing number of lady teachers. In some schools, especially in cities, the population of lady teachers could be as high as 90% or more. Now, some of these teachers were not good at mathematics at all when they were in school but are faced with the task of teaching it. It is evident in Malawi that girls in schools resent mathematics more than boys, or at least this has been the trend. Present lady teachers have been under such a trend hence one can confidently feel that most lady teachers may not have been good at mathematics. Whilst these comments are more applicable to lady teachers, it is possible that the same problem exists with male teachers in that the best mathematicians are attracted to industry and commerce rather than teaching. This is possibly true in western countries more than in the third world.

The author does not suggest that lady teachers need not be allowed to teach mathematics but is only emphasising the need to know well what one teaches and a little more. In other words it is difficult to teach effectively something you know hazily or something you are not confident on. Therefore whoever teaches mathematics must be seen to have an interest in it and also be creative in the way different concepts are taught. If one knows his subject matter, he can find different ways or methods of communicating it to his students. For students to effectively understand what they are learning, it requires good teaching methods, to be able to change teaching methods to suit students with different learning problems, requires a good knowledge of the subject matter. Psychologists agree with the importance of learning methods, Skemp [21 p.36], states,

"Now to know mathematics is one thing and to be able to teach it - to communicate it to those at a lower conceptual level- is quite another; and it is the author's belief that it is the latter which is most lacking at the moment. As a result, many people acquire at school a life long dislike and even fear of mathematics."

This then brings the suggestion that the TTCs should partially categorise teachers in terms of what they can teach. The idea of one teacher teaching almost all subjects is economically a good one but side effects of it may prove a bit unhealthy. This calls for some specialization in teaching subjects. This is what is being practised in secondary schools now but is greatly neglected in primary schools. Most people think that primary mathematics is so simple that anyone can teach it. This is totally wrong. Those responsible for the transfer of teachers, which is why there are so many lady teachers in cities, should seriously consider a teacher's speciality before approving of the transfer. The author realises clearly that this is not a simple issue and needs to be looked into extensively by concerned parties.

The mathematical concepts in children which they acquire in their enviroment before school are practical oriented, i.e. they learn counting because they have to count something or measure something. It is therefore important that this should not be distracted by the introduction of mathematics as an abstract subject which is difficult to learn. There should be a smooth transition from the practical aspect to the abstract. Pupils must always see mathematics as a "doing" subject, it should, especially in primary education, contain lots of practicals in form of games and projects with mathematical concepts embedded in them. In that way it will be easy to learn and the development of abstract concepts can easily be taken. Credit must be given to the pactical aspects in primary school teaching in Malawi presently. Children usually learn by doing things and the Ministry of Education has made it a point that this is done. Some teachers still have a tendecy to ignore practicals and teach by chalk and talk. Children get bored and lose concentration hence they miss important lifelong mathematical tips.

Lastly, Malawians can learn a lot from the Cockroft Committee's report entitled "Mathematics Counts" which was published in 1982 to consider the teaching of mathematics in primary and secondary schools in England and Wales. In UK they did what Malawians also ought to do, reviewing our teaching methods and the content in primary and secondary school mathematics. In their summary, the Cockroft report states the following important points for the mathematics teacher,

"In our view, the mathematics teacher has the task,

- of enabling each pupil to develop, with his capabilities, the mathematical skills and understanding required for adult life, for employment and for further study and training, while remaining aware of the difficulties which some pupils will experience in trying to gain such an appropriate understanding.

- of providing each pupil with such mathematics as may be needed for his study of other subjects.

- of helping each pupil to develop as far as possible his appreciation and enjoyment of mathematics itself and his realisation of the role which it has played and will continue to play both in the development of science and technology and of our civilization.

- above all, of making each pupil aware that mathematics provides him with a powerful means of communication."

These points are clear and easy to follow. The Malawian TTC mathematics departments could look at these objectives and see whether they achieve this or feel like adopting some of the above ideas.

2.2 SECONDARY SCHOOL MATHEMATICS.

After eight years in primary school, a student in Malawi then enters secondary education. The determining factor for level of education in Malawi is not age as is generally the case in Britain but simply the completion of the first eight years in primary school. One of the reasons age is not a determining factor is that pupils start school at different ages due to lack of fees for some and slow mental development in others. After passing their primary school leaving certificate, the next task after another four years is to pass their 'O' levels and then go to university.

The Malawi School Certificate Examinations and Testing Board is responsible for the Malawi School Certificate of Education (MSCE) examinations which are held after four years of secondary education whereby students obtain their 'O' levels if they pass at least six subjects including English with credits in at least two of the subjects. The MSCE examinations are held in conjuction with the Associated Examining Board for the General Certificate of Education in the United Kingdom. This is done to keep the standards of the MSCE 'O' level certificate in line with other international certificates.

The new GCSE 'O' level examinations 1988/89 which became operational this year (1987) has several differences with the MSCE. The GCSE to which the MSCE emulates, has brought changes in teaching methods and content. Statistics and Probability, Matrices, Vectors, Sets and Differentiation are topics which are absent on the MSCE syllabus. It may be argued that those taking additional mathematics at MSCE may come across some of these topics but considering that selection to university or other colleges is not based on additional mathematics, it would be worthwhile including the said topics in the general MSCE mathematics syllabus. How important are these topics to require inclusion in the MSCE?

At the Polytechnic and most other tertiary education colleges, there is a lot of experimental and research work in which students are expected to take an active part. Most of such work requires data collection, classification, tabulation, interpretation and ability to draw simple inferences from the data. This is done from first year. Statistics deal with data collection, analysis and presentation. First year students at the Polytechnic do not have any statistical knowledge because this is not part of their 'O' level curricula. As a result of this, students find analysis and presentation of data, a difficult task. Statistics is not taught (at the Polytechnic) until the second or third year by which time a lot of experimental work will have been done blindly i.e. without much appreciation of the data.

If, on the other hand, the first year common course tries to emulate the 'A' level syllabus to a certain extent, then in the 'A' level syllabus statistics is included. As a matter of fact, most mathematics syllabi in Britain include statistics because of its practical oriented nature. The inclusion of the above mentioned topics at 'O' level would greatly improve the quality and level of mathematics taught at the Polytechnic and other tertiary colleges. Even the approach to data of students, from such a programme, will significantly show a change. It would be reasonable for the Polytechnic to seriously consider introducing statistics to students as early as possible as this is where they really need the subject.

It must be realised that if students, engineering students in this case, do not have an appreciation of their experimental work due to lack of a strong statistics base, then their confidence as engineers may be threatened and even if statistics is introduced at a later date, it may fail to avert the situation.

2.3 THE COMMON COURSE MATHEMATICS SYLLABUS

2.3.1 INTRODUCTION.

Most members of staff and students who have stayed long enough and have closely followed the developments of mathematics teaching at the Polytechnic, would agree that the engineering department has on several occasions given its reservations on the level and quality of mathematics taught by the Department of Mathematics and Science to first year engineering and technician students. It is more likely that, most of the staff who raise this topic are expatriate or those that have studied other syllabi, and their expectation of a second year student in engineering is mathematically low. Such staff argue that the first year common course fails to bring up a mathematical aptitude necessary for them to easily teach most engineering concepts. On several occasions, they argue, an engineering concept has been difficult to get across because students haven't covered the mathematical pre-requisite for it. It is probably right to suggest that most of such staff are used to the educational system where students go to university after passing certain specialised subjects at 'A' level. Among other things, the first year common course aims to cover a considerable amount of 'A' level quality mathematics relevant to engineering and technology. Because of continued criticism, the mathematics syllabus has been, on several occasions, reviewed and altered to meet particular needs. In this section of the thesis we take a thorough review of the syllabus and comment on what implications on the subsquent years' mathematics topics are.

2.3.2 THE COMMON COURSE MATHEMATICS SYLLABUS

Appendix 4 is the September version of the first year common course mathematics syllabus. Item 11 on Appendix 4 is a list of topics of study in the common course. Item (a) is a revision of secondary school mathematics ('O' level mathematics). Arithmetic calculations and plane geometry theorems are emphasized in this course. The revision is necessary because students will have come from a three month vacation and they surely need an interim topic to enable them fuse smoothly into higher mathematics. Having come from an 'O' level background, topic (b), i.e. Binary arithmetic, is the first new topic to the students. Imaginably, and from the author's own experience, it is more motivating to learn new things than repeat what one knows already. Topic (c) however is not necessarily new. This topic is covered at 'O' level such that it would be fitting to include it in (a). The same argument can hold for topics (e), (f), (g), (h) and (l) all of which are more or less repetitions from the 'O' level syllabus. It is a justified argument to say that some of these topics are not as well covered at 'O' level but they don't deserve such dedication either. It is for that reason that it would be better if these six topics were covered quickly and at the beginning of the course i.e. should be included in (a). Another option is to cancel some of the more obvious repetitions and introduce new topics thereby motivating students more.

Except for topics (b), (m), (n), and (o), the rest are topics which have either been wholly or partially covered at 'O' level hence the time spent on them can easily be reduced provided proper teaching strategies are taken as will be explained later.

The big disadavntage of this syllabus is that lecturers spend more time on topics which students, either already or partially, know. Important topics such as (m), (n) and (o) come at the very end and from experience, there is usually little time for their thorough coverage. As a result of this, students go into second year with a very faint idea of calculus which forms almost 80% of the mathematics in subsequent years.

Statistics is a subject which could be introduced at this stage. With experimentation playing a greater role in the science subjects, a statistical approach to the data obtained would help verify or validate their findings.

2.3.3 IMPLICATIONS OF THE COMMON COURSE ON SUBSQUENT YEARS.

Due to weaknesses in the common course first year syllabus, the second year mathematics still contains some topics which are actually of first year level. Appendix 5 contains study topics for the second year mathematics. Item (b) was partially covered at 'O' level and could as well have been extended in the first year. As pointed out above, if statistics were introduced in the common course, item (f) could have been covered then. This would allow more time to be spent on probability theories which some people find difficult to comprehend. If probability were thoroughly covered in the second year, other topics, vital to a graduating diploma student, would be introduced e.g. Quality Control, Significance Tests, Correlation and Regression etc.

The key to the whole problem is the improvement of the first year syllabus, which will bring an improvement in the subsquent years. Most of the mathematics topics covered in the second and third years are reasonable, new and are reasonably easy such that they could be shifted a year back to enable mathematics phase with other engineering courses.

In Britain, for the G.C.S.E. examinations of 1988, questions for the 'O' level paper will include such topics as differentiation, statistics, computation, matrices, vectors, sets, transformation and symmetry. It is easy to envisage such students doing better and more advanced mathematics at 'A' level after having done the above topics at 'O' level. After their 'A' level,when they choose to do engineering, they would likely find most concepts easy to understand having such a background. The mathematics included in the engineering courses is bound to be more interesting and challenging.

Whilst there is need in Malawi to review the 'O' level mathematics just as in Britain today, the Polytechnic ought to take a leading role by restructuring its mathematical requirements and then using its influence to bring about a reasonable change in the Malawi School Certificate of Education (M.S.C.E.) 'O' level curriculum.

2.3.4 SUGGESTIONS FOR IMPROVEMENT.

In the stated aims of the mathematics syllabi for years one to three at the Polytechnic, there is a constant mention of "consolidation" of the mathematics of the previous year. This is necessary. Concepts must be built systematically and logically. This however does take a lot of time which, if alternative methods of quick revision were available, could be devoted to new topics. One of the new ways of attaining quick revision, as will be seen in chapter 5 is through using the philosophy underlying "Computer Enhanced Learning (CEL)".

Most of the topics in the mentioned syllabi are such that computer packages could easily be made thereby providing the student with an alternative lesson. As will be seen in this thesis, such computer packages bring effectiveness and efficiency to the lesson. When the Teachers' Centre proposed in chr six becomes operational, software packages will be easy to get as, it is hoped, staff will work hard in making it available to students.

What improvements will computer packages bring about?

It is true to say that a lot of time is spent by lecturers trying to convince slow learning students over difficult concepts. Since the only source of information (lesson) is the teacher and books are difficult to understand, the teacher is sometimes forced to repeat lectures. Computer packages would help both slow learners and fast ones. The slow learner, after the lecture, would be given the package to follow at his own pace and time. The interactive nature of the packages would make it easy for him to understand without the teacher's assistance. If in case he doesn't understand certain parts of the lesson, he can specifically ask for help thereby reducing the teacher's load and also saving time for new topics to be introduced. Fast learners would find it easy and quicker to revise using the packages. Students would also be made more responsible as they would have to work at their own time and pace. Apart from these advantages some packages contain a section on 'work ahead' hence students would know in advance what is to come and would make relevant research on it.

With computer packages learning could be made faster and easier. The teacher could find his load reasonably reduced and teacher -student discussion would be more meaningful. As the survey in chapter five shows, computer enhanced learning makes the learning/teaching task an easy one. Computer packages need not be restricted to mathematics only, other subjects can equally benefit. Presently the Polytechnic has all the MIME (Micros In Mathematics Education) Project units in Mechanics, Statistics and some general mathematics software. It is hoped that an organised system will be set up whereby students will have access to them and the ones to be produced later.

CHAPTER 3

COMPUTERS IN EDUCATION

CHAPTER 3

3.1 Computers in Society

A computer is an information processing device. Since there are vast areas where information processing is done, there equally are a lot of areas where computers are used or could be used. It is not possible therefore in this thesis to give completely, a list of all the areas where computers are utilised. A classification and application of areas of computer technology will be given. Didday [10] classifies computer application into six inter-related categories viz;

1. Control
2. Communication
3. Computation
4. Simulation
5. Organization
6. Recreation

He further points out that each of these categories can have three different approaches. Take application 6, Recreation, for example, this can be approached in three different ways;

(a) recreation for personal satisfaction or use e.g. sport,

(b) recreation for educational purposes, e.g. educational games,

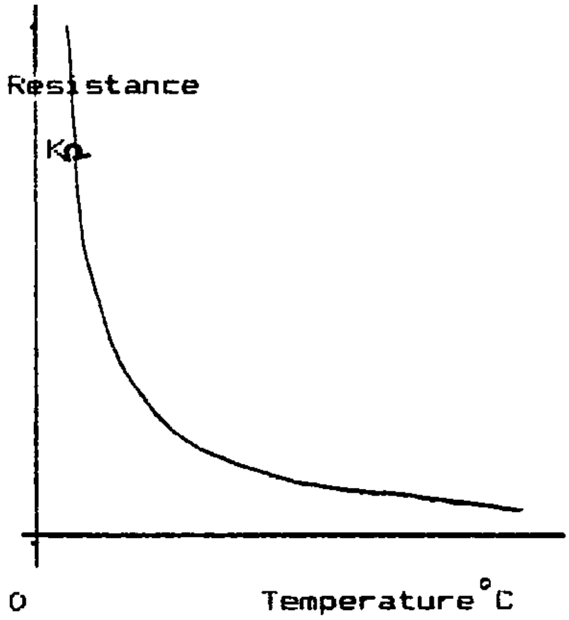
(c) recreation for profit making, e.g. game machines.

Programs written specifically for any of these can achieve all the mentioned intended goals on a computer. To get a better idea of what all these mean, a closer and reasonably brief account of each will be given.

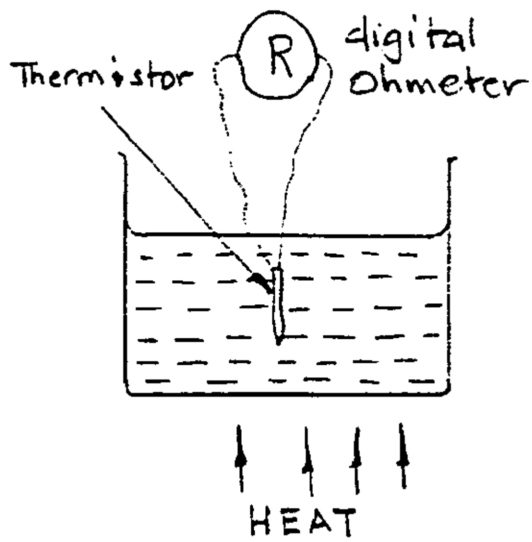
3.1.1 CONTROL

Computer application falls under the control category when a computer is used to monitor and direct some physical system. There are numerous cases where a computer is used in the control of physical processes. There usually is a need for a converter, analog to digital or digital to analog (A/D), to turn the signals produced in the physical processes into binary values which the computer can use. An example of such a situation is a simple voltimeter chip which can be used to convert a physical signal or process into an electronic one.

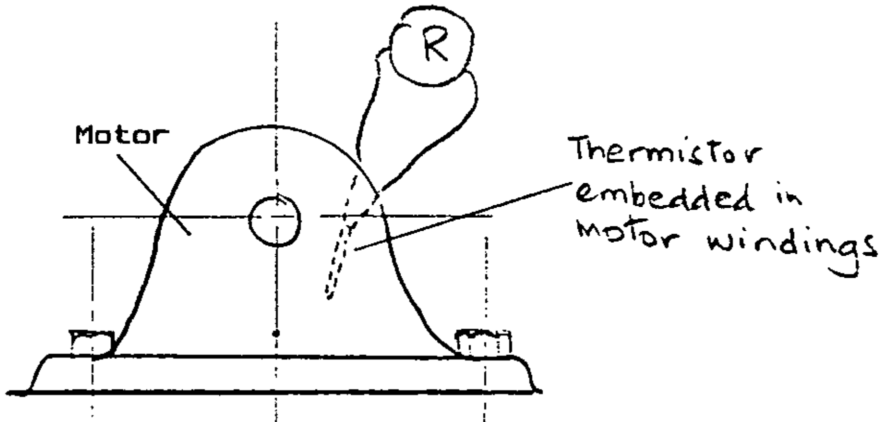
Consider a situation where a thermistor is to be used for the thermo-characteristics of an electrical motor. The problem would be to find a way of accurately measuring the heat changes inside the motor's windings using a thermistor as a simple thermometer could not be used. The thermistor would have to be calibrated first. This could be done by connecting the thermistor to an ohmeter and then placing the thermistor in freezing water(see figure 3.1 (a)). The resistance of the thermistor in freezing water would then be noted. The beaker, in which the freezing water is, would then be heated to boiling temperature i.e. 100 degrees Celcius, resistance readings would be taken after say, every five degree's temperature rise. The thermometer placed in the beaker as shown below would show the temperature rises while a digital ohmeter would accurately give the resistance readings. A graph of resistance against temperature would then be plotted to give the inverse relationship shown in figure 3.1 (b). The calibration done, the thermistor could then be easily placed in the motor's windings and through cables connected to an ohmeter outside, see figure 3.1 (c). Whoever is interested in the thermo-characteristics of the motor would then simply read resistances from the ohmeter and interpret them from the graph.



(b) Calibrated characteristic of a thermistor



(a) Calibration process.



(c) Application

Figure 3.1

In the above example, a digital ohmeter chip was used to convert the heat in the motor into digital signals which could be read on the screen as thermistor resistance. The same digital pulses could be connected to a computer which could then monitor the motor i.e. switch off when a certain temperature is reached or switch on, or increase/ reduce motor speed.

There are many areas where computers direct control mechanisms in machines and these vary with field of application. Just to briefly mention a few examples, car parks in the United Kingdom are computerised such that doors/barriers will open only when the right payment is made. In this case, the motor which opens and closes the door is monitored by a computer. In underground stations, some doors will open only when you slide your ticket through a slot. Doors to some banks outside opening hours can only be opened by using the cash-point card through a special slot. Cash-point card holders can therefore have access to the machines at any time. Most washing machines are computerised such that temperature changes, spin speeds etc. are all monitored by computer. Traffic lights are also computerised.

It is difficult to give Malawian examples because computers are not as yet widely used. Society is somehow hesitant to computerise because of unemployment fears and also lack of proper computer manpower and adequate financial resources.

3.1.2 COMMUNICATION

There are several cases where computers are used for communication purposes. In some situations, computers may not be seen to be involved in the communication process but basically they are behind it all.

Some television sets, for example, receive information such as teletext. In that case information is fed into the computer at the central broadcasting station and a decoder in the television set displays the information on the screen at the viewer's choice. In teletext a viewer can choose from several 'pages' of news, weather forecasts, entertainment, games, recipes, advertisements from retailers etc. These can be viewed any time.

Another information service in use in Britain and other developed countries is view data or videotex. This was pioneered in Britain where it is called prestel. It makes use of telephone systems as well as television. Information from a central computer is, this time, transmitted through a telephone line. Terminals of the system consist of television screens with a decoder and a keyboard linked via telephone wires to the memory banks of the computer. This has extensive fast improving application. Ardley [16] states,

> ".....Already in France they are planning to use videotex to hold the telephone directory and in this country (Britain) there are plans to use it to inform bank customers of the state of their accounts instead of sending printed statements."

Another application of viewdata is sending messages between distant places through the screen. The travel agents in Loughborough for example, use this to book their customers on different flights and airlines with their London headquarters. Telex messages are also a form of viewdata in the form of printed matter.

Most railway stations in Britain have at least one screen on each platform where a computer sends information about train services and timetables. In some stations, especially London's underground, some companies advertise on "running" screens, where a message runs across the screen every so often. A computer sends the message to the screen and also determines the speed of run. A similar use can be seen in footbal grounds where scores are given on digital screens. On BBC television, the weatherman uses a BBC micro to show his forecasts. This list can go on, the computer's use in information processing in form of communication is very divergent indeed.

3.1.3 COMPUTATION

Computation refers to the use of the computer in handling data, processing it to give mathematical, statistical or logical models. Such models are found in numerous cases in real life. Most of the computer usage in different fields involve computation of one form or another. Computation refers to the number crunching capability of the computer. Microcomputers are not as powerful number crunchers as supercomputers. They can do, but are comparatively much slower. Below are practical computation cases.

(a) Most graphics output need computation before display, e.g. the trigonometric function program included in this thesis [4.3], the student may not necessarily see what is happening when he enters an amplitude of say 4 but the computer is involved in heavy computation to produce values for the graphics output.

(b) In banking, there is a lot of computation going on. Everytime a withdrawal is made, computers are involved in the updating of that account, checking whether the account is overdrawn or not and sending appropriate messages to the customer. In most western countries, cashpoint cards are in use where the holder can withdraw money at any time. The cashpoint terminal is actually a computer network terminal and all information is handled by the main computer (Mainframes).

(c) Early computers were, in some cases, used to calculate ballistic firing tables for guns and missiles. In that case as well, the computer was involved in the computation of barrel elevation, shell types, wind velocity, temperatures etc.

Again there are numerous examples where computers are used for computation and it must be borne in mind that almost each and every computer application does involve computation in one way or another, i.e. binary (through compilers or interpreters) or the interpreted figures as displayed on the VDU.

3.1.4 SIMULATION

Simulation is a way of creating a model of reality. Creating a picture or model that resembles the real thing for the purpose of training or experimentation. The role of computers in simulation is a great one because of the graphics capabilities of computers and the speed in computation. Programs are written which, using real life data, produce models graphically from which an understanding and analysis of certain aspects of the real world may be made. It is safer and cheaper to use models than to test in situ all the time. Simulation testing can be compared to sampling in statistics. For example, space researchers use simulations to test a missile's design before building it. It is safer and cheaper to have a missile crash on the computer model than on a real launch. Pilots are trained in computer controlled simulators to avoid catastophic disasters. Simulators are therefore important in bringing a low cost improvement on society or technology by pretesting models and experimenting with different parameters before manufacture. Simulations can also help those in decision making positions see what lies ahead by looking at computer simulation models.

3.2 COMPUTERS AND LEARNING

Presently in Malawi, computers are widely used in the industrial sector. There is also a reasonable amount of use in wordprocessing both in industry and in education. The Malawi Polytechnic started using computers for adminstrative work in 1985. The computers are used to store students' records and possibly updating them from time to time. Keeping records by computer is versatile in that updating, cancelling, and print -out is easily done.

The Department of Mathematics and Science at the Malawi Polytechnic has been running computing classes since 1982 and since then the syllabus has undergone several changes because of a number of reasons,

(i) availability of computers, in terms of numbers,

(ii) availability of other high level languages i.e. computers containing such ROM, (iii) teaching staff.

In 1982, the Polytechnic had fewer than 4 Tandy TRS 80 and 3 Sinclair microcomputers. The computers then were not enough for a student population of 1000 students. In 1984 another 4 TRS 80 micros were added. The problem then was that there was no one who had the expertise to repair the machines whenever something went wrong. As a result, most of the computers had to be removed from the lab even if they had a minor fault. This problem is apparently still there (March 1987) although there was at last talk of an attempt to alleviate it. In 1986, a 24 IBM mini computer terminal was bought from the United States of America. The memory available in these computers is so extensive that other high level languages like FORTRAN and PASCAL are available apart from BASIC which has been the traditional language taught. Since 1983, computing has only been taught to engineering degree students. In 1984, degree students following the Bachelor of Science (Technical Education) course and the Bachelor of Commerce were for the first time allowed to take computing. Already there are plans to introduce computing to technician courses in engineering (Diploma) and City and Guilds courses and also the diploma in business studies. Judging from the way computers are trickling into Malawi and the way government values education, chances are that in two or so years the Polytechnic and other university colleges, as well as technical colleges will get more computers. Apart from these, secondary schools will get their share in the near future. However, there are several questions we must address ourselves to before these changes come;

(i) Do we have enough teaching personnel to cope with the rate at which computers are coming?

(ii) Do we have guaranteed maintenance of the machines as they come in?

(iii) How best can we utilise the computers apart from simply training our young men and women in computers?

(iv) What will happen to the numerous number of mathematics teachers in secondary, technical schools and even university who at one time will be without suitable training when computers eventually influence the mathematics syllabus?

In this thesis, answers to the above questions are attempted. Chapter 6.2 on the "Teachers' Centre" attempts to answer questions (i), (ii) and (iv). In this section we attempt to answer question (iii) in which we look at how best we can utilise the computers we have apart from the general computing lectures.

Why are computers destined to be such important factors in human learning? Can a computer improve learning? Do computers improve learning/teaching methods? It must be realised that whatever philosophies may go about us, one thing is that mathematics teachers and other teachers as well have been provided with a new tool, the computer. There are so many computer applications which have positive and negative effects. There is therefore great need to do research in this area to examine the strengths of the computer based learning and its weaknesses and see how the weaknesses may be averted. Alfred Bork [19], on why the computer is destined to be such an important factor in human learning levels , says:

> "Fundamentally the major factor is <u>interaction.</u> The fact that the computer can make learning an <u>active</u> as opposed to a passive process implies other important consequences."

The present learning process in Malawi is a passive one. An active process allows the student, or at least expects him, to interact with the machine (computer), the teacher or sometimes with himself. Active learning processes are obviously desirable as heuristic approaches to learning have always proved more successful than the traditional ones. The active learning process can be compared to the socratic learning process where the teacher's attention is directed at individual students. However in the third world and in some western countries, it is not possible to achieve a socratic learning/teaching situation. Classes are generally overcrowded with sometimes fifty to a hundred pupils to a teacher. A teacher in such a case has no alternative but to sit all his students in a convenient class and have them listen to his lecture. Whether there are slow learning students in the class or not does matter but he may be unable to help it. Actually, an attempt to give attention to individual students can deter the teacher's aim to go through the syllabus. This problem is more serious in primary schools, where most schools will have more than 80 students to a teacher, and secondary schools where there will be more than 30 to a teacher. At the university level e.g. the Malawi Polytechnic, tutorial classes are trimmed down to 16 students. Lectures may have more than 50 students in some cases. Despite this reduced number of students to the teacher, the socratic approach to learning is still a distant dream. This is because the socratic approach is expensive in that it will require more lecturers who are not easy to get and also expensive to employ. It may also require a lot more room considering the number of students available. The socratic approach is an ideal learning situation. The reality, on the other hand, for third world countries is that our classes are overcrowded. What can be done then to make sure that our learning is effective in such overcrowded and mixed ability classes? One of the new methods of learning which is still under intensive research is computer based learning. Chapter 4 in this thesis gives an outline of an experimental teaching/learning situation utilising the computer.

It is apparent especially in the western world that we are at the verge of a major change in the way we learn.

> "This change, driven by the personal computer will affect all levels of education from earliest childhood through adult education. It will affect both education and training." Alfred Bork [19].

This change might not be that apparent in third world countries. Computers are just coming in and are used more in the industrial and administrative sectors. Computer technology is improving tremendously as seen in 3.1. It will not be long therefore before the industrial and administrative sectors are flooded with computers and very shortly the education sector will have lots of computers coming in. There is need, therefore, to investigate before hand, what effect computers will have on third world education. Will the computer bring positive educational effects as is the case in some western countries? Will students in overcrowded classes benefit from the computer's facilities? How about slow-learning students? These are some of the questions researchers will have to face themselves with in the third world.

Having looked at a general view of computers and learning, we shall now look specifically at the various advantages computer based learning has over the basic traditional method and also how computer based learning may help improve the present teaching methods.

(i) <u>the interactive nature of computer based learning and also the ability of the computer to individualise the learning process to take account of the needs of each learner.</u>

As pointed out earlier, it is almost impossible for the teacher to entertain the individual needs of every student in overcrowded classes. The computer does provide the stated facility. It was observed (see chapter 4) that 4 students seated in front of a computer created an atmosphere which invited more student to student interaction about what was going on in the lesson. Sometimes heavy arguments could arise in which the teacher was invited to give a verdict to the row.

With 3 or 4 micros, a roster could be organised whereby students could come in the evenings or any free time and run the lessons in groups of 4 or 5. This would be after the lecture. Students would benefit by either revising, learning, reinforcing or testing their own special cases about the lesson.

(ii) <u>the ability in computer based learning lessons to stop, review and store the whole lesson and change the variables all the time.</u>

All pupils are different, each pupil or student is unique in terms of learning speeds, background, psychological make up and interest. The background of most Malawian students is that of extended family relationships. Family events traditionally affect students so much. They may be absent from school because of funerals of what people in the west may call 'distant' relatives. They miss lectures in the process. Teachers are generally not willing to repeat lessons for individual students hence from then on such students are at a disadvantage. They find it very difficult to catch up. Computer based learning systems allow for lessons to be stored in backing memory and students who either did not understand or missed the lecture can just pick the stored lesson, load and run it. The interactive nature of the program (if it is) helps reinforce the learnt ideas. If a student doesn't understand a point in the lesson he may ask his teacher for that specific point and most teachers would be willing to assist in such circumstances. Weak students are helped more in that the lesson goes at the pace they can take. Alfred Bork says that where students are learning at their own pace, they will tend to respond frequently to questions. He quotes a survey;

> "we have found in our recent programmes that a pupil responds about every fifteen seconds."

(iii) <u>access to computer based learning packages will act as a mechanism for equalizing the learning opportunities for people of different areas of the world.</u>

A practical example of this are the MIME Project packages in Mechanics which the author took to Malawi for the trial lesson (see chapter 4). These are presently being used in the 'A' level mathematics lessons in Britain, simultaneously, a

Malawian student, more than 4000 miles away, will have exactly the same material before him. Diskettes and cassettes are reasonably cheaper and lighter than books hence it will be easier to get more software or courseware. Projects like the "Teachers' Centre" (chapter 5) can help ensure that other software packages are produced locally to feed the secondary education and technical colleges.

(iv) compared to teachers, computer learning/teaching packages are cheaper.

Teachers take a long time to train, and even then you are not assured of a good teacher. It would prove cheaper to buy 1000 lesson packages than recruiting and training 1000 new teachers. These two are not independent entities and ought not be compared but are here just to illustrate the idea of how cheap courseware can be.

Having looked at the good side of computer based learning, we shall now examine briefly the negative side of it.

(i) Sometimes new technology may get pupils carried away such that they become more interested in it to the exclusion of learning.

As pointed out in chapter 4, this is a factor which teachers must watch out for. It is necessary sometimes to allow pupils to play games on the computer, let them have first hand experience on it and get over the first shocks. In so doing, students will not look very amazed with the animations in a lesson. Teachers can use different methods to solve this problem. On the other hand, this is a short term problem. Students may, if using the computer for the first time, miss the early parts of a lesson but experience shows that this problem does not carry on.

(ii) There is presently a shortage of good software. This may be due to the difference between computers i.e. software in some cases may not be used in more than one type of computer. On the other hand, the amount of work so far done in producing software is of a limited nature even in the United Kingdom and the United States. This therefore means that it will take some time before this new technology is fully developed.

(iii) Production of good software for pupils is time consuming and requires a lot of concentration. Participation of the present teacher is of fundamental importance. The teacher, much more than the programmer, knows how best his students learn. Unfortunately, most teachers are not programmers and are generally too busy with their present load such that they can't help with the programming of computer software, as a result, programmers have ended up doing it all on their own and the packages produced have overlooked many educational and psychological aspects. The Teachers' Centre (Chapter 5) is one of the ways of overcoming this problem.

Apart from the points raised above, it must be pointed out that the act of using a computer does not automatically lead to an improvement in the teaching/learning process. Like all tools in use in whatever field, the computer can serve well or badly depending on how best we utilise it. Proper planning is therefore necessary. It is also necessary to bear in mind that changes such as these need to start at grass roots level, i.e. teachers under training in teacher training colleges and universities must be introduced simultaneously to these ideas as training (in-service) of serving teachers is being carried out.

It must be borne in mind that the third world is just seeing the beginning of the effect of computers on the teaching and learning processes. There is some way to go before definite strides are made. One of the problems involved are some of the present serving teachers who will possibly be resistant to change. Such people tend to have preconceived ideas that a new thing will not work, or is bound to fail and tend to have an intrinsic belief that learning can only be successful through the book, chalk and talk only. Revolutionary ideas such as technological developments are absolutely unacceptable to them. However, it should be recognised that the computer can be used in many ways in education and philosophical discussion or natural change-resistance should not rule out some of the ways. Decisions should be made on pedagogical grounds only. It is almost certain that the computer will be used very widely in education, not only in university as the case is now in Malawi but, in a few years' time, in secondary and primary schools. This is already the case in Britain, the United States and many western countries. Soon computers will be on our door step whether we like them or not and we must therefore get ready for that situation in Malawi.

Finally, apart from the trials carried out at the Malawi Polytechnic in 1986 (October to December), there are two other success stories in Africa where computers or computer based learning programmes have brought about a change in results. According to an article in Malawi's Daily Times of 15th October, 1986 titled "Kenyan School sets example with computer program."; the school, Starehe Secondary School, was a school meant for poor pupils which started off with one computer but over the years, the number of computers increased mostly through grants. It is also interesting to note that teachers were also equally having an interest in computer lessons (instead of resisting). Although this example does not say that computer based learning is already in use, it is interesting to note the effect of computers on motivation of pupils, employment prospects and also how teachers are seeing themselves as part of a learning ecosystem rather than being the masters of it.

Another example is from South Africa and this appeared in a magazine called TOPIC, issue number 164, page 54, titled "Computer Learning for South Africa". In this case computers are used to help children learn spellings and the eradication of illiteracy. The project called "Writing to Read" was introduced by IBM of USA and was installed firstly in 18 black schools in 1986. It is expected that by the end of 1987, 42 schools will become part of this project. It is very interesting to note that this project already involves teacher training colleges in Soweto, Fort Beaufort, Pretoria and Durban. Another computer based program in South Africa is dealing with a difficulty common in developing countries: a shortage of personnel to teach mathematics and sciences. 175 computer terminals and an educational program called PLATO designed by an American computer company are being used by a university near Cape Town to combat the problem. Details of the project can be read in the above mentioned magazine but notice should be taken to the fact that at one school the pass rate rose from 21% to 100% in Physical Science. In another school, the pass rate rose from 15% to 63% in Mathematics and 65% to 85% in Physical Science. The closing comment in the article says,

> "The job of the computer is not to teach students from scratch but to supplement the teaching they are getting-to fill the gaps in what they are learning in the classroom."

Another comment agrees with the earlier claim made that there is equalization in computer based learning.

> "However inadequate the educational setting may be, the computer ensures that the pupil is exposed to material of the highest quality under optimal learning conditions."

3.3 COMPUTER ENHANCED LEARNING

3.3.1 INTRODUCTION

The present learning/teaching system in Malawi is largely teacher centred. Without teachers most pupils would find education a difficult task. The author does not wish to disregard the importance of books in Malawi but realises that there are still definite strides to be made before books are made available to each and every Malawian student although efforts are being made by the National Library Service to achieve that. The situation places the teacher as the only major source of information for the primary, secondary and some technical school students. At the Polytechnic, there is a reasonably good library service and generally facilities for education are much better than in most schools and technical colleges. Despite these deficiencies, the teacher's role hasn't changed much. In the developed countries, computers are already incorporated in the educational system. Despite the advent of computers in these countries, the teacher's role is still significant. What are the strengths of the teacher? What are his weaknesses?

This section of the thesis attempts to answer the above questions and goes on to reveal advantages in the classroom using Computer Enhanced Learning (CEL), bearing in mind that the computer is there to enhance the teacher's teaching and the pupil's learning.

3.3.2 The Teacher's Potentials

In section 3.2, the advantages of computer based learning were discussed. The computer's potentials were expounded and its contribution to education discussed. Although the computer is such a technological development in education, it is not meant to replace the teacher or the book.

Bajpai et al [31,p.784] says,

> "The microcomputer is a powerful teaching aid - an animated blackboard that can be used by the teacher or pupil to enhance but not replace the standard material on mathematics found in books."

The teacher still remains the most versatile teaching device. Rushby [19,p.39] says of teachers,

> "Their outstanding ability is their adaptability which even for a poor teacher potentially exceeds that of the best adaptive CAL package."

Teachers have certain potentials which are unique to them. They can sense and dig deep into a students's learning needs. Where necessary they can change teaching strategies to fit particular needs of pupils. Computer packages are programs written to behave in the author's style. They are insensitive of learning difficulties in children. In summary then, teachers have three qualities to their credit; intelligence, adaptability and versatility.

The teacher's disadvantage is that he is expensive in terms of training. Apart from that he can fall ill and stop his teaching. Social pressures affect his output. His ability to adjust his teaching to the needs of individual students can easily be diluted in overcrowded classes. The media of presentation for the teacher is speech and gestures, hence, unless supported by other media, he finds it difficult to convey graphical concepts. His speed of calculation is slow. These weaknesses are actually the power base of computers; excellent graphics output and high calculation speed.

3.3.3 Present teaching/learning styles

With the teacher's position as described above, the present learning system in Malawi can be simplified as in figure 3.2.

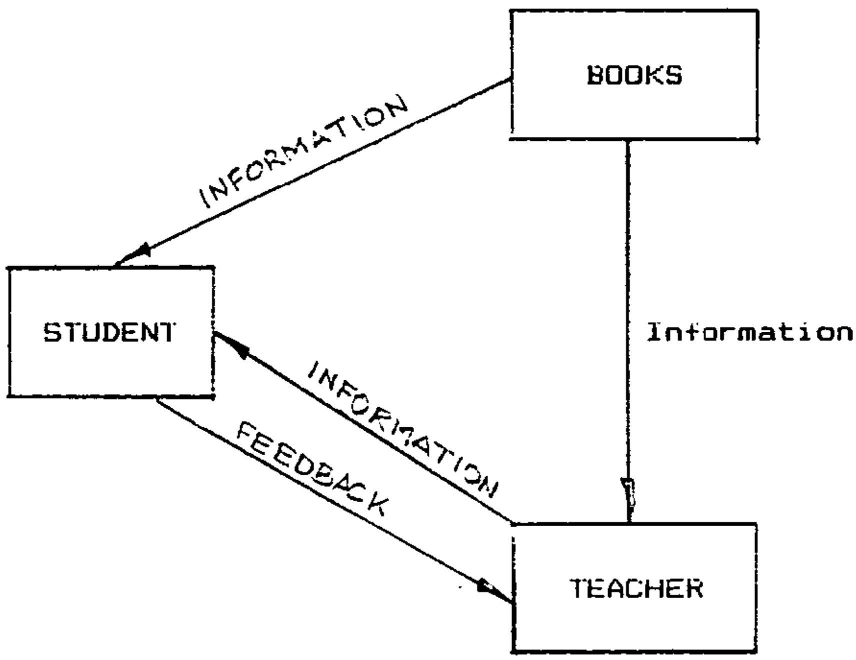


Figure 3.2

The actual learning process is a complex one such that the model above is an oversimplified picture of what actually takes place. Both the teacher and the students use books. The teacher to recap and organise his teaching approach, the student to reinforce what he has learnt. The student responds (feedback) to the teacher through coursework, exams or questions etc. For example, a student may read on the topic Z-transforms, defined by,

$\sum_{n=0}^{\infty} f(nT)\, Z^{n}$ and know from there that $f(nT)$ will be a sequence of numbers i.e. U_0, U_1, U_2, U_3, ...etc. from which the definition becomes

$$Z(U_n) = \sum_{r=0}^{\infty} U_r Z^r \,.$$

He can go on to read further on the subject without having to do anything i.e. the book does not interact with the reader. On the other hand, with some programmed learning books e.g. [3], [13], [14], and [24], the student may give some feedback before proceeding to the next frame e.g

the expression $\sum_{r=0}^{\infty} U_r Z^r$ can be regarded as a Maclaurin series for F(Z) or a Taylor Series about the origin,

$$\text{then } U_n = \frac{1}{n!}\left[\frac{d^n\left(F(Z)\right)}{dz^n}\right]_{Z=0}$$

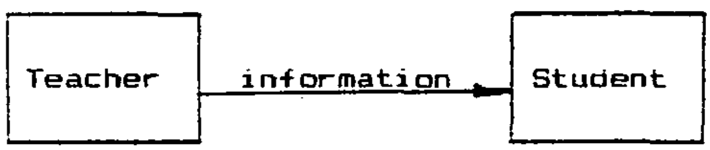
the $\Big/^{Z=0}$ indicating that the differential is evaluated at the origin. It will be noticed that this is the standard formula for Maclaurin coefficient, i.e. it is the coefficient of Z .

If $F(Z) = \dfrac{1}{(1-2Z)^3}$, what will be the coefficient of Z^n?

---END OF FRAME

The student then goes on to solve the equation by a series of differentiation processes. He is advised to answer questions fully before moving to the next frame.

As mentioned earlier, most students do not have access to proper books in Malawi such that their dependence on the teacher is much more than should be the case. The teacher therefore is the only major informer. Again with overcrowded classes, the interaction between the teacher and his students is greatly reduced such that the teaching/learning model given above is sometimes reduced to



i.e. whether the student understands or not, the teacher may not know, he simply lectures and hopes everything will be alright. This is a one way process which students find difficult to cope with. As a result of such a model, the failure rate is very high, more so for mathematics.

The objectives of CEL packages (MIME), Bajpai et al [31, p.785] show that CEL can improve the model above. The CEL objectives are,

(i) to aid understanding...

(ii) to add interest....

(iii) to be interactive....

(iv) to be user friendly....

(v) to be idiot-proof...

It is clear that these objectives do answer the needs of the model above thereby suggesting that computer packages such as the MIME packages can be a part solution to the teaching /learning atmosphere in Malawi's overcrowded classes whose access to books is limited. The pilot project at the Polytechnic in chapter 4 investigates how computers can be incorporated in the classroom to enhance learning.

3.3.4 Styles of Computer Based Learning

There are several projects in computer based learning already functioning in different parts of the world espcially in the United Kingdom and the U.S.A. Though the styles are defined differently, most of them have overlapping definitions and the literature is confused with near synonyms such that some of the styles are used interchangeably e.g. J.L.Alty [18, p.5-13]. The styles include CAI (Computer Aided Instruction) where the computer stimulates the teacher/student providing him with instructions and then testing for learning and responding according to the outcome of the test. CML (Computer Managed Learning) refers to the case of the computer being used to collect, analyse and present pupil's results. CML is presently being used at the Polytechnic. Computer Assisted Learning (CAL) refers to a self-discovery learning process where the computer acts as an extenSion of the user's mind, directing him from one part of the course to another assessing him through. In CML, the learning material is not provided in the computer. Bajpai calls his application of the computer in the classroom, Computer Enhanced Learning (CEL) [32,p.412]. The author agrees with Bajpai's definition or name because in this type of application, the computer does not revolutionise the teaching methods nor does it attempt to replace the teacher; it simply enhances the present teaching /learning methods. How does the computer enhance learning? Section 4.1 is a report of a project which is trying to answer this question. The section below looks in more detail how the computer actually achieves all the credentials it has and reveals to a certain extent, what really took place in the classroom in section 4.1.

These styles and many others are being used in different parts of the world in computer associated educational projects. Most of the projects are involved in the production or use of educational software.

The MIME Project at Loughborough University, see [31], [32], and [36] was set up with the aim of producing software units on Mechanics for 'A' level and first year university students. The Project has so far produced 13 CEL units on Mechanics, 5 CEL units on Statistics and some units on Pure mathematics. The software is written in Basic and a little of Machine language. The software allows interaction as much as possible thereby making it possible for students to learn through their own experimentation and also making available to the classroom near real-life situations which make learning easier and enjoyable. As has already been mentioned, these units are presently being used in different parts of the world including the Polytechnic in Malawi.

The CALM Project (Computer Aided Learning in Mathematics) [37] at Heriot Watt University in Edinburgh (Scotland) provides another practical example of software development in the United Kingdom. The software is written in the programming language of Pascal. The basic structure of the CALM software has,

(a) a theory section - a series of screens of notes to consolidate the lecture,

(b) a worked example section - as a demonstration of methodology and,

(c) a weekly test section - for evaluation and activity on the student's part. Details of CALM are given in [37].

CEL is making a significant impact at the City University for first year students in Mathematical Science, in which learning is encouraged through self-discovery and guided laboratory work. The original stimulus was provided by Bajpai and the MIME Project but further improvements have been made through the ideas of Beilby [38]

There are several similar projects in other universities in the United Kingdom and other western countries. The CATAM project (Computer Aided Teaching of Applied Mathematics) was launched at Cambridge University in 1969 see in [18] and its aims and objectives are along those of MIME and CALM projects.

As may be noticed, most styles of computer based learning are similar and have the same aims and objectives. The difference comes in the presentation and naming of the software or project.

3.3.5 <u>The Computer in the Classroom.</u>

The roles of the computer in the project, section 4.1, were;

(i) Illustrative,

(ii) Instructional,

(iii) Revelatory.

We shall now look at each of these paradigms individually and see how they were achieved at the Polytechnic, bearing in mind the advantages computer enhanced learning has, as outlined earlier in 3.2 i.e.

(i) interactive nature of computer enhanced learning.

(ii) the ability in computer enhanced learning lessons to stop, review, repeat and store the learnt material.

(iii) the possibility to change parameters, thereby having different simulations of models,

(iv) as an aid to the teacher i.e. a powerful electronic 'blackboard' in bringing near life situations to the classroom,

(v) individualised learning.

(i) <u>The Illustrative Role</u>

This is the role where the computer is used with already prepared software. The teacher uses the computer to illustrate some concept during a lecture [CEL] or students at their own time can see the illustrations [CAL]. When the computer is used by the teacher, the interactive nature of the CEL may not be apparent. He can however stop, repeat and discuss the illustration depending on the students' response. On the BBC micro, using the MIME packages, pressing the ESCAPE button can get you to the 'current status page' and a re-run is possible. Pressing the BREAK button can get you to the main menu and the user can go to any section of his choice. The PSB (Press Space Bar) instruction at the right hand corner holds the present page allowing viewing and progress of the lesson to be controlled by the student.

Sometimes students have problems imagining real life situations which they have never come across. In Malawi, for example, most students will never have visited an airport to see a plane landing. For such students to imagine things like touchdown velocities, taxiing velocities, runway length etc. will not be easy. They get slowed down by trying to build a picture in their minds such that they miss the basic theories of motion involved in the example. It is expensive and difficult for all mathematics teachers to arrange visits to the airport or such educational places. Computer enhanced learning packages successfully bring to the class simulations of real life situations of that kind. The high resolution graphics output in modern microcomputers allows students miles away from real things to see them in the classroom as and when the teacher or the student requires it. Figure 3.3, an extract from Linear Motion, shows one such case.

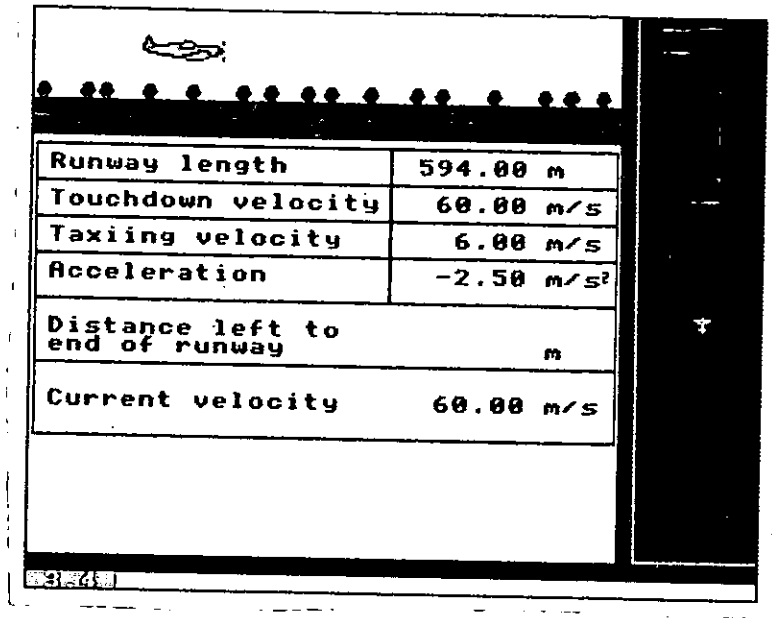


Figure 3.3

Students can see the plane come to land like in a movie, they can also see it in plan on the right hand side such that the distance left to the end of the runway can also be seen. The touchdown velocity is entered and the current velocity i.e. as the plane slows down, is seen to drop so is the distance to the end of the runway. With such <u>illustrations</u>, students don't have the problem of creating pictures earlier suggested. Since they can see on the screen, hear from the lecturer and prove the calculations, students' learning has stronger foundations.

(ii) <u>The Instructional Role</u>

Programmed learning is a form of Skinner's theory of conditioning, see [21]. Whether in the form of text as in [3], [13], [14] and [24] or CEL packages, the nature of presentation is more or less the same. The subject matter is broken into several small learning tasks and concentration given on each in turn, rewarding success for reinforcement and holding the flow of the process if no progress is shown. In holding the lesson, more exercises may be given until a certain level of understanding is achieved. In that way, there is an <u>immediate</u> evaluation of a student's progress thereby improving the learning/teaching efficiency.

When a package is used for instructional role, the computer (to the student) acts as tutor or mentor of unlimited patience and hence drill and practice is easy to achieve. How exactly is this achieved? The end result of the data entered in figure 3.3 above is shown in figure 3.4, the plane crashed at the end of the runway, i.e. due to inertia caused by high touchdown velocity, the plane failed to negotiate the corner at the end of the runway and crashed.

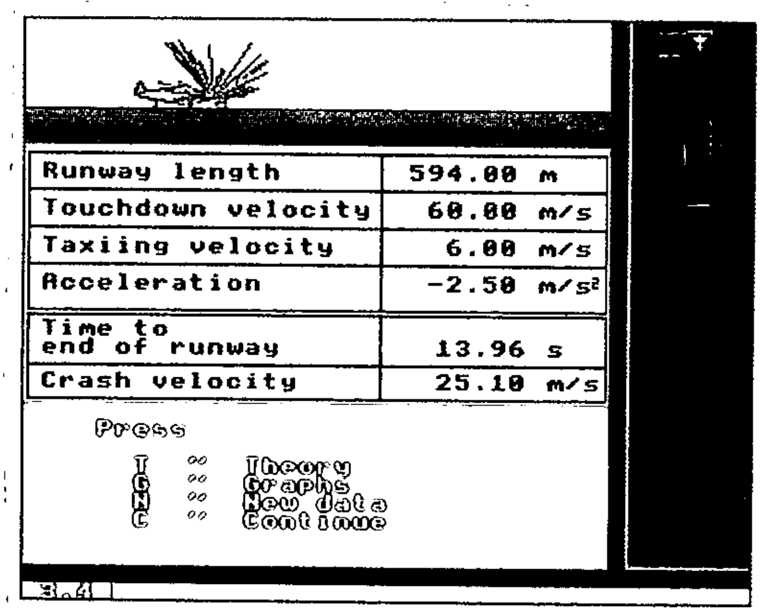
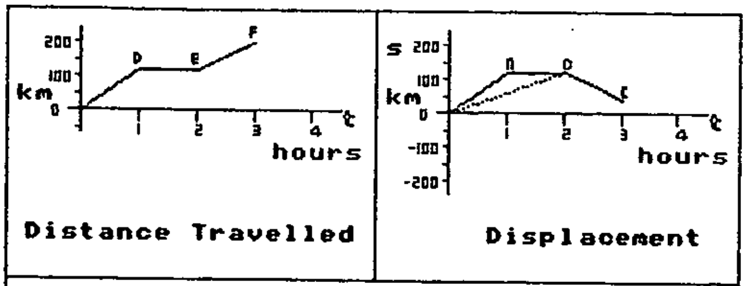


Figure 3.4

The package then asks the student to press T, G, N or C for theory, graphs, new data and to continue respectively. This makes the student an active member of the learning process. Pressing T, the student is able to see the theory behind what he is seeing i.e. the formulae derivations used to predict acceleration required to make maximum use of runway. Pressing G gives the v-t and s-t graphs for present data. N allows the student to enter new data by varying runway length, touchdown velocity, taxiing velocity and acceleration. Through such new data the student can enjoy the lesson seeing that his data successfully makes the plane land or not. There is a recreational element in the lesson at this stage. Button C obviously gets you out of the present section and takes you to the next one or the main menu. The computer to the student /teacher acts as a powerful electronic 'blackboard' accessing near real life situations.

Computers also help clarify certain concepts through orderly presentation which is difficult and time consuming for teachers. Figure 3.5 for example, clarifies the difficult concepts of distance travelled and displacement. Students, the author observed, find these terms and interpretation of their graphs difficult to understand.



Time Range hours	Average Speed km/h	= Slope of	Average Velocity km/h	= Slope of
0 – 2	60.0	OE	60.0	OB
0 – 3				

Figure 3.5

With figure 3.5 in view, students can see or be made to see that distance travelled is a scalar quantity while displacement is a vector quantity. The teacher could take advantage of the two graphs and stimulate thought by asking such questions as, why does the graph between 2 and 3 hours i.e. EF, have a positive gradient on the distance travelled graph while within the same time on the displacement graph the gradient is negative? The teacher could also use the pause allowed on the table to ask students to answer the questions i.e. calculate average speed, determine which slope and on which graph, average velocity etc. This would reinforce the theory ealier developed.

(iii) <u>The Revelatory Role</u>

The real purpose of Applied Mathematics which forms a larger part of Engineering Mathematics is to gain an insight into the real world by setting up mathematical models. Teachers often find it difficult, within limited time, to bring such mathematical models into real life situations. Most engineering students at the Polytechnic can develop and solve differential equations or difference equations but they have so far not seen or been made to see what those equations mean. Teachers at the Polytechnic are able to teach differential, difference and differential-difference equations but because of the complex calculations required, they are unable to draw or plot simulations of the mathematical models. With computers now in education, the teacher's effectiveness is enhanced in that computer programs can be written which can draw or plot the simulations of the models accurately. Students then find it easy to interpret the equations or the mathematical models.

To produce simulations, we start with a real world problem and then go on to create a mathematical model from which a computer simulation is made. Then the user uses the simulations to interpret the mathematical model or mathematical solutions. The whole process forms a cycle as shown in figure 3.6;

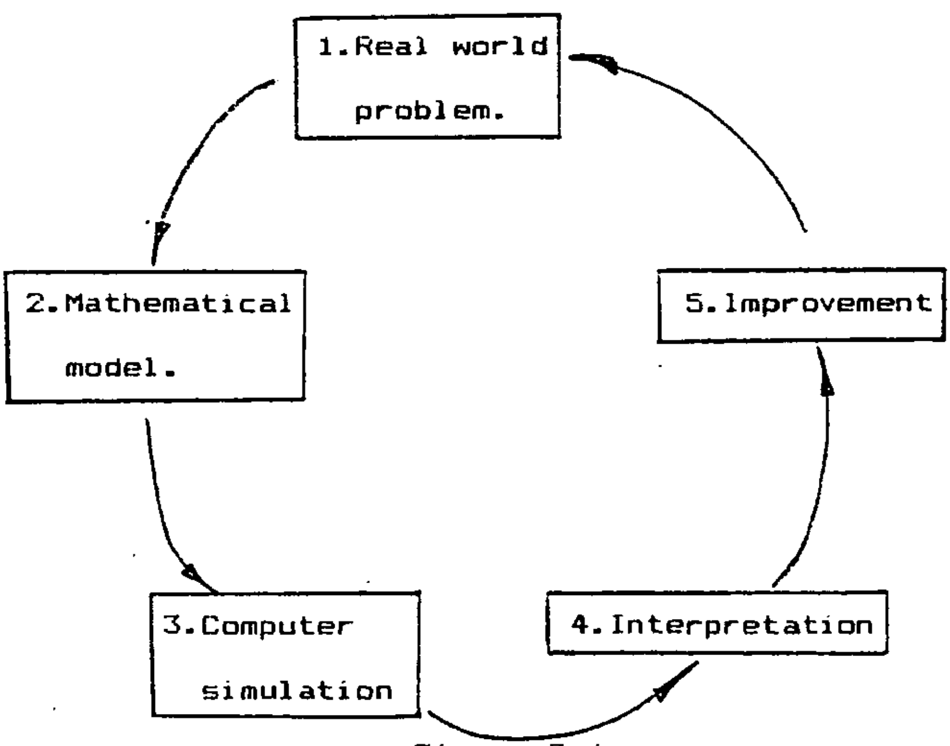


Figure 3.6

We shall now briefly look at an example of how the cycle may be followed for the eventual solution of a world problem.

1. World Problem

A zoologist for example may be interested in the distribution of foxes and rabbits or jackals and antelopes or any combination of preditor and prey interacting in an environment. Obviously the foxes will prey on the rabbits. Assuming also that there is no time lag, i.e. reproduction processes are normally distributed as the mortality rate, what are the chances that the two species will survive together in the same ecosystem?

2. Mathematical Model building

Let x be the number of rabbits

Let y be the number of foxes

Assuming there are no foxes i.e. y=0, the rate of growth of rabbits would be proportional to the number of rabbits.

i.e. $\frac{dx}{dt} \propto x$, therefore $\frac{dx}{dt} = ax$ where a is some constant.

If y is not equal to zero i.e. there are rabbits and foxes together, then the rate of killings (foxes killing rabbits) would be proportional to the number of foxes and rabbits

i.e. rate of killings $\propto xy$

i.e. rate of killings = bxy

therefore, rate of change of rabbits $\frac{dx}{dt} = ax - bxy$

therefore, $\frac{dx}{dt} = f(x, y)$

Assuming there were no rabbits i.e. x=0, then we will assume that foxes will have no food hence they would slowly die off. Therefore,

$$\frac{dy}{dt} = -py$$

If however x is not equal to zero, then the rate of change of foxes will be proportional to xy

i.e. rate of change of foxes = cxy

Therefore, $\frac{dy}{dt} = cxy - py$

Hence, $\frac{dy}{dt} = g(x, y)$

Therefore the rate of change of foxes with respect to rabbits will be

i.e.

$$\frac{dy}{dx} = \frac{g(x,y)}{f(x,y)} = \frac{cxy - py}{ax - bxy} = \frac{y(cx - p)}{x(a - by)}$$

We have a differential equation which we can easily solve. Equations are dependent upon the type of problem at hand. In other cases, we could end up with a difference equation or a differential-difference equation.

Solving the equation above, we have, $\frac{a-by}{y}dy = \frac{cx-p}{x}dx$

Integrating,

a log y − by = cx − p log x + log k

a log y + p log x − log k = cx + by

$$\log_e \frac{y^a . x^p}{k} = cx + by$$

Therefore, $k = \frac{y^a . x^p}{e^{cx} . e^{by}}$ ****

where k is not a function of time.

Grouping functions of variables together we get

$k = W(y) . Z(x)$

where $W(y) = \frac{y^a}{e^{by}}$ and $Z(x) = \frac{x^p}{e^{cx}}$

3. Computer Simulation

Plotting Z(x) against x and W(y) against y, solutions of x and y can be found from the corresponding curves, bearing in mind that on turning points both Z'(x) and W'(y) are equal to zero. The solutions of x and y may not be that simple to find and the plotting of equation **** for y against x may not be easy either hence computers are used to plot the curves of the model using the mathematical model as shown in figure 3.7.

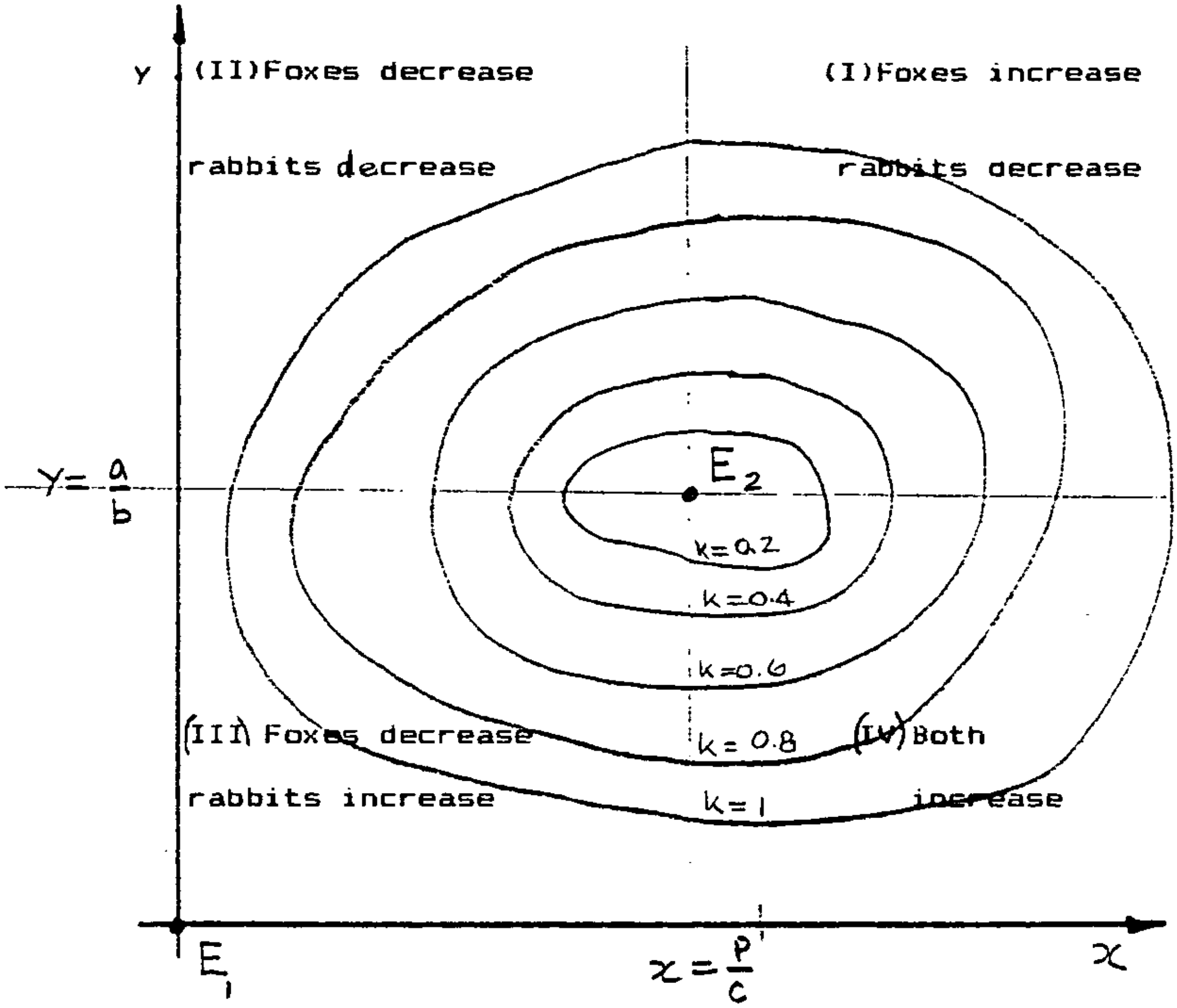


Figure 3.7

4. Interpretation

The next thing is to interpret the model. Questions like what does the diagram tell us in terms of rabbits and foxes? What do the two points E1 and E2 represent? etc.

5. Application or Improvement

Whatever ideas one may get from the model, improvements on the real world model can be made. For example it may be decided that for a more stable ecosystem, there will be need to increase the initial number of rabbits or foxes. Without computers such decisions would be difficult to arrive at let alone simulate. Other areas of simulation application include, weather forecasting, medical education, science, business, space, military etc.

3.3.6 Other Attributes

Some CEL packages have parts of some lessons where an element of game playing is employed. This is done to arouse interest and motivate the student into seeing the lesson as fun. He can relax and enjoy the lesson by playing a game. Consider the MIME lesson package on PROJECTILES and the section "Hit a Target",

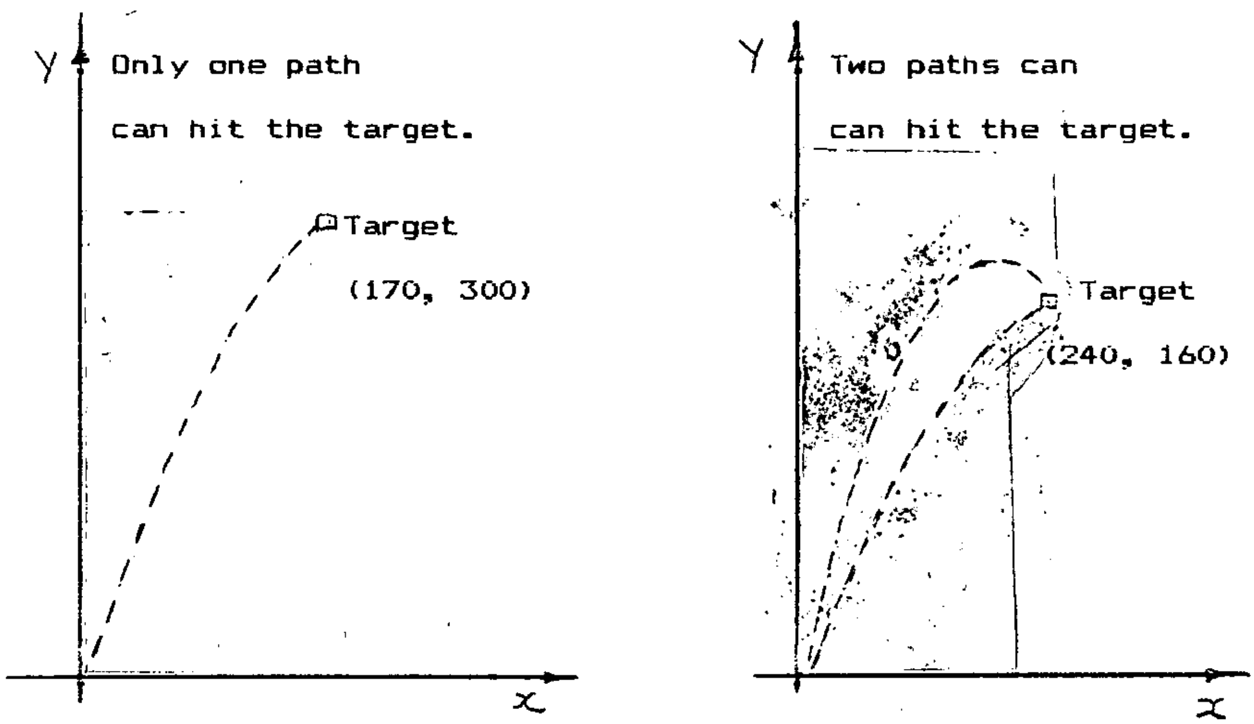


Figure 3.8

Students at the Polytechnic found this part of the lesson quite exciting because of the recreational aspect it has. The students got practically involved in estimating the angle of elevation which could make the missile hit the target. Student participation in this lesson is maximised. Interaction is also greatly utilised as messages are flashed on the screen as to whether the target has been hit or not. The coordinates given near the point help the student in the estimation of ~~the~~ ~~∠~~ required angle (if necessary).

3.4 CREATING COURSEWARE

3.4.1 INTRODUCTION

Some DO's and DON'T's in writing software units given by Bajpai et al [32,p.408-410] are fundamentally important in the writing of good educational software. Bajpai emphasises on having a definite aim for the software unit i.e. have definite objectives as to what the software will do.

Interaction is very important especially in packages. The interaction must be seen to involve both the teacher and the student, keeping their traditional relationship intact. Bajpai discourages the use of the micro as a textbook or conventional blackboard. However, he advises against the provision of long text on the micro as printed word must still have its place hence the overhead projector, the blackboard and handouts will continue to play their role as a media of presenting notes to students. The micro will just supplement this. In writing software, it is important to consider the needs of the inexperienced user. His mistakes must be taken into consideration i.e. the program should not fail if he presses the wrong button by mistake. He must be made to feel confident that he will succeed in using the software. This section briefly discusses the difficult task of writing educational software. Software need not be in the form of packages only but short and specific programs are also considered. The strengths and weaknesses of packages are also discussed. The need for teachers to write their own software has also been expounded.

3.4.2 COURSEWARE PACKAGES

These are usually characterised by length, sophistication and usually come in the form of packages or units. Units have the advantage that they may cover the whole subject and to a reasonable detail. They are well documented and the good ones provide interaction in the form of questions and answers, reinforcements i.e. rewards and punishments. The details of the layout of a lesson in packages are given in depth by Bajpai et al [31] and Ruth Landa [34]. Points raised in these references are worth considering especially by those intending to go into software writing.

With all the advantages packages have, they have some weaknesses. Most packages are published and the software is generally protected from copying (technically) and through copyright restrictions. Due to this fact,

(a) program alteration is almost impossible which can be a problem at certain times; for example when using one of the MIME Project units on "Vectors" in Malawi, students were not helped much by considering displacement vectors of places they did not know. Displacement vectors from London to Norwich, Oxford, Birmingham etc. were given with their values; it was difficult for students to appreciate the values because they did not have a real life picture of the United Kingdom. Local names could have made a bigger impact on them. The teacher could easily change this if it were possible but since the programs were protected, this was not done. There were several occasions in the packages where one would have liked to change the notation, terminology or even the method.

(b) Since these programs are non-transferable, they can prove expensive considered at national level, i.e. each school will require a separate copy. Teachers are restricted from extending the material using their own ideas. As a result of this, teachers may sometimes get discouraged and even decide not to use the packages at all.

3.4.3 <u>WHY TEACHERS SHOULD WRITE SOFTWARE</u>

Just like everywhere else in the world, teachers at the Polytechnic are very busy and loading them with another job of writing software, will be a difficult task but the advantages of teachers writing their own software are equally attractive. Software written by teachers themselves;

(i) is more suited to their own syllabus, methodology, terminology and notations,

(ii) helps the school save money which could have been spent on buying similar software,

(iii) can be of help to other nearby schools as well since copies of the program(s) can easily be made available to them,

(iv) has specific applications i.e. the teacher knows where, when and how to use the software.

It must be realised that the programs need not be long and sophisticated to achieve the above ideas. The program below can be used in a Statistics class to generate, at random, tosses of a coin to any number entered. The results printed on the screen can be counted and used to demonstrate probability theory.

```
10 CLS
20 INPUT"Enter number of tosses"N
30 FOR J=1 TO N
40 K=RND(2)
50 IF K=1 THEN PRINT "H" ELSE PRINT "T"
60 NEXT J
70 END
```

This is a simple program, short and specifically needed for the random variable in line 40 the result of which is printed as Heads (H) or Tails (T) in line 50. The nature and application of this program supports the argument raised in (iv). The program can actually be improved to print "Heads" or "Tails" by accordingly changing the "H" and "T" in line 50. Another improvement is to let the program count the number of heads/tails, calculate the relative frequency of heads/tails etc. This can be achieved by adding more lines to the program e.g. IF K=1 THEN C=C+1 (where C is a counter of number of heads/tails, set to zero at the beginning of the program); a line to count the total number of tosses and a line to calculate the Relative frequency given by the formula,

$$\text{Relative Frequency}= \frac{\text{number of Heads/Tails}}{\text{Total number of tosses}}$$

3.4.4 SIMPLIFYING THE TASK

(a) Short programs, as demonstrated above, can easily be written, and can be improved through consultation with other members of staff. Several such programs can be chained together to form packages which students can use in their own time.

(b) Involving students at the Polytechnic in the production of educational software. Instead of asking students to write programs which just perform a task e.g. find the average of several numbers, more constructive programming with the basic aim of "writing programs to help others learn from it" could be more valuable both to the students writing the programs (will improve their skills) and to those who will use the program (will learn from them). This is the approach adopted by some universities in the United Kingdom. Students in that case appreciate the application of their programs. Teachers can also improve students' programs and use them in their teaching or make them available to other institutions.

(c) There are published "Procedures" which teachers can use to develop software. Software writing is a time consuming and difficult task. It is not as easy as it looks to produce animated figures or even draw scales on the screen, yet these are usually basic necessities for simulations and graphical work respectively. Because of their importance, some experienced programmers have presented such procedures to computing and educational magazines, e.g. [33], for publication so that others may benefit from them. The program in Appendix 11 uses some procedures written by Hunt [33]. The author has little experience in programming but found Hunt's procedures easy to use and achieve what he wanted. The Mathematical Association in the United Kingdom has a booklet with programs [34] in Mathematics and Statistics which are also available for use.

3.4.5 CONCLUDING REMARKS

With a short period's training in computing, programs like those in Appendices 11 and 12 were written. The author strongly believes that spending more time on improving the programs, and reading more on computing can enable him write better quality programs. Knowledge of other high level languages is also necessary for the improvement of program efficiency. In summary, software writing can be achieved at the Polytechnic's Teachers' Centre and the following points need to be seriously looked into;

(i) Those involved in writing programs should consider learning other high level languages to help improve program efficiency,

(ii) Teachers of computing should consider giving assignments which will eventually help other students learn from what the present students are doing. Some programs can only help do a task e.g. the program in Appendix 12 can integrate a function using the Typical Rectangles method but does not help anyone using it understand the method while the program in Appendices 11 and 12 can help a student understand Trigonometric and other functions. The latter is the method which the author is advocating,

(iii) Procedures from other journals/magazines should not be used as they are, but be adopted into the teachers' own programs to achieve certain effects. Teachers should consider sharing written procedures and discuss improvements on them. As a starting point, some simple procedures are given in Appendix 13 which can be used as a demonstration for drawing a sine function. As may be observed, after 'running' the program, on the menu are options of other possible procedures for a complete lesson on trigonometric functions. The same procedures provided in this program can be used to draw the other trigonometric functions ie cosine, tangent and their combinations. The procedure, PROCpart in line 1740 is where the computer can branch to the new procedures which the interested teacher may have written. This can easily be achieved by changing PROCgraph and PROCsine (notes about the sine function). In PROCgraph, the changes could be in lines 810 and 860 which could be changed to read ;

```
IF G=1 THEN Y=A*SIN X: IF G=2 THEN Y=A*COS X:
IF G=3 THEN Y=A*TAN X: IF G=4 THEN Y=A* ( ) ELSE Y=A* ( )
```

( ) :The contents of the brackets would depend on the inputs in the PROCEDURES, i.e. PROCphaseangle and PROCsuperposition.

The other case is where the teacher can delete PROCsine and change PROCpart to choose his own procedures other than trigonometric functions. This, however, would require, among others, some changes in PROCmenu as well.

CHAPTER 4

FIELD SURVEY

CHAPTER 4 FIELD SURVEY .

4.1 THE MALAWI POLYTECHNIC COMPUTER ENHANCED LEARNING PROJECT.

4.1.1 INTRODUCTION.

The Malawi Polytechnic is part of the University of Malawi. It encompasses the Faculties of Applied Studies, Engineering, and Commerce. These faculties are subdivided into departments as illustrated in figure 4.1;

FACULTIES	DEPARTMENTS
ENGINEERING	Electrical Mechanical Civil
COMMERCE	Business Studies Management Accountancy
APPLIED STUDIES	Mathematics and Science Language and Communication Technical Education

Figure 4.1

Apart from these Faculties which are run by the University of Malawi, the Malawi Polytechnic Board of Governors runs the Evening Classes covering wide ranging subjects, and technician courses (see chapter 1.2).

The three faculties offer diplomas and degrees to students who do well after three years (Diploma) and five to six years (Degree). It must be realised that some departments are actually service departments for example, the departments of Language and Communication and the Department of Mathematics and Science serve the entire college on mathematics, sciences, language (English) and communication (report writing, communication studies etc.). The figure 4.2 gives a summary of the different courses and qualifications offered at the Polytechnic (1987).

FACULTY	DEPARTMENTS	COURSES
APPLIED STUDIES	Language and Communications Mathematics and Science Technical Education	Service Dip.Pub.Health B.Sc(Tech.Ed)
COMMERCE	Business Studies Accountancy Management	Dip. Bus.Stdies B. Commerce Dip.Management
ENGINEERING	Electrical Mechanical Civil	Diploma and B.Sc(Eng)

Figure 4.2

Of the courses listed above, the longest course is the Bachelor of Science degree in Engineering which takes 6 years. The Bachelor of Science (Technical Education) and the Bachelor of Commerce degrees take 5 years while all the diploma courses take 3 years except the Management diploma which takes only 2 years. In Malawi, unlike some countries, students go to university after their 'O' level examinations.

The 'O' level results greatly determine what course a student will take. With one university in a country whose population is approximately seven million (1977), the competition for places in the university is very high. There is, at present, little or no deterministic value placed on course work in the national 'O' level examination (Malawi Certificate of Examinations or MCE). There is coursework in the course but this has little or no effect on the final result. Emphasis is therefore placed on the result one has at the final 'O' level (MCE) examinations. The Malawi Certificate of Education (MCE) Board recommends that a grade of 1 and 2 be distinction. Grades 3, 4, 5 and 6 are credits whose value decreases with numerical value e.g. 3 is a better credit than 5. Grades 7 and 8 are pass and marginal pass respectively. Grade 9 is a fail. The aggregate grade for the best 6 subjects is very important for a students chance of selection to the university i.e. the university considers first good all-round students. English being a compulsory subject for a certificate i.e. irrespective of how well you do in other subjects, a failure (grade 9) in English may mean that one may not be selected. The University Office in conjunction with the MCE Board pick students with the best overall grades, the respective colleges of the university; Chancellor College (education, arts and science), Bunda College of Agriculture, The Polytechnic (engineering, technical education, commerce and technician courses) pick their students according to the grades in their principal subjects. For the Malawi Polytechnic (engineering and technician courses) the principal subjects are Mathematics and Physics (see Appendices 6 and 7). The aggregate grade is the sum of points of the best six subjects including English. A student with a smaller aggregate is considered better than another with a bigger one. To a large extent, only this one performance is used to determine one's intellectual capabilities. This has mescess to a certain extent but there is an error element in it. Some students have been found to work hard for the exam only. Most students have even resorted to memorising (rote learning) the examinable part of the syllabus and indeed some have managed to pass well while their normal ability is generally low. One may argue that the probability of this happening while one is weak, i.e. memorising and passing, is low and that might be right as this would involve an upward task of retaining what one has read and reproducing it at the right time and in the right way.

The other end of the scale is different, this is where a student does not do as well as he normally does. This is the probability that an intelligent student will, on an examination day be confused, write while sick, not be in the right mood for the exam etc. and thereby perform below standard. The author has seen this happen in his school time. He remembers several brilliant friends who failed to pass as well as everyone expected. An element of this reasoning can be seen in some students on the technician side at the Polytechnic.

When students join the Polytechnic, they are initially catagorised by their 'O' level performance. In other words, students come to the Polytechnic and register as diploma/degree students in engineering or business studies while some register as technicians and secretarial students. For the engineering and business, after three years, another exam is held - the diploma exam. Out of 60 students in each course only 14 are selected to do the B.Sc. (Engineering) and another 14 for the B.Sc (Technical Education). In the business studies section, 25 students are selected to do the Bachelor of Commerce degree. Selection is in order of merit. The rest of the students go on to join industry in employment.

Technician students attend their courses on block/release basis. After each academic term, they sit an examination which improves their position in terms of grade or rank. This goes on for 4 years after which they sit the final City and Guilds exam.

This thesis concentrates on the mathematics taught to both the technicians and diploma students in their first three years in college. There will be little or no reference made to students in the business studies section although much of what is discussed will equally apply to them as far as mathematics is concerned.

Upon entering the Polytechnic, all students in the engineering department undergo a common course run by the Faculty of Applied Studies. In the common course students are taught basic engineering sciences. It is 'A' level oriented and includes courses in Mathematics, Language and Communication, Mechanics, Electrical Science, Physics, Materials, Chemistry and each of these subjects has both tutorial and lecture sessions.

Diploma students are divided into four groups - A, B, C and D. This is done for convenience i.e. to cut the number of students down to 15 per class during tutorial sessions. The four groups are identified as D1A, D1B, D1C and D1D. The meaning of the abbreviations are D for diploma/degree; 1 for year one; and A, B, C, D are the group names. From now on, in this thesis these groups will be referred to by these names.

Technician groups are so named in accordance with the courses offered after the first year common course. The courses offered are Motor Vehicle Technology, Welding, Electrical, Mechanical, Printing and Telecommunications technologies. These are generally abbreviated to MVT, WT, ET, MET, PT and TT respectively. These abbreviations will be used for the above groups in this thesis.

The teaching of the first years in the common course is unsegregated. Technician groups are mixed with diploma groups during lectures. For example, in the 1986/87 academic year, D1C and MVT had lectures together in mathematics and other subjects. D1D and WT combined to form another group. Similarly the other groups D1A and B were combined with the other technician groups to form 4 distinct lecture groups. Basically, the common course is run by the Departments of Mathematics and Science, and the Department of Language and Communications. These departments teach the mentioned subjects to all first years without particular regard to the background or learning speeds of individual groups. At the end of the academic year, they all sit the same paper and are graded in the same manner. The common course was designed to act as a bridge between the 'O' level through 'A' level and the engineering courses.

The mathematics taught in the common course is equivalent to the Technician Education Council level II mathematics syllabus - TEC U 80/691, 692, and 712 in the United Kingdom and this is taught up to the third years of the diploma and technician courses. Holders of the diploma in engineering are usually employed at technician level although at times may stand a better chance of promotion than their counterparts. All in all, diploma and technician groups undergo similar courses, the difference being that technicians are practical oriented. Technicians spend most of their time practising in industry while their counterparts spend more time on sciences and theories behind the practical aspects. This is the major reason why technician courses last four years instead of three or less. It must be noted that in industrial terms both groups are regarded as technicians. In this thesis therefore, the term "technician mathematics" refers to all the mathematics learnt between years one and three for the diploma students and between years one and four for the technician students. This section of the thesis reports on the "pilot" project carried out at the Malawi Polytechnic. The project was launched in October 1986. The aim of the project was to see how Computer Enhanced Learning(CEL) can help in third world education. The pilot project started off with 3 BBC computer systems which Professor A.C. Bajpai through Loughborough University of Technology had donated to the Malawi Polytechnic for the project. CEL was adopted for the pilot project to achieve the following objectives;

(i) to improve teaching methods and as much as possible ease the teacher's work,

(ii) to make learning easy and enjoyable for students,

(iii) to improve syllabus standards,

(iv) to provide students with an alternative to the source of information apart from the teacher and the book both of which are not easily accessible and easy to understand.

This chapter therefore describes how the project was carried out, the methods employed to carry out the tests and how results were obtained, analysed and appropriate conclusions and recommendations made.

4.1.2 METHODOLOGY

The micro as a unit may alone not be that useful. There is need for proper software to run in the machine. Preparation for educational software is both difficult and time consuming. Good software can best be attained by a combination of experience in teaching and expertise in computer programming. Missing one of these can lead to software which is either confusing or one which fails to meet its objectives. Since different countries have different educational systems, there is need for software to be developed for specific areas (see chapter 5, Teachers' Centre). Countries in Europe and America have done quite a lot in the production of educational software for their countries. Africa and the rest of the third world have done little or nothing in this sphere. From the success of this new technology in the western countries, third world countries will soon have to follow suit. Already some countries in the third world have received grants and gifts in the form of computers. The Malawi Polytechnic received more than 24 IBM Computers from the United States of America and 3 BBC computer systems from Loughborough University in 1986. This trend is expected to continue. Will the Malawi Polytechnic use these computers for the teaching of programming only? An alternative use which this thesis (project) suggests is to use them for the teaching of mathematics and other subjects. Before looking into the main report, we shall examine the different ways in which computer based teaching/learning can best be achieved. Alan Maddison [15] classifies computer based teaching/learning into three categories.

(i) <u>A computer package or lesson which controls the student and the whole lesson.</u>

In this method, the computer provides stimulus and assesses the student's response to decide what stimulus to give next. The lessons are divided in sections or frames and evaluation is done after each frame. The result of the evaluation may decide a repeat of the frame or a continuation. If a student used the MIME PROJECT(Micros in Mathematics Education) packages with the self-teaching notes, the lesson would fall under this category. This method is appropriate when there are small numbers of students and the school has an adequate number of computer systems. Where overcrowded classes are the order of the day and national economic problems affect the educational system, this method may not be practical. If resources are available this method can be very effective because each student would be assigned a computer on which he independently would follow lessons at his own pace. The teachers role in that case changes tremendously as he becomes more of an adviser than a traditional teacher.

(ii) <u>The teacher versus the computer - no student</u>.

An alternative use of the micro is where a teacher alone uses the micro to prepare his lesson. He may run a disk or tape just for recap, i.e. just to update himself for more efficiency when he meets his students. Reviewing a lesson on the micro is quicker, easier and more motivating than alternative methods e.g. reading a book.

The teacher may also use the micro to produce up to date handouts which may be difficult or impossible to update on the stencil. This is because text and graphics can easily be edited and revised on the micro hence a teacher's notes or handouts can always be up to date. Where accurate drawings and diagrams are required the micro can produce them quicker and more efficiently. Most teachers find it difficult to draw accurate diagrams on the board due to lack of resources, experience or because of pressure of work.

This second use of the computer in education can actually be used at any time irrespective of the method of teaching being employed. This is because it is always better for the teacher to be ahead of his students to enable him answer their questions. The computer is therefore a useful tool to every teacher whether he uses it in class or not.

(iii) <u>The teacher using the computer as a visual aid (sometimes referred to as the electronic blackboard)</u>.

This third method of computer based learning is where the teacher generally teaches using the traditional teaching methods and then turns to the computer to utilise the animations and graphics capabilities of the micro. The teacher may also use the micro to summarise the lesson, introduce it or provide notes (from the screen) or he may use it through out the lesson. The whole class has its attention on the screen where the teacher refers to it time and again. This may be disadvantaged by the size of the screen but with a reasonable number of students (a maximum of 16) one screen can serve the purpose. An alternative method is to use several screens fixed at convenient positions on the ceiling or the side walls. For third world countries, this method may be the best of the three as it does not strain the school's budget so much. The school or college would just need 2 or 3 computers and several screens well arranged in a room and an appropriate timetable set to enable the whole school to utilise the computers. This is the way Biology, Physics and Materials laboratories are run to ensure maximum utility for schools. The other methods mentioned above would not work in such a case. The advantages of this method may be summarised as;

(a) the use of one computer simultaneously benefits many students, hence the school would not have to buy many computers for the lessons and thereby saving money for other priorities.

(b) class control is easy for the teacher and he has more time to do examples than in a traditional lecture method. All students participate in the lesson as students' attention is directed on the screen.

(c) the multi-media input i.e. the teacher's voice, computer graphics and animations etc. bring more reality and motivation to the lesson.

(d) this method gives the teacher more calculation speed. The students see the computer through their teacher hence as the micro calculates, students develop more confidence in their teacher thereby making him more effective.

With these advantages, this method was chosen for the CEL project at the Malawi Polytechnic. The section below describes how this was done using the technician groups mentioned in the introduction.

(a) THE EXPERIMENT.

Upon hearing of the project, the Malawi Polytechnic organised a Research Committee comprising five other members of staff to help the author with administrative matters and also hear progress reports. The committee agreed to meet every fortnight to review the progress of the project. Two groups were set aside to be taught using CEL and the other two were identified as control groups. Apart from that, during the 5 weeks, it was arranged that all first year students do the same topic. This was done for consistency reasons. The topic chosen was LINEAR MOTION. The groups to be taught using CEL were D1C and MVT. The control groups were D1D, PT and WT. It was agreed that at the end of the experimental period, objective questions (multiple choice) be set up and given to all first year students, i.e. including those not involved in the experiment. It must be noted that D1D, D1C, WT, MVT and PT were a sample of the first year population. The author came up with the project when these students had already been grouped and therefore it was not possible to make the samples as random as one would wish.

For the CEL lessons, it was difficult to hold a class for 32 students, most of them would not see what was on the screen. Hence the CEL group was divided into two groups of 16 each. The control groups were left as usual.

(b) Class organisation of CEL

The room temperature in Malawi is about 25 C. The seasons i.e. summer, winter, spring and autumn, are not as distinct as they are in the sub-tropics. The seasons are generally classified as the hot, cold and rainy seasons. The rainy season is from November to April. The cold season is from May to July and the hot season from August to October. In the cold season temperatures can go as low as -1 degrees Celsius in the night and 15 degrees during the day. The rainy season and the hot season don't significantly differ in terms of temperatures. Temperatures during the hot and rainy seasons can go as high as 40 degrees Celsius. These high temperatures greatly affect students especially in the afternoon lessons when it is hottest. Students, soon after their lunch, on a hot afternoon, have the tendency to doze off in the afternoon lectures. This apparently is a problem which Malawian educationalists have to seriously think about and find a lasting solution to it.

The survey was carried out in October (the hot season) and the experimental group had their mathematics lesson from 1:30 pm. It was very hot indeed. The control groups had their lessons in the mornings when it was a bit cooler. This arrangement was not planned for the experiment, it was just by chance.

The experimental group had their lectures in a special computer laboratory which was set so as to accommodate 16 students at a time. The seating plan for the room was as shown in the diagram below. The computer system was placed in front of the class, on a raised trolley.

Figure 4.3 shows a plan of the laboratory where the experimental group had its lectures. Notice;

(a) The zig-zag seating arrangement. This was done to enable every student to clearly see the screen.

(b) The overhead projector was used to avoid chalk dust getting into the computer system.

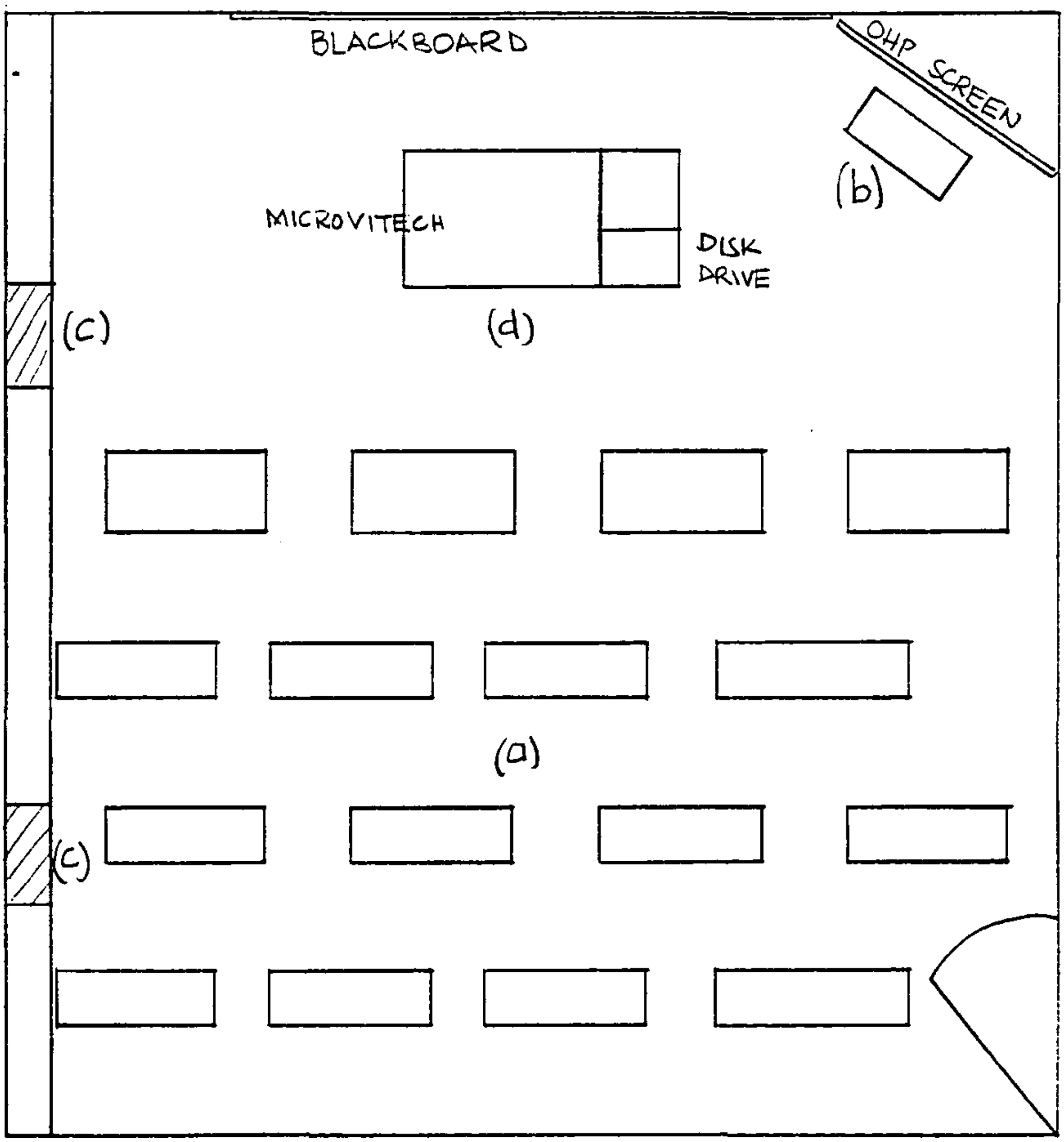


Figure 4.3

(c) The 2 side bench BBC computer systems which were used in the evening classes.

(d) The computer system used for teaching was always infront, on a raised trolley, details of which are given overleaf.

With the screen raised to a height of 1.5 metres as shown, 16 students were able to see, without difficulty, all that was on the screen.

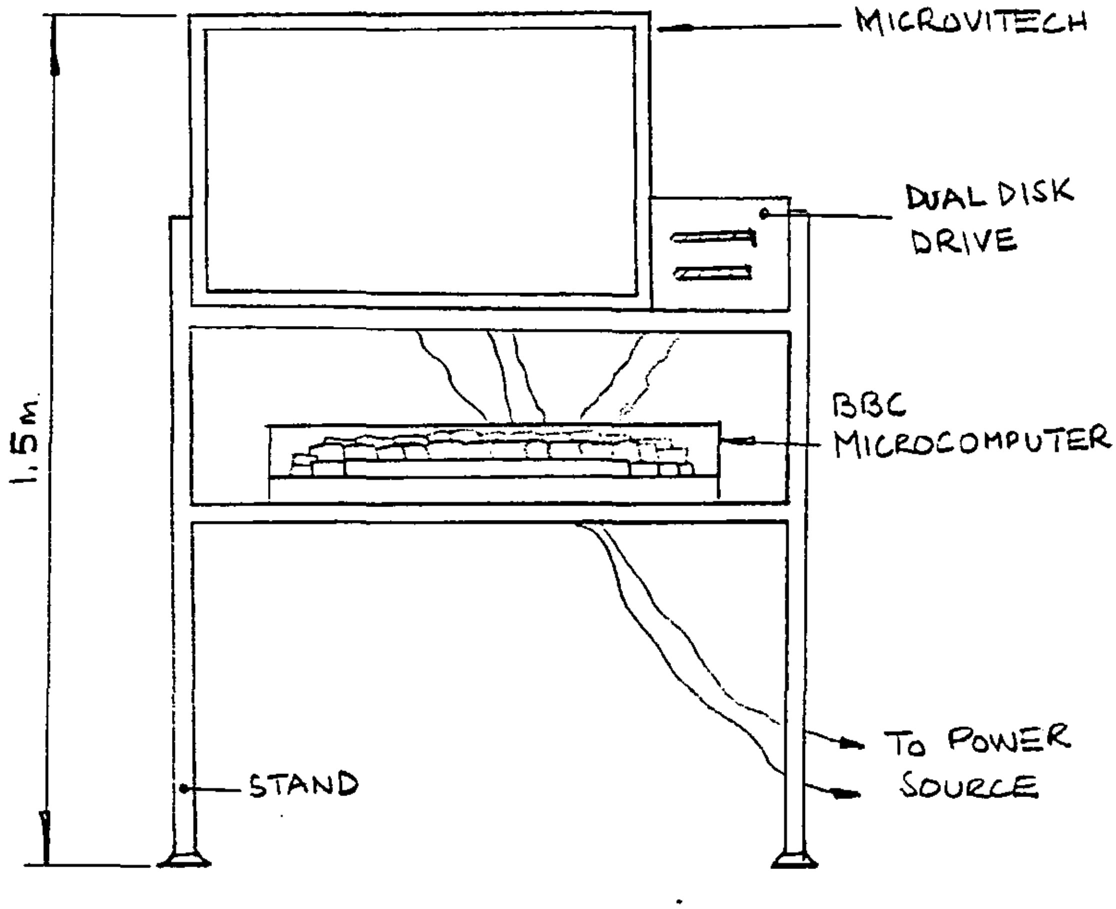


Figure 4.4

Figure 4.4 shows the computer system on a trolley. To prevent chalk dust damaging the computer system, an overhead projector was used for any necessary comments or notes from the teacher.

(c) THE LESSON PLAN

It was discovered that the lesson plan for the experimental group could not be exactly the same as that for the control group. The control groups' lesson plan comprised of summarised notes of the topic which the teacher could scan through as a reminder of the whole lesson.

The CEL lesson plan comprised of headings and instructions as to what should be done next. There wasn't much detail in the lesson plan as all details were in the package. For ease of reading, the lesson plan was placed on top of the microvitech and different colours were used in its preparation. The different colours were used to help the teacher read from a distance as to what he should do next. This helped the teacher overcome the problem of "stopping to read" which induces loss of confidence in most students for their teacher. All headings and "action words" (requiring the teacher's action) were in capital letters and in red colour e.g. words like COMPUTER, STOP, EXPLAIN, ADD NOTES, EXERCISES etc. This was discovered to be very helpful because in CEL lessons, it is very important for the teacher to know when to bring in the computer otherwise negative results may be obtained if the micro is used without timing. The teacher needs to prepare before hand the orderly interchangeability between his lecturing and the computer usage. With a properly set lesson plan, a teacher can at a glance look at it and know what to do next without necessarily having to stop the flow of the lesson.

(d) EVENING CLASSES

The experimental group was voluntarily allowed to come in the evenings to run the lessons at their own pace. The students were allowed only on the evenings of the lecture days. The turn up for the evening classes was reasonably good in that out of 16 students, a minimum of 10 students turned up on every other evening class. These evening lessons were very helpful to students who found the afternoon lectures a bit too fast for them.

It was noted that students came to the evening classes with different reasons other than the lesson alone. Whatever the case was, one thing true was that this method had aroused interest in them for their lessons. Asked as to why they came for the evening classes, some students said they came;

(a) to reinforce what they had learnt in the afternoon,

(b) because they wanted a first hand experience on the computer,

(c) because they wanted to try their own examples because they felt the teacher had left other cases untried,

(d) they benefitted from the discussions with other students in the evenings. They enjoyed the freedom given to them in the evenings where the lessons were informal and they discovered new ideas from discussion with fellow students.

4.1.3 RESULTS

The use of the computer in education is not geared at revolutionising present teaching methods, it is meant to improve present methods by integrating it in the system. The computer or any other method of teaching cannot by itself make bad teaching good or improve ill-chosen teaching objectives. The computer is there to aid and not replace the teacher.

The results of this survey, therefore, do not compare teaching methods or compare the teacher and the computer but actually give a revelation of how advantageous it could be if the computer were integrated in the present teaching methods by utilising its capabilities.

After four weeks of lectures, the groups of students mentioned sat an exam. The exam consisted of 27 multiple choice and 3 other questions. Below are the ranked grades for the different groups. The question paper for these grades is given in Appendix 8.

RANK	GRADES (%)				
	D1D	D1C	MVT	WT	PT
1	85	95	81	78	83
2	83	85	69	71	77
3	77	80	68	64	75
4	74	80	66	59	74
5	73	75	66	56	58
6	71	73	64	54	57
7	70	71	64	53	55
8	70	70	63	46	53
9	68	69	62	42	48
10	67	67	61		47
11	61	67	58		46
12	48	65	57		45
13		55	48		43
14			45		33
15			40		

Table of grades for the exam in Appendix 8.

4.1.4 DISCUSSION OF RESULTS

The statistical analysis of the above results is given in 4.3. In this section we deal with observatory results which are not numerical.

(i) Class Means

It is interesting to note that diploma students D1C and D1D notably have higher class means than technician groups PT, MVT and WT irrespective of the method of learning. D1C and D1D had means 73% and 69% respectively while MVT, PT and WT had 61%, 57% and 58% respectively.

(ii) Standard Deviations

The two experimental groups D1C and MVT both had lower standard deviations at 10% than the conol groups, D1D, WT and PT i.e. 11%, 11% and 15% respectively. The lower standard deviation indicates the closeness of the grades around the mean.

(iii) Highest and Lowest Grades

These values do not say much about the distribution of grades in the class. These have a lot to say about the individual's performance. It is, however, worth noting that the highest grade was from D1C (experimental) i.e. 95%, with D1D second with 85% (control). According to the Polytechnic's assessment committee, the pass mark is 55% which means all students in D1C passed the exam while 2 students in D1D failed.

On the technician side, the highest grade is from a control group PT with 83%, WT 78% and MVT the experimental group, with 81%. This simply confirms that the highest or lowest grade is not a reliable statistic. As for the number of failures per class,

MVT (E) -- 2 failures with grades 48% and 45%

WT (C) -- 4 failures with grades 54%, 53%, 46% and 42%

PT (C) -- 7 failures with grades 53%, 48%, 47%, 46%, 45%, 43% and 33%

The number of failures in the control groups is therefore higher than in the experimental groups giving failure rates as shown below;

Class	Failure rate %
Experimental groups	
D1C	0
MVT	14
Control groups	
D1D	14
PT	50
WT	44

The above discussion has shown that CEL groups i.e. experimental groups had better grade distributions than the rest of the control groups noted by higher group means, lower standard deviations and much lower failure rates i.e. higher pass rates.

4.1.5 IMPORTANT OBSERVATIONS

Some important observations noted during the experimental period could help explain why the Computer Enhanced Learning (CEL) or experimental groups edged the other groups. The validity of the observations is based upon the author's personal experiences in the classroom and the views and ideas shared with students through the responses they gave to the questionnaire in Appendix 9. That, combined with discussions with experienced teaching staff and backing literature made the following observations look valid.

1. Standardised level of teaching and content

All members of staff at the Polytechnic teaching in the first year Mechanics common course were asked to run the trial package titled LINEAR MOTION together. This made all staff know how far the topic had to be covered in terms of content. Generally, i.e. without computer enhanced learning, each teacher could have taught the way they felt and topics covered as far as the teacher's knowledge and comfort could take. With computers, every teacher had a chance to extend his/her knowledge by using the micro at his or her own time hence different groups of the first year common course would be taught by teachers with standardised knowledge and hence teaching levels.

2. With voluntary evening classes available to students,

students who missed lectures for one reason or another were not totally at a loss. The absent student could this time get a disk and run the lesson and follow the lesson at his own pace. The computer package did not replace the teacher as he was always needed to give complementary advice but then he was not the only bank of knowledge, students had at least an alternative.

3. With computer enhanced learning, the teacher's work was made much easier, hence teachers could use the time saved for other pressing demands in his work. The teacher's work was made easier in that;

(i) no board sketches, drawings or graphs as these were provided for in the package,

(ii) as notes were provided on the screen, the teacher was there just to expand on certain points. Students copied notes from the screen and the additions the teacher made. This could help schools make substantial savings in paper expenses as the need for handouts would be reduced,

(iii) student/class control was easier as most students were eager to see what would happen next on the VDU,

(iv) the teacher's lesson preparation was made easier and the package gave him extra confidence in himself in that he was sure he would not be stuck at any point in the lesson as a mere pressing of a button on the micro could come to his rescue.

4. Since most students had never used a computer before, most of them were motivated and keen to learn. Whether this is a lasting effect needs to be verified further. This in a way

provided a solution to the problem of dozing, common in afternoon lectures in that part of the world. There was no student who dozed in the CEL lectures as opposed to several in the control groups. Students saw learning as a dynamic process which changes with technology.

5. During the exam period, revision for students was easier, quicker and motivating. Students could run the package several times, try different parameters, do several examples within a shorter period. Such repetitive runs helped reinforce whatever they had learnt.

6. The graphics output accompanying the notes helped bring more realism to the learning process.

7. The software was prepared beyond just the first year or 'A' level hence at the end of each lesson students could see what was to come thereby arousing student's interest to go further in education

4.1.6 TREATMENT OF THE QUESTIONNAIRE

The above observations were evaluated by a 15-question questionnaire (Appendix 9) given to the 27 students in the experimental groups. The questions and responses are tabled below with the proportion responses given in percentages. These percentages with confidence limits placed on them determined the estimated class opinion on each question.

QUESTIONNAIRE ANALYSIS (see Appendix 9)

QUESTION	CHOICES	Responses	%
1 . Ever used a computer?	Never	27	100
	Once	0	0
	Twice	0	0
	Many times	0	0
2 Your reactions?	Interest to operate	27	100
	boring	0	0
	frightening	0	0
	unsure of myself	0	0
3 .Who operates the computer?	Teacher operates	3	11
	student operates	18	67
	both operate	6	22

4 .Better to use packages without teacher?	yes	4	15
	no	23	85
5 Lecture first, computer use at the end or vice versa?	lecture only,no computer	0	0
	lecture first,comp. last	22	81
	computer fist,lecturelast	5	19
	comp. only,no lecture	0	0
6 Time for lecture (monday -2hrs) (wednesday-1hr.)	monday alright,not wed	4	15
	Wed. alright,not monday	0	0
	alright as it was	9	33
	better if 2hrs each day	14	52
7 .Need books after using package or notes in package were adequate?	adequate notes on comp.	4	15
	notes adequate but books needed for reinforcement	21	78
	notes not adequate	2	7
	only book helped,not comp	0	0

8 .Revision easier with packages or books?	easier on computer	16	59
	easier with books	0	0
	better using both	11	41
9 Practicals. Did you feel any need for practicals after lectures?	animations enough,no need for practicals	5	19
	animations were alright, still needed practicals	22	81
	animations not alright	0	0
10. Retention After 2 weeks did you easily remember what you had learnt	yes,all of it	14	52
	animations yes not the notes	12	44
	notes yes,not quite the animations	1	4

11. Pictures on the screen were ;	not good	0	0
	relevant and closer to real situation	27	100
	not necessary	0	0
12 Package lesson better than books	yes	19	70
	no	8	30
13 How did you find the computer lesson package	discouraging and boring	0	0
	interesting & motivating	27	100
	time wasting	0	0
14 Evening classes necessary?	yes	24	89
	no	3	11
15 Advanced material at the end of each lesson did you find that,	disturbing	1	4
	encouraging	23	85
	not enough	3	11

4.2 ANALYSIS OF SURVEY RESULTS

The statistical implications of both the 'O' level and test results will now be reviewed. The questions answered in this section are; Are groups in the common course grouped in the way they ought to be? Are these groups matched? Do the results indicate success of CEL? Is the grading of Malawi School Certificate of Education (MSCE) exams accurate? Is there any significant change in student performance through CEL? At the end of this chapter some conclusions and recommendations are made based on the sample results and inference from the author's experience with the students which cannot be shown statistically.

In the initial analysis of the results, the two groups i.e. technicians and diploma students, are treated equally since this is the stance the Malawi Polytechnic initially takes in its teaching, evaluation and even grouping methods. This means that results of D1C and MVT (the experimental groups) and D1D, PT and WT (the control groups) will be combined to form two groups, experimental and control. D1C and MVT will hereafter be referred to as the experimental group (E) and D1D, PT and WT will be referred to as the control group (C). These groups attend lectures together and were separated only for the sake of convenience i.e. to enable students see the screen clearly. The combined results of the two groups therefore become:

E	95	85	81	80	80	75	73	71	70	69	69	68	67	67	66	66	65
	64	64	63	62	61	58	57	55	48	45							
C	85	83	83	78 / 77	77	75	74	74	73	71	71	70	70	68	67	64 / 61	59
	58	57	56	55	53	54 / 53	48	48	47	46	46	45	43	42	33		

We establish the <u>NULL HYPOTHESIS</u> H that CEL, the new method does not improve student's performance.

The <u>ALTERNATIVE HYPOTHESIS</u> is that CEL does improve student's performance, i.e. the mean of the experimental group will significantly improve.

Sample size for experimental group $n_e = 27$

Sample size for control group $n_c = 36$

$$\bar{x}_e = \frac{\sum x_e}{n_e}$$

$= 67.5556\%$ = mean of the experimental group.

Mean of the control group $= \frac{\sum x_c}{n_c} = 62.0833\%$

Standard deviation for the experimental group, $\sigma_e = 10.6086\%$

Standard deviation for the control group, $\sigma_c = 13.4503\%$

The difference between means $d = \overline{X}_e - \overline{X}_c = 67.5556 - 62.0833$

$d = 5.4723\%$

The statistical question is, is the difference of 5.4723% between means bigger than the difference one would expect if the two groups were taught using the same method? In other words, is this difference bigger than the difference which could be expected to occur by chance sampling variation? We therefore apply a Student's t-test to see if there is a statistically significant difference between the two means i.e. to see if 5.4723% is a significant difference.

To compute t, we need to estimate the standard deviation of all the differences i.e. d's that could have occured by chance. This pooled estimate will be symbolised by S_d.

$$S_d = \sqrt{\frac{(n_e - 1)\ \sigma_e^2 + (n_c - 1)\ \sigma_c^2}{n_e + n_c - 2}}$$

$$\sqrt{\frac{(27 - 1)\ 10.6086^2 + (36 - 1)3.4503^2}{27 + 36 - 2}} = \sqrt{\frac{26\times112.5424 + 35\times180.9106}{61}}$$

$S = 12.3195$

The t value, $\dfrac{\overline{X}_e - \overline{X}_c}{S_d\sqrt{\frac{1}{n_e} + \frac{1}{n_c}}}$ $\dfrac{d}{S_d\sqrt{\frac{1}{n_e} + \frac{1}{n_c}}} = \dfrac{\text{Difference between means}}{\text{Standard error}}$

$$= \frac{5.4723}{12.3195\times0.2546} \qquad \underline{=1.7448}$$

Most tables give t values to 2 decimal places, therefore, t = 1.75. In this case we are seeking to detect an increased difference, i.e. if there is a decrease, it would not be worthwhile doing all these calculations as the new method would be considered harmful. That being the case, we shall use a one-tailed test. From tables (Percentage points of the t-distribution), for 61 degrees of freedom i.e. $\nu = 61$, the value under the 5% column is 1.67. What does this mean?

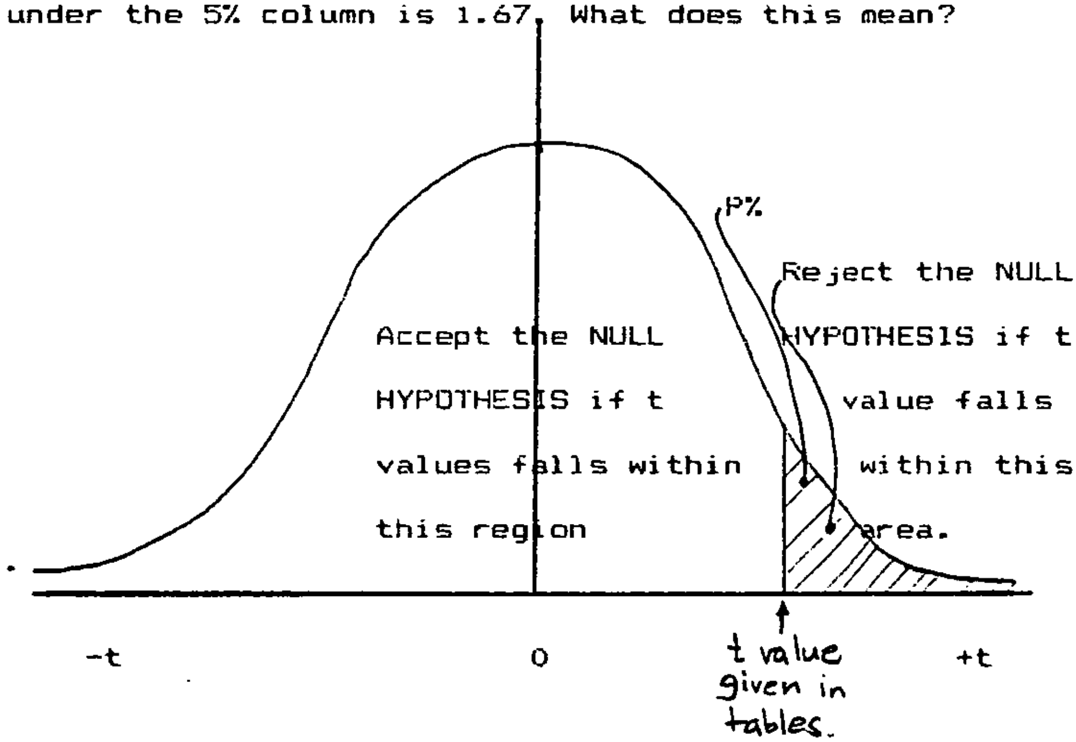


Figure 4.5

If the calculated t value falls within the acceptance region i.e. the calculated t value is less than that given in the tables then accept the null hypothesis as being true. If, however, the calculated t value falls outside the acceptance region i.e. the shaded area (see figure 4.5) or in other words if the calculated t value is greater than the value given in tables then reject the null hypothesis and hence accept the alternative hypothesis. The percentage e.g. 5% gives the probability of the t value being greater than the one given in tables. In this test, 1.75 is greater than 1.67 i.e. 1.75 falls in the shaded or reject area. We therefore reject the null hypothesis and adopt the ALTERNATIVE HYPOTHESIS. This tells us that CEL does improve student's performance. There was only a 5% chance of our calculated t being greater than the one given in tables i.e. 95% probability that our t would be less than 1.67. Since it was greater, under the probability of 0.05, then the difference of 5.4723% between the means is significant enough to enable us adopt the alternative hypothesis. This means the experimental group did significantly better than the control group. In other words an advantage of 5.4723% in favour of the new method over the 30 questions in the exam was educationally significant. This simply supports the theoretical advantages the CEL group enjoyed mentioned in the DISCUSSION OF RESULTS above.

STATISTICAL ANALYSIS OF SAMPLES

We shall now answer two of the questions above; Are the groups in the common course grouped as they ought to be? How accurate is grading at MSCE exams?

The grades of students in the common course are given in Appendices 6 and 7. These are aggregate grades for the best six subjects at MSCE. The smaller the figure (grade) the better or brighter the student. Appendix 6 contains names and grades of diploma students while Appendix 7 contains names and grades of technician students. There were 59 diploma students and 48 technician students in the 1986/87 academic year. The column of concern in this section is the aggregate one.

For the diploma students, the average aggregate grade, $= \frac{\sum \text{aggregate}}{59}$

$$= \frac{961}{59}$$

Which is approximately 16 points.

For the technicians, the mean number of points $= \dfrac{\sum \text{aggregate}}{48}$

$$\frac{1237}{48}$$

Which is approximately 26 points.

The sample standard deviations are;

Diploma = 3.0866

Technicians= 0.8718

The pooled estimate of the standard deviation for the two samples = 2.367

therefore $$\frac{26 - 16}{2.367\sqrt{\frac{1}{59} + \frac{1}{48}}}$$

$$= 21.7348$$

For 105 degrees of freedom, the given t value is 2.00 at 5% (two tailed). 21.7348 is by far greater than 2.00 hence there is a statistically significant difference between the two groups. At MSCE therefore, the technician groups performed comparatively poorer than the diploma students.

After a term at the Malawi Polytechnic, the grades in the table of values indicate that the mean of the diploma students is still higher. Taking D1D (the control group) as the unbiased representative of the diploma students' mean grade, i.e. 69%; the other control groups WT and PT give a mean of 57.5% between them.

The standard deviation for D1D = 11%

The standard deviation for the technicians = 13%

The pooled estimate of the standard deviation = 12.2952

$$\frac{69 - 57.5}{12.2952\sqrt{\frac{1}{14}+\frac{1}{23}}} \qquad \frac{11.5}{4.1678}$$

$$= \underline{2.76}$$

For 35 degrees of freedom, the t value at 5% is 1.70 which is less than 2.76. This shows that even after a term in higher education, the two groups are still significantly different. This significance test somehow indicates that the MSCE board is reasonably accurate in its evaluation of 'O' level students. If there was error in the evaluation, the t value could have shown that. The MSCE Board therefore needs to be congratulated for a job well done. On the other hand, some errors can be noticed especially in technician groups. Some students performed so well that they stand out of the whole class. Consider the PT grades for example,

RANK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GRADE	83	77	75	74	58	57	55	53	48	47	46	45	43	33

Obviously numbers 1 to 4 stand out of this group. The groups average grade was 57% with a standard deviation of 15%.

Removing the four out of the group, the mean drops to 48.5% and the standard deviation goes down to 7%, for the remaining 10 students. The four students had a mean of 77% with a standard deviation of 3.5%. These figures clearly show that either teaching methods at the Polytechnic have rejuvinated them or they were wrongly placed at MSCE exams in that they performed badly when they actually should have been on the diploma side. This is just a hypothesis, it could be wrong, it could be right. It would be interesting to watch the performance of these students and confirm the hypothesis. From the same reasoning, grades 81 in MVT , 78 and 71 in WT significantly stand out of their groups. These grades were picked using confidence limits. As pointed out already, this is just a hypothesis, it is possible that these students could have scored highly just by chance or due to the nature of the exam - multiple choice.

COMPARISON BETWEEN DIPLOMA STUDENTS

Applying a t-test to D1C and D1D gives a t value of 1.1 At 5%, one tail, for 25 degrees of freedom t= 1.71. Since 1.1 < 1.71, we therefore conclude that CEL did not bring a significant change in the grades of D1C. The higher mean in D1C could have been by chance. It must be realised that although there is no significant difference in the grades here, there was a significant difference in the ease and enjoyment of learning and preparation for the exam as discussed in the section DISCUSSION OF RESULTS. From the MSCE results and the present ones, these groups have proved generally bright or intelligent. It would be difficult for any significant difference to show out between these groups since their grades are usually very high. A significant difference, if it appeared between these two groups, would have raised suspicion on the teacher's efforts as he taught the control group.

This is an important result in that it shows that a change in methodology does not necessarily alter an intelligent pupil's performance, it however does something to the way or ease at which the pupils learn.

COMPARISON BETWEEN TECHNICIAN STUDENTS

If the analogy of chance error at MSCE grading mentioned above were true, what effect would this have on the results on the technician side? In that case MVT, the experimental group, would be compared with WT and PT, control groups. Results for MVT were,

R	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
G	81	69	68	66	66	64	64	63	62	61	58	57	48	45	40

The results for WT and PT were,

R	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
G	78	71	64	59	56	54	53	46	42						
G	83	77	75	74	58	57	55	53	48	47	46	45	43	33	

R="RANK", G="GRADE"

Looking at the pretest standard deviation i.e. from the MSCE grades for the three groups which was 0.8718, the conclusion that there was no statistical significant difference in the student's abilities was a reasonable one. In other words it would be expected that, all aspects of learning kept constant, these students would perform almost equally in another test given to them. This of course assumes that the MSCE results were a true representative of the students intellectual capabilities.

Practically though, it has been discussed above that there could be errors involved. Carol Taylor-Fitz Gibbon [20, p.42] says about statistical data,

> "..note, as well, that the t-test does not tell you whether or not a statistically significant difference is an <u>important</u> difference. <u>You</u> or <u>your evaluation</u> audience will have to judge this for yourselves by examining differences and asking if they are large enough to be considered important educationally."

Gibbon in this case considers the experience one is having with his sample as being also important. Knowledge of the sample parameters is another aspect which can influence final conclusions on a statistical survey. As a demonstration of what effect the 'error' students can bring to the sample, students who stood out of the whole class in performance in this particular test were taken out. This was done by placing confidence limits about the mean. From MVT, the 81% grade was taken out. WT, 78% was taken out and for PT, 83%, 77%, 75% and 74% were taken out. These grades even by inspection did stand out. The revised results therefore become,

MVT (Experimental group), E

R	1	2	3	4	5	6	7	8	9	10	11	12	13	14
G	69	68	66	66	64	64	63	62	61	58	57	48	45	40

WT and PT (Control groups)

R	1	2	3	4	5	6	7	8	9	10
PT	71	64	59 56	54	53	46	42			
WT	58	57	55	53	48	47	46	45	43	33

$n_e = 14$ and $n_c = 18$

$\bar{X}_e = 59.36\%$ and $\bar{X}_c = 51.67\%$

$\sigma_e = 8.62\%$ and $\sigma_c = 8.65\%$

$$S_d = \sqrt{\frac{(n_e - 1)\,\sigma_e^2 + (n_c - 1)\,\sigma_c^2}{n_e + n_c - 2}} = \sqrt{\frac{13 \times 8.62^2 + 17 \times 8.65^2}{14 + 18 - 2}}$$

$S_d = 8.64$

$$= \frac{\bar{X}_e - \bar{X}_c}{S_d\sqrt{\frac{1}{n_e} + \frac{1}{n_c}}} = \frac{7.69}{3.078} = 2.49$$

i.e. <u>$t = 2.50$</u>

for 30 degrees of freedom, at 5%, the t value is t=1.70. Since 2.50 > 1.70, we would have rejected the null hypothesis that pretests and postests would produce the same results even if CEL had been used on the experimental group. We therefore would have accepted the alternative hypothesis that CEL had improved the MVT group significantly. This statistical test of significance is simply an illustration of what the case would be if there was evidence that there was error at MSCE placings, it is not what is, it is what would be. What this test has revealed is that, a few wrongly placed students can totally alter the class performance. This test deals with all possible errors in the sample i.e. diploma students have been treated separately from technicians, and all students who may be on the technician side by mistake have been reasonably considered. This has minimized the possibility of wrong judgement i.e. the differences in the test become more genuine when all possible errors have been removed. However, there is a possibility that the students who did well in this test did so by chance, in which case the above argument will be invalidated.

4.3 CONCLUDING REMARKS

From questions 1, 2, 11 and 13, all students opted for one choice giving significant support for the options in those questions. From these questions therefore it can be concluded that;

(i) Despite not having had contact with computers ever before, students were not afraid of them but were rather eager to have a go at them.

(ii) Students appreciated the graphics output and capabilities of the microcomputer and found them closer to real life situation.

(iii) Students were motivated to learn by the new technology in education - the microcomputer.

Placing the 95% confidence limits on the rest of the

questions, only questions 8 and 10 had answers whose limits overlapped meaning that although there were higher percentages in some choices, they were not statistically significant.
From question 8 therefore, it can be concluded that,

(iv) Students see Computer Enhanced Learning as an improvement of the present learning methods hence they will still need books to reinforce whatever they have learnt by computer methods. This ties with question 7 where 78% of the students showed that they still needed books for reinforcement.

From question 10, it can be concluded that,

(v) The graphics capabilities of the microcomputer help in retention of learnt material. Notes being limited in packages, some students found this difficult to cope with but more than 50% did not find this much of a problem.

From questions 4 and 5 it can be noticed that,

(vi) students do not see the computer as a replacement of the teacher. The teachers role still remains, a mentor, students see the computer as something which is improving their learning.

The rest of the questions invite the following deductions,

(vii) Students would rather operate the microcomputer and determine the speed of the lesson. They were not quite pleased with the teacher operating it.

(viii) The teachers' importance was still intact despite the fact that lessons could be accessed through computer packages. Most students would have loved to see the teacher give a lecture first and then summarise it with a computer package as a reinforcer.

(ix) Students were not in favour of one hour lecture sessions because they felt there wasn't enough time to change from the lecture and computer within an hour.

(x) Students felt that computer graphics was not a replacement of laboratory practical work.

(xi) An arrangement for students to run the packages at their own time and pace was necessary and the new material at the end of each lesson did encourage them to work hard for the future.

CHAPTER 5

PROPOSAL FOR A TEACHERS' CENTRE

CHAPTER 5 THE TEACHERS' CENTRE

5.1 INTRODUCTION

The term "Teachers' Centre" is a temporary name for something which is hoped to grow to CAMET's size (Centre for Advancement of Mathematics Education in Technology) at Loughborough University of Technology or the Centre for Innovation in Mathematics Teaching at Exeter University in the United Kingdom. It is also hoped that the name (Teachers' Centre) will be changed to a better and more descriptive one in the near future. The idea of a Teachers' Centre was first conceived in 1986 by Professor A.C.Bajpai and members of the department of Technical Education. To that effect, a meeting was organised on 10th December, 1986 at the Polytechnic (see Appendix 10) comprising some teachers from the surrounding secondary schools and members of staff from the Polytechnic. The meeting had, among other things, to draw up tentative aims and objectives of the centre. Four members of staff from the Polytechnic were given time to give a talk on varying subjects in mathematics and science teaching. The Teachers' Centre is expected to be operational in the next academic year (1987/88) with the main aim of establishing ties between secondary school mathematics and science teachers and the Polytechnic. It will also cater as a centre where teachers can share educational problems and exchange ideas in teaching methods. The objectives of the centre are being reviewed in a series of meetings taking place now.

The idea of such a centre is necessary for a country like Malawi where the literacy rate is still low and where educational standards, in terms of teaching aids, methods etc. need improvement. Western countries e.g. Britain have what they call University Summer Schools where members of the community who are not in formal education (and some of those who are) come and attend special courses. These courses have proved successful in the countries concerned in that they have improved individual standards, provided personal educational satisfaction and helped in the creation of a well informed and educated society. The Polytechnic is therefore trying to adopt the Teachers' Centre idea along such lines. The teaching of mathematics and science will improve through in-service training, seminars and workshops which lacked an organising leader in the past.

In this chapter, therefore, we shall look at;

(i) The contribution the Computer Enhanced Learning Project will make to the Teachers' Centre.

(ii) In-service training/seminars for teachers.

5.2 A LESSON FROM THE 'NEW' MATHEMATICS MOVEMENT

The new mathematics movement which took the world by surprise in the fifties was actually a crusade against uninspired teaching of mathematics in schools all over the world. The realisation that most children (pupils) developed a dislike for the subject made mathematicians point a finger at teaching methods and content. Mathematics, a subject considered exciting by most mathematicians most of whom had registered success in different areas e.g. Von Neumann and Stan Vlam in atomic energy work, electronic calculators etc.; could not be as boring as the failure rate projected. The movement was launched with the aim of achieving a situation where most children would love mathematics thereby making most sciences more mathematical. The idea was a good one to most people (even non-mathematicians) who were actually unhappy with the record failure rate in mathematics. Most people who were against the old mathematics joined the new mathematics movement. In the U.S.A large funds were made available for the project and some people even went abroad to spread the gospel of the new mathematics. The new mathematics movement included pure mathematicians and teachers at different levels, psychologists, publishers, politicians, authors and many more. These groups of people joined the movement for different reasons which were to their advantage. Among many objectives for the new mathematics a few of interest to the Computer Enhanced Learning project are;

- The concepts of function, graphs of functions, probability, statistics and linear programming were to continue in the curriculum.
- Flowcharts and computer programming should be introduced whenever possible.

These points show overwhelming support for the new technology (computers) from the critics of the old mathematics and supporters of the new mathematics.

New mathematics did meet some opposition. Some accused it of being inconsistent in that it lacked formality in teaching /learning atmosphere. There were so many projects of the new mathematics going on at the same time. Different ideas were being tried at the same time. Teachers were not well prepared for the new syllabus hence those who were pushed into accepting the ideology never transferred the theme very well. Books were written in a hurry and some of them were therefore badly written. Professor J.N. Kipur of India [28, p.259-267] comments on the critics' reaction to these badly written books,

> "Critics of the new mathematics caught hold of these books and said, 'if this is new mathematics, we would be better off without it'. They collected examples of classroom teachers who had imperfectly understood new ideas, and ridiculed new mathematics. They overlooked hundreds of other new good text books and hundreds of new ideas that had been thrown up by the new mathematics movement."

As a result of this, new mathematics is to-date failing to make any impact on both teachers and students in some parts of the world. In Britain, some projects of the new mathematics dating back to the sixties are still being reviewed now e.g.

1960 Contemporary School Mathematics (St. Dunstan's)
1961 School Mathematics Project (S.M.P.)
1961 Midlands Mathematics Experiment (M.M.E.)
1962 Manchester Mathematics Group
1962 Psychology and Mathematics Project
1963 Scottish Mathematics Group (S.M.G.)
1964 Nuffield Mathematics Teaching Project
1967 Mathematics for the Majority Project
1967 Mathematics in education and industry

It must be noted that most of these projects were actually aimed at 'O' level and 'A' level markets. Michael Cornelius in his article titled "1944 Mathematics in Schools 1984 - From Jeffrey Syllabus to Cockroft Report." which is in [29, p. 31-34] comments on how hard teachers found it to cope with the new mathematics;

"For teachers the trauma of having to cope with a new comprehensive breed of pupils and having to think about 'modern' mathematics proved too much. Mathematics teachers tended to be split into 'modern' and 'traditional' categories to such an extent that some schools began to advertise for 'teachers of modern mathematics'."

Cornelius covers this topic extensively and interested readers are encouraged to read this article to see the changes mathematics went through from 1944 where the media of teaching was chalk and talk to the eighties where apart from the traditional methods were added individualised learning materials such as worksheets, workcards, programmed learning etc. It can be noticed from the two papers by Kapur and Cornelius in which they point out the need for preparation of teaching staff for the new mathematics revolution. New mathematics had its advantages outlined in [28] and [29] hence after some years, it proved to be most appropriate for science, engineering, technology, medicine and many other professions. The point of interest here is preparation of teaching staff. New mathematics found difficulties in being accepted because teachers were not well prepared for it. There were not many good books for reference. There was resistance to change both founded and unfounded. Fear of new knowledge which some teachers were not willing to learn are among the reasons for the slowness of new mathematics' take off. Today another technological revolution is taking place - the computer. It has already affected education - teaching and learning, in most partsof the world.

We are on the verge of a major change in the way we learn. Teaching methods have changed over the years. Audio-visual aids have been made and applied but none of these has hit education with more impact than the microcomputer. The change in learning methods will affect all levels of education i.e. primary to university, teacher training colleges to adult education. The reasons why the computer will become the dominant educational delivery system have been discussed thoroughly in chapter 4 of this thesis.

Summing up the discussion above, there are several aspects to be learnt from the new mathematics movement e.g.

(a) the central issue of the movement was WHAT should be taught, HOW it should be taught was regarded as a secondary issue. When the new or modern mathematics was introduced, the problem of HOW it should be taught was more evident and hence things slowed down.

(b) Teachers were swamped with new material and had embarked on the new course without knowing WHY. They were not made to feel part of the whole thing i.e. the new mathematics, to other teachers, was imposed upon.

(c) In-service training, needed for most teachers to adjust to the demands of the new mathematics, either came late or was not provided which made some teachers side with traditional mathematics.

The above problems delayed the progress of new or modern mathematics. There are many people today who developed a permanent dislike for new mathematics because of the above reasons. Computers in education may face the same danger in Malawi if no action is taken to introduce computers to teachers at different levels before they are fully operational in schools and colleges. There are some teachers in Malawi now who do not want to hear or know anything about computers, not even calculators. These have continually resisted the use of calculators in their classes and have encouraged the use of log. tables, slide rule and traditional arithmetic manipulations. To such teachers, computers are an even bigger threat. Despite opposition, calculators became more and more popular in Malawian colleges and university. Calculators are reasonably cheap, easy to use, fast, and chances of making a mistake are minimal. Some secondary school pupils are now using calculators. Calculator technology developed fast and within years flooded the market. At the Polytechnic for example,in the academic years;

1979/80 calculators were only issued to third year students in engineering (before the B.Sc course was introduced).

1980/81 both fourth year and third year students.

1981/82 second year students as well.

1982/83 third and fourth year technician students.

1983/84 All courses except for first years.

1986/87 Almost all students are issued with calculators.

For computers;

1979/80 The college had no computers. No computer course was being offered.

1982/83 2 Sinclair computers and 4 TRS80 computers. Computing course offered to degree students only.

1983/84 4 more TRS80 computers added. Computing course extended to Bachelor of Commerce students. Computers in adminstration.

1985/86 24 IBM computers added. Main Frame computer system. 3 BBC computer systems for the Computer Enhanced Learning project. Plans are there to introduce computing to diploma and technician courses (i.e. all courses.)

From 1983 to 1986 i.e. three years, the number of computers owned by the Polytechnic rose from zero to over 30 and the courses taking computing also rose tremendously. In the next five years, chances are that the number of computers will continue to rise. How prepared are we for the increasing number of computers coming into our college? What other uses can the computers provide apart from general computing lectures? How can we prepare secondary schools and later primary schools for the computer invasion? Teachers who are ignorant of computers, how can we imrove computer literacy among teachers? One of the answers to these questions is in-service training courses for serving teachers, immediate inclusion of computer education in teacher training curricula, seminars and workshops for teachers and more research on the effects of computing on mathematics teaching and student motivation in secondary schools. There will be need to verify computer successes in education experienced in western countries. It will not be right for us to rush into adoption before research. Now that computers are just coming in, there is a chance for us to prepare and slowly adjust to the new ways of learning.

5.3 IN-SERVICE EDUCATION FOR SERVING SECONDARY AND COLLEGE TEACHERS.

In-service education will be one of the main features in the Teachers' Centre. Courses will be arranged during which time several aspects of mathematics education will be discussed. Secondary school teachers would find a platform where they could voice their feelings about the mathematics they are teaching and how it should be taught. The first such meeting demonstrated this (see Appendix 10). Some teachers actually said they have for sometime wanted something like the Teachers' Centre.

Success of centres of this kind has brought positive changes to mathematical content and methodology. In Britain, for example, changes in school mathematics have been implemented through such centres coordinating with appointed research groups. To that effect, mathematics has moved from the 1944 "Jeffrey" syllabus to the 1982 "Cockroft" one, see [29, p.32]. The lists of contents for the two syllabi do overlap in some cases although the Cockroft report recommended several new topics as seen below.

JEFFREY	COCKROFT
Number	Number
Mensuration	Money
Formula and equations	Percentages
Graphs, Variation, Functionality	Use of Calculator
2 Dimensional figures	Time, Measurement
3 Dimensional figures	Graphs and pictorial

	representation
Practical Application	Spatial concepts
	Ratio and proportion
	Statistical ideas

The Teachers' Centre could provide teachers with news of new developments, as above, in mathematics. They could then discuss this and see which aspects to adopt or reject. After such discussions, the Teacher's Centre could draw up conclusions and recommendations to the Ministry of Education who would act on the recommendatons.

The other aim of the Teachers' Centre would be the eradication of both "computer illiteracy" and "computer unawareness". Whatever ideas are presented for or against the use or usefulness of computers in education, the microcomputer is a flexible resource for the pupil, teacher and school. It is getting cheaper and cheaper such that eventually most schools should easily afford it. Apart from mathematics, music, language learning, science, music and other subjects will also benefit from its potentials.

Most serving mathematics teachers in Malawian secondary schools, technical colleges and some university staff have never received any computer education. This is because as seen in the earlier chapters, computer technology is reletively new. It has been emphasized throughout this thesis that computers have much to offer in education and computer literacy is one of the contributions. It is necessary that teachers should know this new technology to be able to use it effectively and efficiently. Colin Terry [19] stresses the importance of computer literacy for teachers;

> "Teachers in all areas therefore need to learn about how the computer can be used as a learning environment for their particular pupils, for their particular subject discipline."

He further points out that teachers need themselves to be literate in all the possible uses of computers in education. Teachers hence need to have some level of understanding and experience of computing (i.e. computer programming). One may ask, why should serving teachers bother themselves with computer literacy or computer programming?

In 4.1, "Computers and Learning", it was mentioned that the difficulties involved in the production of software. It was mentioned that programmers alone could find it difficulty to produce good software without the help of experienced teachers who have a deeper understanding of the learning needs of students. In the same chapter, mention was made of the need for teachers to produce software locally. The in-service courses will help bring presently serving teachers to that level. The majority of them need <u>not</u> be expert programmers, they need to be literate enough to be able to read programs and interact intelligently with those producing software or writing programs for their particular needs. In such a case, the teacher and the programmer will work hand in hand - the programmer looking at the computer programming techniques while the teacher concentrates on presentation, relevance, pedagogy, level, order etc. Cooperation of that level can be facilitated at the Polytechnic Teachers' Centre. Teachers would be invited to a month or two month in-service course during the long vocation where the above ideas could be implemented. Such arrangement have worked before for technical teachers when they were reviewing their syllabi. Colin Terry [19] again suggests that;

> " LEAs must be encouraged to allow in-service projects to take place during school time,..."

(L.E.A. - Local Education Authority)

It is worth mentioning that a bold initiative was taken by Sir. Keith Joseph, former Secretary of State, Department of Education and Science, in encouraging every primary school in the United Kingdom to have a microcomputer. There is undoubtedly a time lag between the acquisition of such machines and their efficient use.

The aim of such a part of the Teachers' Centre would be to have a computer literate teaching force before computers come to Malawian secondary schools. After having attended such courses, schools would be expected to use their own computer "experts" who would be available for discussions on central issues of computer education. Alfred Bork [19] says;

> "computer literacy is a pressing national issue."

It should therefore be taken seriously now that we have little time. In one of the countries in the Pacific, many computers were donated to the country, the government then gave the computers schools at a time when there were no computer literate teachers, the result was that the computers just lay in the headmasters' office as monuments without any educational benefit. Similar examples are available from other parts of the third world. The Teachers' Centre will help avoid such a problem in Malawi.

How shall we achieve the reality of all these dreams? Firstly there are already several members of staff in the Matnematics and Science Department who showed a lot of interest in the 'pilot' project. These members actually formed the Research Committee mentioned in 5.1 (Introduction). Some of the members have had computing training and have indicated that they would be willing to give talks and lectures and also contribute to software production whenever the centre was set up. As for the availability of computers, mention has been made of the newly acquired 24 IBM and the 3 BBC computers. It can be argued that the variety of computers may pose a problem as to which machines the software will run.
The organising committee will have to consider the quality of the graphics output of the machine, memory, availability of software on the market for the machine etc. before choosing one. Loughborough University of Technology through Professor A.C. Bajpai have indicated their continued support for the project. Through strenghthened ties with the Department of Engineering Mathematics and the Polytechnic exchange visits could be arranged from which the Polytechnic would be kept up to date with new software.

Prospects are also there that some international organisations may help by donating more computers and even software. The MIME Project units in Applied Mathematics and in Statistics were donated to the Polytechnic by Professor Bajpai to help the Polytechnic students and also help the Teachers' Centre see these packages as a model of what is expected of the centre to produce in its efforts for self-sufficiency. The centre will be established with the full blessing of the Ministry of Education as its fruits will be enjoyed by probably all students in secondary schools, technical colleges and the Polytechnic.

5.4 COURSEWARE PRODUCTION

The ideas discussed in 4.3 in this thesis would be done with success at the Polytechnic. As indicated ealier, some members of staff have some computing experience hence the Research Committtee showed enthusiasm in the idea of the Polytechnic producing its own software or courseware. There will have to be a lot of coordinated work between staff for the successful production of courseware. The programme (courseware) provided in Appendix 11 is a starting point of how much is to be done. It is all written in BASIC, but there is need to study other high level languages as well for special effects.

Loughborough Univesity of Technology's Department of Engineering Mathematics members of staff coordinated to produce the MIME

Project packages. It took cooperation of almost the entire department to have the packages produced. They managed to produce standard high quality software. Through similar dedication the Polytechnic can do the same. Distribution of tasks and coordinated program writing can help ease the task of creating courseware. The Teachers' Centre would then work on the basis of the guidelines outlined in 4.3 to produce courseware for the Polytechnic, technical colleges and secondary school mathematics in Malawi.

CHAPTER 6

CONCLUSIONS, IMPLICATIONS, RECOMMENDATIONS AND FUTURE RESEARCH

CHAPTER 6 CONCLUSIONS, IMPLICATIONS, RECOMMENDATIONS AND FURTHER RESEARCH.

6.1 SUMMARY

Computer technology is developing at a very fast pace. The world in which today's children will live will definitely be different from the present one. Tomorrow's world will be characterised by the widespread use of computers, especially microcomputers in every area of life. Computers have always been associated with mathematics, science and technology, industry and the business sector but today computer application covers areas like libraries, travel, communication, education, languages etc. Education has a role to play in providing an understanding and use of computers now and in future so that man continues to control computers and not be controlled by them. Programming will remain important to research in revealing more channels of application. This thesis has considered these ideas for the third world and Malawi in particular. In summary, the ideas have been chronologically presented as follows;

6.1.1 PROBLEMS.

In chapter 1, especially 1.1.1 and 1.1.2, educational opportunities in Malawi have been discussed. Statistical data based on the 1977 population census has been used to verify some of the main revelations i.e.;

(i) there was a high number of children not in school.

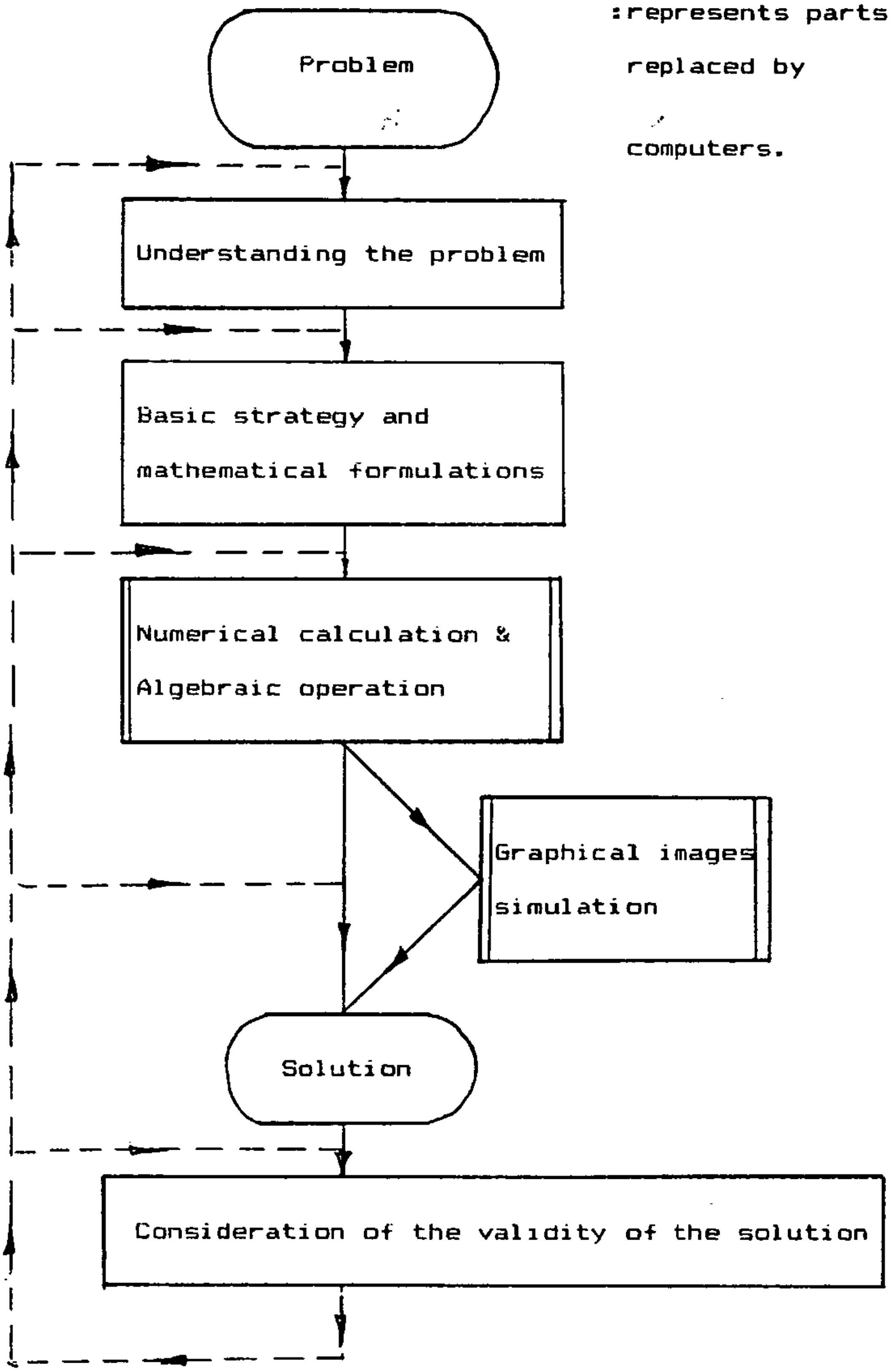
It was shown in 1.1.2 that the probability that a child , of age between 5 and 25, was in an educational institution was 0.12 compared to the expected 0.43 indicating that 31% of the children supposed to be in schools, colleges or university in that year never had their chance.

(ii) overcrowded classes are a common feature in the third world thereby diluting direct teacher-pupil relationship and forcing teachers to lecture other than instruct (the Socratic approach). This problem reveals that the number of schools may not be enough at the moment as is the number of teachers. The Ministry of Education has already begun to respond to this need and demand by the recent secondary school expansion programme and the establishment of three new teacher training colleges.

Chapter 2 has suggested that problems in mathematical education, especially the dislike for mathematics in children may be due to the way mathematics is introduced at primary school level. Teacher training, mathematical background of teachers, overcrowded classes, absence of in-service courses for teachers and disregard of practical-oriented teaching methods have been identified as being among the reasons which put mathematics as the most difficult subject on the curriculum in the third world. The discussion in chapter 2, especially 2.1 and 2.2 has dealt with the above problem in great detail. 2.3 has focussed on the curricula strengths and weaknesses of the first year common course mathematics syllabus at the Polytechnic. The effects of the syllabus on mathematics for subsequent years have also been discussed including suggestions for improvement. Among the suggestions has been the use of computer based learning materials or computer courseware or software in the teaching of mathematics.

6.1.2 THE MODEL.

The discussion in chapter 3 has centred on the use of computers in education. Mention has been made that computers are generally used to solve world problems by using mathematical/numerical models. The solution model suggested for education is 'computer enhanced learning'. The way the socratic approach to learning could be achieved has been discussed stressing that computers make learning an active process. Fundamentals of courseware production have been discussed mentioning the importance of cooperation between teachers and programmers. The influence computers will have on education has been discussed and could be summarised diagrammatically as Mukarami and Hata of Japan gave in [17,p.90] (see figure 6.1), this represents the new teaching method.



:represents parts replaced by computers.

Figure 6.1

In chapter 4, the pilot project on Computer Enhanced Learning (CEL) in Malawi has been discussed. Data, which was collected, has been analysed in this chapter. Hypotheses were set up and verified using statistical significance tests on the data available and the effectiveness of this was validated by student responses to the questionaire in 4.1.6.

6.1.3 PROCEDURE AND ANALYSIS.

The data used in this test was not immune to weaknesses of data collection and sampling. There were several other influences on the students on whom the experimental examination was given apart from the simple fact of measuring the effectiveness of CEL packages. This however does not dispute the fundamental attributes of CEL which have been statistically analysed in 4.3 and 4.4. Among the influences on the sample were;

(i) This was the first term of higher education for these students and most of them were very afraid of failing because the university makes it clear that failing in terminal examinations may lead to a scholarship being withdrawn at the end of that academic year.

This "threat" makes most students work harder than normal to make sure they keep their place. Apart from the computer method of learning provided them, there was a high probability that students reservedly trusted the "new" method of learning.

(ii) The samples used were not randomly picked as ought to be the case because, admininstratively, it was difficult to organise a randomly picked class because as stated in 4.1.1, these classes are grouped according to courses or alphabetically (for diploma students) immediately they enter college.

This can raise questions as to whether the samples were biased, especially on the technician side where one would claim that students who choose to do MVT would generally be better than WT and PT groups, some of whom are doing the course not out of choice.

(iii) The sample sizes were small. The author would have preferred bigger sample sizes and even carry out the tests over a longer period to get a better estimate of the population.

When carrying out significance tests, the sample sizes n and n have very important roles to play in determining the pooled estimate of the sample standard deviation i.e.

$$S_d = \sqrt{\frac{(n_e - 1)\ \sigma_e^2 + (n_c - 1)\ \sigma_c^2}{n_e + n_c - 2}}$$

which in turn influences (S) the value of the standard error and the Student's t value respectively.

$$t = \frac{\bar{x} - \bar{x}}{S_d\sqrt{\frac{1}{n_e} + \frac{1}{n_c}}}$$

i.e. standard error = $S_d\sqrt{\frac{1}{n_e} + \frac{1}{n_c}}$

It must be borne in mind that this was a small scale investigation and the results so produced are therefore illuminative rather than generalised. In view of these weaknesses, which were in some cases unavoidable, and because some of the weaknesses were not against the objectives of the research i.e. qualitative as opposed to quantitative measurements, taking also into account the fact that, the project had to start, it has been suggested in 6.5 that more large-scale research should be carried out. Bajpai believes that qualitative research such as this will generally produce "soft" data which may be difficult to verify statistically. In Educational research, bureaucratic difficulties, class changes (sample) and other administrative problems may make it hard for researchers to obtain large samples for a long time in order to obtain data from them. Hence, data collected from small samples, as is the case now, may provide an idea of what the whole population would behave like.This therefore means that the number of times tests are carried out may not necessarily be the answer. Positive results from small samples like this need to be monitored in real life and necessary adjustments made to accommodate any errors in sampling. Bajpai's view is shared by R.C.Bodgan in [33] where he defines qualitative research as an umbrella term referring to several research strategies that share certain characteristics, rich in description but not easily handled by statistical data.

6.1.4 Mathematics Teachers and Computers.

Chapter 5 has looked into the future to see what could be done to bring about computer awareness and literacy to the present teaching force especially in secondary schools. The Teachers' Centre mentioned in chapter 5, whose aim and objectives have been given, is expected to be the platform on which mathematical exchange of ideas and computer literacy and awareness will take place. Production of educational software is described in 3.4 and Appendices 11 and 12. Finally, in the same chapter, and on courseware production, Bajpai [32,p.423-424] comments on,

> "...the importance of investing large sums of money for the production of suitable, good and well-tested educational software without which the hardware that is available in academic institutions in not being 'properly utilised.'"

He goes on to say

> "production of educational software is a long and laborious process requiring the expertise of experienced teachers and the knowledge and skill of good programmers capable of producing animated programs with provision for suitable interaction."

Bajpai's above ideas tie in with the discussion raised in 3.2, 3.3, 3.4, 4.1.4 and 4.4. For the ideas raised in chapter 5, i.e. Teachers' Centre, Bajpai [32] says to teachers and educationalists,

> "we have a duty to take on this exercise and may have to produce software for our students even without the help of the funding authorities. It is bound to be a slow process and will be rather "patchy" unless funding is provided in selected institutions where staff have an interest, a willingness and dedication to develop these."

The author strongly believes that the Polytechnic is the best place in Malawi to take the lead in the production of software both for secondary schools, colleges and university, because of its technological nature.

6.2 FINDINGS AND OBSERVATIONS.

The following are the findings derived from the different parts of this survey,

(i) From the data analysis, it was revealed that there was a significant difference in performance between the experimental groups and the control groups showing that Computer Enhanced Learning does improve the learning /teaching process.

(ii) Technician and diploma groups perform significantly differently irrespective of whether they are being treated as experimental or control. This revealed that the learning rates of these groups are different. Their 'O'level results in 4.3 also showed a statistical difference.

(iii) Computers allow the learning/teaching process to investigate deeper into concepts which are usually just accepted without experimentation. For example, the concept of tossing a coin, it is believed that as the number of throws increases, the relative frequency (H or T) approaches 0.5. In class, however, it may be difficult to experiment say 10 000 throws of a coin. Computer simulations can be used to show such a high number of throws graphically as in figure 6.2.

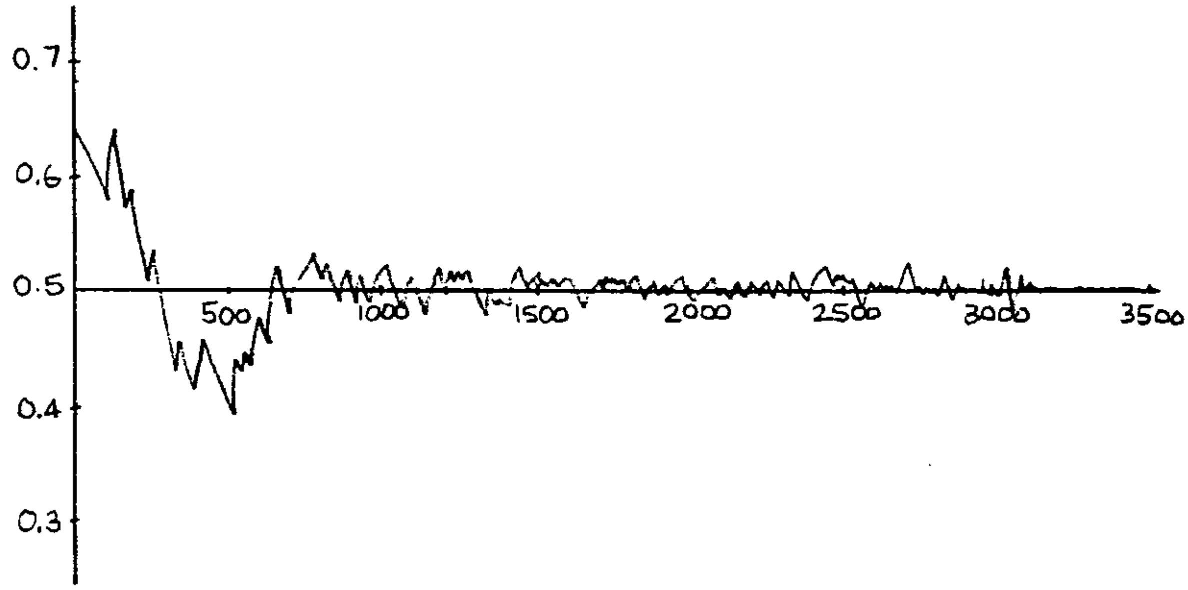


Figure 6.2

On the investigation side, it would be expected that if a coin were tossed several hundred times, and the number of Head or Tail occurrences plotted continuously, the graph would be moving up and down the 0.5 line which would support the theory that the probability of getting a Head or Tail is 0.5. However, computer simulations can show that this may not necessarily be so as shown in figure 6.3.

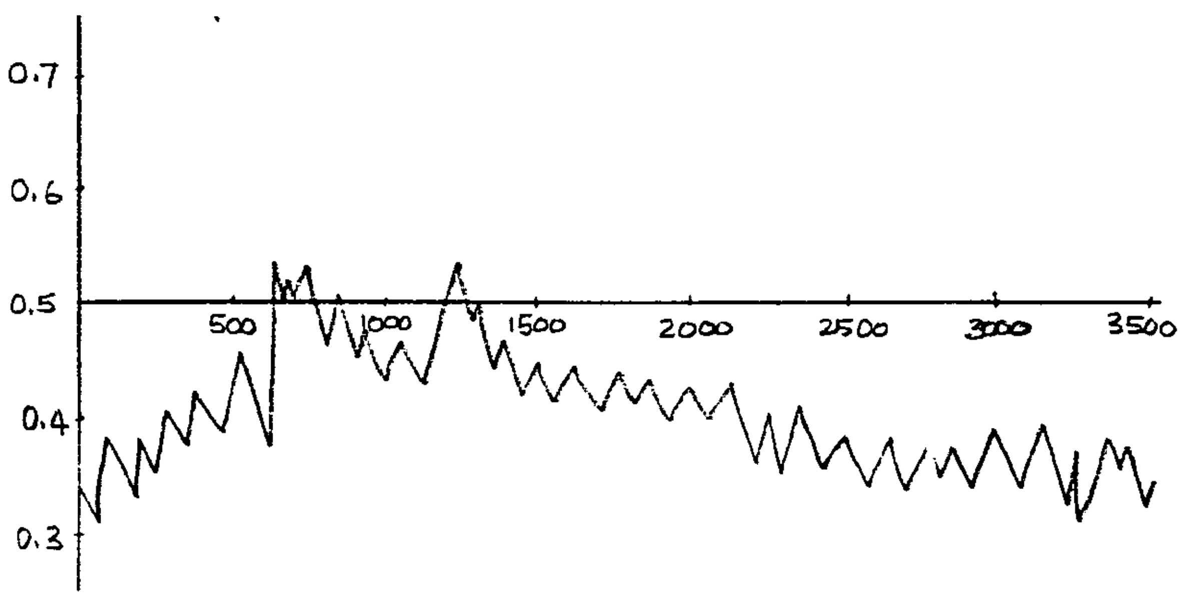


Figure 6.3

In this case, as the number of tosses increases, the relative frequency goes further and further away from 0.5. A class discussion on diagram 6.3 would bring interesting ideas from students and excite their thinking as well.

(iv) Computer Enhanced Learning would be the solution for slow learners since if they are left behind in a lesson, they can run the lesson over again in their own time and at their own pace.

(v) CEL gives confidence to the teacher in that he is assured that he is covering the syllabus to the required standard in terms of content. Levels of teaching/learning will therefore be standardised all over the world when more development has taken place in this area.

(vi) CEL makes it easy for teachers to try difficult examples on their own within a short time thereby increasing their personal confidence in class. It is also easier for the teacher to do more examples within the normal class period resulting in reinforcement of the theory being learnt and achieved. It must be realised that teachers normally do one or two examples because of limited time.

(vii) CEL helps teachers save more time and lighten their work load because lesson preparation, graphical work, diagrams etc. are done more efficiently i.e. accurately and within a shorter time.

(viii)CEL gives students an alternative source of information apart from the teacher. The teacher is however always needed in his traditional role as a mentor. Students are unlikely to see the CEL as a replacement of the teacher or the book but as an integral part of the whole learning system.

(ix) CEL makes revising (for examinations or otherwise) easier and quicker than the book. Animated simulations and graphical presentation of data are accurately done and make learning interesting and easier. Computer learning methods are therefore an incentive or motivation to students.

6.3 COMPUTER IMPLICATIONS ON MATHEMATICS EDUCATION IN MALAWI.

The incorporation of the microcomputer in the teaching of mathematics will have some definite implications, not only in the way people learn but also WHAT they learn.

6.3.1 Implication: Schools.

As discussed throughout this thesis, methods of learning will change, it is expected that there will be content changes as well. For schools, topics like Number, Money, Percentages, Time, Measurement, Graphs and Pictorial representation, Ratio and Proportion, Two- and Three-Dimensional figures and Statistical ideas will all be done more efficiently through the use of CEL. As explained in 3.2, computers in education have already registered success in Kenya and South Africa. Computers make recognition and pictorial learning easier. The above topics need either pictorial or graphical representation for their clarity hence programs could be made to take care of that. Number "crunching" is one of the main properties of the microcomputer and this it does more efficiently than a normal teacher would. Because of the efficiency computers will bring to the learning process, it is reasonable to suggest that most school topics will be covered within a shorter time than before. Geometric concepts will be easier to teach since programs usually allow users to vary diagram dimensions.

This will either require more topics to be included in the present syllabus or the present topics will be studied to more depth than is the case now. In general, therefore, computers will produce richer and more diversely educated output from the educational system.

6.3.2 <u>Implication: The Polytechnic.</u>

The software available at the moment and the programming capabilities of staff, will mean that CEL will only be available to first, second and third year students in Applied mathematics and Statistics courses. With time though, it is hoped that other courses will have software for them as well. The first year mathematics common course (see 2.3) which was noted for repetition of secondary school material and limited new topics, is bound to benefit more from CEL. The present common course syllabus (see Appendix 4) contains a lot of easy numerical and graphical topics whose software the author strongly believes can easily be produced. The third year students will benefit more from the statistics packages while the first and second years will benefit from the MIME Project Mechanics units as well. As discussed in 3.2, 3.3, and 5.4 there will be need for cooperation between staff at the Polytechnic and staff from the nearby schools to ensure that more relevant software (to Malawi) is produced. The implications of this software at the Polytechnic will be:

(i) the first year common course mathematics syllabus will be taught more effectively and extensively e.g. topics like Relative Motion, motorway simulations can be studied, practically achieving the effect of freezing motion in different lanes. Most packages include simulations of examples which some teachers would not touch if they were covering the topic.

(ii) it will be possible then to combine the two syllabi into a one year course. This is because most topics would be revised easily and within a short time, hence leaving room for new topics to come in. Since lesson packages would readily be accessible it would then be easy for teachers to ask students to revise topics and come up with questions if they could not remember something. The overall effect of this would be the introduction of better quality mathematics and statistics to students in years two and three. Topics like Differential Equations, Transformations, Line Integrals and deeper Statistics could therefore be moved or at least introduced in year three. Such mathematics topics would help students understand better engineering concepts which are generally lacking for those graduating with a diploma at year three.

(iii) it will encourage students to indulge in self-study and learn to control their own learning and seek knowledge at their own pace.

Software is still being developed. Advanced courses in mathematics usually involve a lot of symbolic algebra, this is true especially in engineering and science courses. Calculus therefore features highly. Differentiation and integration forming the basis of more advanced topics such as Transforms (e.g. Fourier, Laplace, Z etc.), Complex Mapping, Conformal Transformations etc. It seems reasonable to suggest that mathematics teachers would appreciate to have a way of checking answers to questions without necessarily having to do it themselves i.e. the way a statistics teacher would use a calculator to find the mean, standard deviation, variance etc. while students follow the normal formulae calculations. There are some computer systems developed already to handle symbolic algebra, these include MACSYMA (University of Massachussettes), MAPLE (University of Waterloo,Canada), MUMATH, REDUCE, and SMP. These computer systems will be on the market in the near future. The following examples will illustrate how these systems work.

Differentiation

DIF (X^3 Y^4, X, 2, Y)

which means;

Differentiate X^3 Y^4 with respect to x (X); twice (2) and differentiate with respect to y (Y).

The computer, after running through the program gives the result,

$$=24X\ Y^{3}$$

Similarly for <u>integration</u>,

$$\mathrm{INT}(\mathrm{SIN}^{2}X\ ,\ X\ )$$

which means;

Integrate the function $\mathrm{SIN}^{2}X$ with respect to x.

The computer gives the result

$$= 1/2(X - 1/2\mathrm{SIN}2X) + C$$

These computer systems are at the moment expensive but just like computers, calculators and many electronic equipments, their prices are expected to go down with time. It, therefore, may not be long before the Polytechnic acquires such systems and hence all classes in mathematics will have access to using computers for symbolic algebra as well.

6.4 <u>CONCLUSIONS.</u>

This thesis has attempted to put on the agenda something which has not been considered before at the Polytechnic i.e. the use of computers in the teaching of mathematics. It is hoped that the thesis will help extend computer usage at the Polytechnic and encourage teachers to use computers by producing or using educational software on the market. This is just the first step on a long journey, more research is expected to follow to make sure computers are utilised to a maximum, especially in education.

The survey, based on the information available, made the following conclusions look probable, i.e. there was;

(i) poor introduction of mathematics at primary school level,

(ii) evidence of some fundamental differences between the Malawi secondary school mathematics 'O' level syllabus and its counterparts in other developed countries, e.g. the United Kingdom's new GCSE mathematics syllabus,

(iii) little or no teacher-pupil interaction in learning (Socratic approach) which in turn has encouraged rote learning at the expense of rational understanding.

From the results of the survey in chapter 4 and the study of backing literature in 3.2 and 3.3, the following conclusions were drawn i.e. computers in education;

(i) are a motivation to students and teachers,

(ii) speed up the learning process thereby allowing a deeper and wider coverage of subject matter,

(iii) provide students with the chance to run or review lessons at their own time and pace thereby utilising the interactive facility in packages. This in turn helps achieve the socratic model of learning in a situation where student-teacher ratios are big (overcrowded classes).

It is further hoped that when the Teachers' Centre becomes fully operational,

(i) the teaching of mathematics will be improved both in content and methodology through in-service courses which will promote interaction between teachers thereby bringing about the exchange of ideas and teaching methods.

(ii) computer awareness and to a certain extent computer literacy can be achieved on the present and future teaching forces.

There will be need to carry out more surveys especially in secondary schools to see how the findings in 6.2 feature for secondary school students. It is hoped that implementation of the ideas suggested in this thesis will be done smoothly and with caution i.e. implementation should be done through pilot projects first and then slowly increasing the field. Computers being new to Malawian students, especially in their learning atmosphere, may, if rushed in, have negative side effects or even prove a failure especially if proper planning is not taken into consideration.

6.5 RECOMMENDATIONS.

I In order to meet present and future requirements in mathematics education, the Ministry of Education in Malawi should ensure that, computer literacy and/or computer awareness is made available to all teachers of mathematics under training. The University of Malawi should also ensure that all mathematics teachers currently under training have studied computing in their curriculum.

II The Ministry of Education and the University should support the Teachers' Centre financially and materially. It would equally be appropriate if international funding bodies were approached on this issue to supplement the existing facilities at the centre.

III An Association of Mathematics and Science Teachers should be formed as a matter of priority in Malawi on the same lines as similar associations in Britain and other developed countries.

IV The Polytechnic should initiate discussion with other universities or institutions in the United Kingdom with the aim of cooperating in the development and production of courseware, having exchange visits, short in-service training schemes and provision of information about educational software on mathematics.

V The present mathematics syllabus for the Teacher Training

Colleges (Appendix 3) should be revised. Wherever possible, repetition of the 'O' level syllabus should be avoided.

6.6 SUGGESTIONS FOR FUTURE RESEARCH

The author as a teacher-researcher believes that as an educational experimentalist, the classroom is the ideal laboratory for testing any educational theory to do with learning/teaching. This is because as an educational researcher, the interest is actually in the naturalistic obervations in the classroom. It is for this reason that further reasearch is necessary in some of the hypotheses and ideas suggested in this thesis.

(i) Effects of computing on secondary mathematics need to be investigated. Is computing necessary in secondary school education in Malawi? What advantages does it bring? What are the weaknesses? It is hoped that a pilot project will be set up in the near future with a class in one of the schools in Blantyre to investigate this.

(ii) Validation of present Computer Enhanced Learning Project as discussed in 5.1. Carrying out more tests and using bigger and better sample sizes for better and more informative significant tests over a longer period.

(iii) Production and application of courseware.
Students and staff at the Polytechnic's Mathematics and Science department to engage in the production of software

for secondary school, technical colleges and the Polytechnic itself. Using the in-service courses mentioned in 6.2, application of the courseware produced will be discussed and experimented.

6.7 FINAL REMARKS.

It is the author's hope that this thesis provides a basis for realistic decisions to meet future requirements in mathematics education in Malawi. There is a pressing need in all walks of education to attain, as close as possible, the socratic approach to learning where there is a stronger teacher-pupil relationship which in turn enhances learning in pupils. The heuristic approach (discovery) to learning must be seen to replace 'chalk and talk' methods as this has proved more suitable for the learning atmosphere. In some cases, due to limitations in funds etc., educationists have been forced to use the lecture method, with total nullification of teacher-pupil relationship. It is hoped that this thesis clearly and definitely introduces Computer Enhanced Learning as a solution to this problem.

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APPENDICES

APPENDIX 1

POPULATION BY SEX AND AGE: MALAWI 1977 CENSUS

AGE GROUP	TOTAL	MALE	FEMALE
0 - 4	1 081 897	529 521	522 376
5 - 9	826 675	409 394	417 281
10 - 14	571 595	294 388	277 207
15 - 19	541 724	261 295	280 429
20 - 24	449 683	195 161	254 522
25 - 29	437 780	204 198	233 582
30 - 34	306 670	145 352	161 318
35 - 39	277 025	131 823	145 202
40 - 44	204 017	94 857	109 160
45 - 49	219 022	105 515	113 507
50 - 54	147 084	65 889	81 195
55 - 59	131 729	64 823	66 906
60 - 64	103 761	48 910	54 851
65 - 69	81 727	40 905	40 822
70 - 74	53 119	25 682	27 437
75 - 79	40 316	20 403	19 913
80 +	73 636	35 473	38 163

APPENDIX 2

TOTAL ENROLLMENT IN PRIMARY AND SECONDARY SCHOOLS, TECHNICAL COLLEGES AND UNIVERSITY, DURING THE PAST 10 YEARS: MALAWI.

YEAR	PRIMARY SCHOOLS (1)	SECONDARY SCHOOLS (2)	TECHNICAL COLLEGES (3)	UNIVERSITY (4)
1975/76	631 709	14 451	461	1289
1976/77	663 930	14 826	502	1178
1977/78	675 741	15 140	913	1153
1978/79	705 956	15 559	791	1563
1979/80	779 676	16 488	694	1854
1980/81	809 862	18 006	637	1756
1981/82	882 903	19 329	619	1861
1982/83	868 849	19 832	514	1896
1983/84	884 157	22 245	522	2321
1984/85	899 459	24 343	500	2411

SOURCE 1,2 and 3 Ministry of Education and Culture; 4, University of Malawi.

APPENDIX 3

MATHEMATICS SYLLABUS

FOR TEACHER TRAINING COLLEGES

MINISTRY OF EDUCATION AND CULTURE 1981

THE TEACHER TRAINING MATHEMATICS SYLLABUS

General Aims of the Syllabus

1. To supply information to the students' which will help them teach the pupils in primary school.
2. To develop students' understanding of the Arithmetical concepts which they will be required to teach in the primary schools.
3. To develop the students ability to reason logically, critically and unemotionally and to communicate their ideas clearly, at the same time developing a flexible approach in that there is not always only one way to solve a problem.
4. To stimulate students interest in Mathematics so that they will wish to continue their studies.

Scheme of the Examination

There will be two papers set for each level (viz)

(i) Arithmetic Method paper (T2 or T3) of 2 hours duration worth 30 marks.

(ii) Mathematics paper (T2 or T3) of 2½ hours duration worth 70 marks.

THE SYLLABUS

COURSE 1: ARITHMETIC METHODS (FOR T3 AND T2)

The course is designed to meet the teaching needs of students. It aims to prepare them for their work in the classroom. It is compulsory for all students throughout the two years.

Formal teaching methods and techniques of all Arithmetic topics in the Arithmetic syllabus for primary schools will be studied. Students will be required to understand the content of the syllabus and the importance of curriculum development. They should also have a thorough knowledge of the Primary School Arithmetic books.

The course will stress practical approach to teaching Arithmetic and re-inforcement of facts learnt by extensive practice and drill. Short methods of calculating should be introduced but only with pupils who show full understanding and mastery of standard methods. As much a possible teaching aids must be used in covering the syllabus.

ARITHMETIC METHODS

1. The Primary School Arithmetic Syllabus: a study of the primary school curriculum with emphasis on Arithmetic. Distinction between syllabus and curriculum.

2. General Principles and Methods of Teaching Arithmetic: The Trio: Speed, Accuracy and Neatness. Layout of work when solving problems, Scheming, Lesson preparation - aim, teaching aids, introduction, development, application and conclusion. Introductory Arithmetic lessons.

3. The Concepts of Number: counting, seriation and equivalence. Introducing number in the infant classes. Counting as meaning addition. The four basic Arithmetic rules. Notation and place value.

4. Number: notation, evens and odds, primes and composites, factors multiples, H.C.F., L.C.M., vulgar fractions, decimal fractions and percentages.

5. Measures: money, time, length, mass, capacity: using the metric system.

6. Mensuration: areas and perimeters of rectangles, squares, parallelograms, triangles, trapezia, circles and other composite figures. Volumes of cubes and rectangular solids.

7. Proportion: ratio, simple proportion (unitary and ratio methods) sharing, compound proportion, time and work problems, time and distance problems, scale and scale drawing.

8. Money: simple and compound interests, discount and commission, profit and loss, telegrams, postal orders. postage and telephone charges, rates and rents, simple accounts (cash book, receipts and payments, income and expenditure), simple ideas of banking and bank accounts (current accounts and savings accounts).

9. Graphs and graphical representation: bar chart, histogram, pictogram and line graphs.

10. The Junior Certificate Mathematics Syllabus: a brief study in relation to the Primary School Arithmetic syllabus.

11. Text Books
    1. The Teaching of Arithmetic in Primary Schools by L.W. Downes and D. Paling.

2. Arithmetic series 1 - 8 Dzuka (Malawi) Limited.

Suggested References

1. General Arithmetic for Schools by C.V. Durell.
2. Arithmetic for Schools by C.V. Durell.
3. The Teaching of Mathematics, A.E. Ashworth (Hodder & Stoughton).

COURSE II: MATHEMATICS (T3)

The course is designed to raise and strengthen students' academic levels in Mathematics. It includes some aspects of Arithmetic, Algebra and Geometry. It is compulsory for all students and will be taken concurrently with course 1. The course is expected to provide material and information for course 1, hence both courses should be emphasized.

ARITHMETIC

1. Elementary principles and processes of Arithmetic including approxiation and decimals.
2. Money: simple and compound interests, discount and commission, profit and loss, rates and rents, simple accounts (Cash Book, Receipts and Payments, Income and Expenditure), simple ideas of banking and bank accounts. The work of the Post Office - postage rates, telegram and telephone rates, postal and money orders; saving bank.
3. Mensuration: rectangle, square, parallelogram, triangle, trapezium, circle and other composite figures, volumes of cube, rectangular solidsand other solids of uniform cross section.
4. Proportion: ratio, direct and inverse simple proportion, (unitary and ratio methods); sharing, compound proportion, time and distance problems, time and work problems, scale and scale drawing.
5. Averages and mixtures.
6. Numerical calculations: use of logarithm and square root tables.
7. Graphs: linear graphs applied to practical cases such as distance versus time in travel problems.
8. Trigonometry: definition of sine, cosine and tangent of acute angles. Application to simple problems and use of trigonometrical tables.
9. Statistics: Methods of collection, classification and tabulation of statistical data. Design of simple questionnaires, sample and

population, bias in sampling discrete and continuous distribution of data, diagramatic representation of data; bar charts, block diagrams or histograms, frequency polygons, pictograms, i.e. charts. Measures in statistics: mean, mode and median. A simple discussion of spread of statistical data using the concept of range.

ALGEBRA

1. Elementary algebraic operations: formulation, interpretation and evaluation of formulas expressing arithmetical generalisations. The formulas for expansion of $(a+b)^2$, $(a-b)^2$ and $(a+b)(a-b)$. Factorization of simple algebraic expressions. Application to mensuration and simple fractions. Indices and logarithms.
2. Equations: simple and simultaneous (involving only two unknowns), solution of quadratic equations involving only one unknown. Application of the equations to the solution of problems.
3. Arithmetical series.

GEOMETRY

1. Angles and Parallel lines: acute, obtuse and reflex angles, bearings, adjacent and vertically opposite angles, corresponding and alternate angles, allied angles, angles of elevation and depression.
2. Constructions: bisection of angles and straight lines, construction of angles equal to a given angle; construction of angles of 60, 45, and 30 degrees. Construction of parallel lines.
3. Triangles: properties of triangles; congruent triangles, similarity, the right-angled triangle and use of Pythagoras' theorem.

COURSE II: MATHEMATICS (T2)

The course is designed to raise and strengthen students' academic levels in Mathematics. It includes some aspects of Arithmetic, Algebra and Geometry. It is compulsory for all students and will be taken concurrently with course I. The course is expected to provide material and information for course I, hence both courses should be emphasized.

ARITHMETIC

1. Elementary principles and processes of Arithmetic including approximations and decimals.

2. Mensuration: rectangle, square, parallelogram, triangle, trapezium, circle (including length of an arc in terms of the angle at the centre) cylinder, cone pyramid and sphere. Sector of a circle.

3. Proportion ratio, simple proportion, compound proportion, proportional parts, time and distance problems, time and work problems.

4. Averages and mixtures.

5. Money: simple and compound interests, profit and loss, discount and commission, rates and rents.

6. Numerical calculations: use of logarithm and square root tables.

7. Trigonometry: sine, cosine and tangent of acute and obtuse angles. Sine and cosine rules. The formula $T = \frac{ab\sin C}{2}$ for the area of a triangle. Practical applications and use of trigonometrical tables.

8. Statistics: (a) Method of collection, classification and tabulation of statistical data. Design of simple questionnaires, sample and population, bias in sampling, discrete and continuous distribution of data.

   (b) Grouped data: class intervals, relative frequency, mean, mode, median, range, interquartile range, standard deviation, simple problems only.

   (c) Elementary examples of simple permutation and probability.

ALGEBRA

1. Elementary agebraic operations, formulation, interpretation and evaluation of formulas expressing arithmetical generalisations. The formulas for expansion of $(a+b)^2$, $(a-b)^2$ and $(a+b)(a-b)$. Factorization of simple algebraic expressions. Application to mensuration and simple fractions. Indices and logarithms.

2. Equations: simple and simultaneous (involving only two unknowns), solution of quadratic equations involving only one unknown. Application of the equations to the solution of problems.

3. Algebraic formulation of ratio and proportion. The linear funct...

4. Arithmetical series. Use of the binominal series for a positive integer index.

5. Graphs of functions: The theory of the quadratic function ax^2+bx+c. Application to practical problems.

GEOMETRY

1. Acute, obtuse and reflex angles; bearings, adjacent and vertically opposite angles; angles of elevation and depression.

2. Constructions: bisection of angles and straight lines, construction of perpendiculars to straight lines, construction of an angle equal to a given angle, construction of angles of 60, 45 and 30 degrees. Division of straight lines into a given number of equal parts or into two or more parts in a given proportion.

3. Triangles: properties of triangles, congruent and similar triangles, the midpoint and intercept theorems. The Pythagoras' theorem and its converse.

4. Polygons: use of triangulation of n-sided polygons to find
(i) the sum of interior angles,
(ii) the area.

Text Books

1. Pergamon series 1 - 4 : Comprehensive Mathematics.

2. Trigonometry at Ordinary Level by L.H. Clarke published by Heinemann Educational Books Ltd. (Second Edition).

SUGGESTED REFERENCES

1. General Arithmetic for Schools: Parts I, II, III by C.V. Durell.

2. New Geometry for Schools by C.V. Durell.

3. School Certificate Algebra: Parts I, II, III by C.V. Durell.

4. School Mathematics: Parts I, II, III by H.A. Parr.

5. Starting statistics by D.H. Hanson and C. Brown published by Hulton Educational Books Ltd.

6. Secondary Certificate Mathematics by D.T. Daniel.

7. Stage A Trigonometry by C.V. Durell (Bell).

APPENDIX 4

N.14

UNIVERSITY OF MALAWI - THE POLYTECHNIC

SYLLABUS

1. Programme : Diploma in Engineering

2. Course : Mathematics

3. Code : D1/M

4. Year : First (D1)

5. Presented to : Faculty of Engineering/Senate

6. Presented by : Maths and Science Department

7. Number of Lectures per Week : 3 x 1 hour (average)

8. Number of Tutorials per Week : 1 x 1 hour (average)

9. Method of Assessment : 3 hr exam (70%) and (30%) coursework

10. Aims

To consolidate secondary school mathematics and further the knowledge of mathematics relevant to Engineering.

11. Topics of Study:

(a) Revision of secondary school mathematics with special emphasis on arithmetical calculations and important theorems in plane geometry necessary for engineering technicians.

(b) The binary notation of numbers, conversion of denary to binary and vice-versa, addition, subtraction, multiplication and division of binary numbers.

(c) Ratio, proportion, variation, percentages and percentage change.

(d) Use of tables of squares, square roots, reciprocals and approximate estimations.

(e) Formation of quadratic equations and their solutions by factors and use of formula. The formation and solution of linear simultaneous equations involving two unknowns and simple problems.

(f) Graphs and graphical solutions of equations.

(g) Indices, fractional powers with positive and negative values. Evaluation and transposition of formulae used in engineering problems.

(h) Logarithms and use of logarithms to any base including e.

2/

(i) Reduction to straight line form of relationships like $y = ax^2 + b$, $y = ae^{kx}$, $y = ax^n$. Graphical determination of the constants from given data.

(j) Sine, cosine, tangent of angles of any magnitude and their graphical representations and evaluations. Simple problems involving their relationships. The radian measure, arcs and areas of sectors

(k) The graphs of $x = a \sin wt$, $x = a \cos wt$, $x = a \sin (wt + \phi)$ and $x = a \cos (wt + \phi)$. Graphical addition of sinusoidol waves of same frequency. Angular velocity, period, frequency, amplitude and phase angle.

(l) Solutions of triangles by sine and cosine rules, area of a triangle, problems on heights and distances, surface areas of volumes of cylinders, spheres, pyramids and cones.

(m) The mid ordinate rule, determination of areas of irregular figures, and the average value of a wave form.

(n) Differentiation from first principles of algebraic functions. First and second order derivatives and applications.

(o) Integration of simple algebraic functions as a summation and a reverse of differentiation .

12. Recommended Textbook

'Technician Mathematics' Level 2
J.O., Bird and A.J.C. May
2nd Edition
Longman Technician Series.

September 1984

APPENDIX 5

UNIVERSITY OF MALAWI - THE POLYTECHNIC

SYLLABUS

1.	Programme	:	Diploma in Engineering
2.	Course	:	Mathematics
3.	Code	:	D2/M
4.	Year	:	Second (D2)
5.	Presented to		Faculty of Engineering/Senate
6.	Presented by	:	Maths and Science Department
7.	Number of Lectures per Week	:	2 x 1 hour (average)
8.	Number of Tutorials per Week	:	1 x 1 hour (average)
9.	Method of Assessment	:	3 hour examination (70%) and coursework (30%)

10. Aims

To consolidate first year mathematics and further the knowledge of mathematics relevant to Engineering students.

11. Topics of Study

(a) The compound angle formulae (Sin (A + B) etc), double angle formulae. Definition of sec, cosec and cot. Trigonometric identities. Solution of simple trigonometric equations (1) containing a single trigonometric function (eg A cos (nx + b) = c) and (2) reducable to quadratic form.

(b) Solution of simultaneous linear equations in two and three unknowns. Arithmetic and geometric progressions, the sum to infinity of a geometric series.

(c) Differentiation of trigonometric functions from first principles. Derivatives of exponential and logarithmic functions. Derivatives of products, quotients and function of a function. Implicit differentiation. Velocity and acceleration. Turning points : maxima, minima and points of inflection. Rates of change with time and engineering applications.

(d) Integration by substitution. Integral of $\frac{1}{x}$ and of trigonometric and exponential functions. Computation of areas, volumes, mean values and r.m.s. values. Numerical integration by trapezium and Simpson's rules.

(e) Probability Definition of probability, compound probability, permutations and combinations, the Binomial Distribution.

2/

(f) Statistics Tabulation of results. Central tendency - mean, mode and median. Dispersion - mean deviation and standard deviation. Graphical representation - histogram, polygon and ogive.

(g) Binomial Series : Pascal's triangle. General expansion; limitations in its use when n is a negative integer or fraction. Application to numerical approximations and to calculations on small variations.

(h) The exponential series, exponential growth and decay involving simple engineering applications.

(i) Error analysis: propagation of errors in expressions like

$a \pm b$ and $a^p b^q$

(j) Simple numerical solutions to equations; regular falsi, Newton Rapheson.

12. Recommended Textbook

Mathematics for Engineers and Applied Scientists

S. Lennox and M Chadwick Heinemann

APPENDIX 6

UNIVERSITY OF MALAWI - THE POLYTECHNIC

1986/87 SELECTION LIST

APPENDIX 6

DIPLOMA IN ENGINEERING

Sr. No.	Cand. No.	Name	School	Maths.	Gen/ Phys.	Reg.	Int. Agg.	Agg.
1	065	Malikita, K M P G	Blantyre	4	1	N	5	19
2	068	Manduwi, P S P	"	2	1	S	3	17
3	081	Ndola, J L M	"	2	2	N	4	20
4	076	Mtambo, C D R B	Bwaila	4	3	S	7	17
5	095	Tafatatha, W E G B	"	3	2	S	5	14
6	013	Chirwa, R L	Chaminade	1	1	N	2	11
7	051	Munthali, V E D	"	1	3	N	4	13
8	053	Mvula, C K	"	1	2	N	3	18
9	077	Phiri, V A	"	2	1	N	3	11
10	045	Gadama, A A J	Chichiri	2	2	S	4	18
11	050	Jumbe, P S S G	"	2	2	S	4	19
12	060	Khoza, D T S	"	2	1	S	3	16
13	062	Longwe, K	"	1	2	N	3	14
14	066	Maoni, M A C	"	2	2	S	4	20
15	079	Mungoni, J	"	1	1	S	2	13
16	027	Bodole, J D K	Chiradzulu	1	3	S	4	17
17	040	Kayange, R D W M	Chitipa	2	2	N	4	15
18	094	Mwasinga, T C	"	5	3	N	8	16
19	033	Kafuwa, G L H	Dedza	1	2	C	3	13
20	063	Malota, M J B N	"	3	1	C	4	18
21	040	Sanje, M N I W K	Kasungu	3	1	C	4	11
22	021	Sambakunsi, E C	Kizito Seminary	2	2	C	4	17
23	050	Manong'a, J T G	Likuni Boys	2	3	S	5	18
24	067	Phiri, M E Z N	"	4	2	C	6	18
25	071	Sichinga, A G A M G	"	1	1	N	2	12
26	049	Mtawali, C M M	Livingstonia	2	2	N	4	10
27	066	Sisya, E D T	"	4	5	N	9	18
28	047	Chikoja, M Z D C	Malosa	3	4	S	7	19
29	069	Ligomba, B H D C	"	1	2	S	3	11
30	075	Migochi, C C	"	3	3	C	6	18
31	094	Siyasiya, C	"	1	1	S	2	9
32	010	Kachule, E F J	Mtendere Jr. Rate	1	2	S	3	14
33	035	Katenje, M G E J	Mtendere	2	3	C	5	21
34	061	Chitonya, R M	Mzuzu	2	3	N	5	19
35	078	Msukwa, K K T	"	1	3	N	4	20
36	003	Chabwera, J	Nankhunda Sem.	3	2	S	5	20

2..

Sr. No.	Cand. No.	Name	School	Maths.	Geo/ Phys.	Reg.	Int. Agg.	Ag
37.	061	Saka, F A	Nkhata Bay	2	4	N	6	19
38	045	Seyala, R J	Nkhota Kota	4	2	C	6	21
39	047	Chodzaza, G E Y M	Ntcheu	1	4	C	5	17
40	088	Mbasa, E M	"	3	2	C	5	17
41	019	Dembo, M J M	Ntchisi	2	2	C	4	18
42	052	Kangunga, P A	Phalombe	2	1	C	3	10
43	011	Chingwalu, J S E	Police	1	1	S	2	18
44	029	Chuthi, N P N S	Robert Blake	1	1	C	2	17
45	045	Kalukusha, M M	"	2	2	C	4	17
46	040	Kaonga, L D K	Robert Laws	1	2	N	3	18
47	042	Kaumba, V P	"	3	4	N	7	20
48	070	Nthara, J B S K M	"	3	1	N	4	15
49	032	Gumbo, A S Z	Soche Hill	2	2	S	4	18
50	059	Phiri, C A D	St. John Bosco	2	3	C	5	18
51	024	Kamanga, T R C	St. Patricks	1	3	S	4	17
52	028	Chiyembekeza, E D R	Thyolo	1	2	S	3	16
53	031	Kagona, C F S B	William Murray	2	3	S	5	18
54	028	Khawela, D E	Zomba Catholic	1	2	S	3	12
55	054	Muriya, R L	"	3	3	S	6	19
56	071	Sichali, F	"	1	2	N	3	12
57								

OTHER CANDIDATES

57	3	Bregger, J W	G C E	3	3	S	6	18
58	4	Kamanga, B	"	2	4	N	6	18
59		Dini, Y	"	3	1	C	4	14

Regional Distribution

N = 20
S = 23
C = 16

59

APPENDIX 7

MALAWI POLYTECHNIC BOARD OF GOVERNORS

1986/87 SELECTION - FINAL LIST

TECHNICIANS PROGRAMME

Sr. No.	Cand. No.	Name	School	Sc.	Maths.	Req.	Agg.	Agg.
1	041	Chilapula, E S A N G	Balaka	3	3	S	6	25
2	112	Phiri, J M	"	3	5	S	8	28
3	010	Chinunda, E D F C	Bandawe	5	4	N	9	25
4	014	Chirwa, B B A W M	"	2	5	N	7	25
5	016	Chirwa, Y M	Chaminade	4	2	N	6	25
6	024	Jere, K M L	"	6	2	N	8	26
7	074	Nyirenda, C H S	"	5	3	N	8	27
8	070	Mawerenga, J C J	Chichiri	4	4	S	8	24
9	074	Mizaya, T W J	"	3	4	S	7	26
10	081	Nadzanja, P R S	"	3	2	S	5	27
11	011	Chiwambo, E H S S	Chikwawa	2	3	S	5	26
12	066	Mtambo, A B O L	Chitipa	4	6	N	10	25
13	044	Kassim, H T N	Dedza	4	5	S	9	26
14	041	Kapangaziwiri, G M R	"	2	4	C	6	26
15	055	Lindima, C B	"	3	3	S	6	27
16	066	Matewere, S C	"	5	6	S	11	25
17	025	Kesakudza, G S M	Dowa	6	2	C	8	26
18	068	Nkando, F T	H H I	4	8	S	12	25
19	024	Mithi, C M N J	Kasungu	4	4	C	8	27
20	012	Kakowa, C	Kizito Seminary	5	4	C	9	26
21	051	Chinkhata, P S A J	Malosa	4	5	S	9	26
22	087	Nsandu, J J W	"	4	5	C	9	26
23	005	Banda, J S A C F	Mangochi	4	5	S	9	26
24	113	Nyangu, C M D A D	Mitundu	4	6	C	10	26
25	022	Chiromo, B J K	Mulanje	3	5	S	8	25
26	026	Mhango, B F T N S	Nkhata Bay	5	5	N	10	26
27	027	Mhango, J K R	"	2	4	N	6	26
28	047	Ngulume, L Z A	"	4	4	N	8	27
29	022	Nyamafumbah, M F	Nsanje	6	4	S	10	26
30	025	Banda, S B L S	Ntcheu	4	5	C	9	26
31	084	Maseya, D K S	"	3	3	C	6	26
32	008	Chadzutsa, B B K	Ntchisi	3	1	C	4	24
33	015	Kadewa, P W M K	Police	5	4	C	9	26
34	043	Kaibinali, I G T	"	4	3	N	7	25
35	048	Kamulete, A K L K K	Robert Blake	4	3	C	7	26
36	020	Changaya, B C M	"	4	2	N	6	26

2...

Sr. No.	Cand. No.	Name	School	Sc.	Maths.	Reg.	Int. Agg.	Agg.
37	067	Ndaomba, B M A G	Robert Blake	3	5	N	8	27
38	022	Kalizang'oma, N A	Salima	5	5	C	10	26
39	023	Chikalipo, R Z L	Soche Hill	5	5	S	10	26
40	041	Mkande, D K M L M	St. John Bosco	4	4	N	8	27
41	035	Malikebu, G W	St. John's	4	4	S	8	25
42	024	Kanyelere, A H M	"	5	3	C	8	26
43	053	Malisamo, L R M	Thyolo	5	3	S	8	26
44	031	Godia, T N S	"	4	2	S	6	26
45	044	Waiyatsa, E M	Umbwi	4	4	C	8	25
46	036	Nthondo, R S C	"	3	5	C	8	25

G C E

47	7	Khan, A	G C E	5	3	S	8	24

CAMBRIDGE

48		Kafansiyanji, A	Cambridge	3	5	C	8	24

NON-MALAWIAN

49	1	De Castro, J F						

Regional Distribution

S = 17

C = 18

N = 13

Non-Malawian = 1

UNIVERSITY OF MALAWI - THE POLYTECHNIC
MATHEMATICS AND SCIENCE DEPARTMENT
FACULTY OF APPLIED STUDIES

MID-TERM EXAMINATIONS

MECHANICAL SCIENCE

YEAR 1

DATE: 21ST NOVEMBER, 1986

INSTRUCTIONS

1 Answer all questions (1 to 30).

2 All questions are multiple choice except question 29 and 30 part b where you have to calculate the answers.

3 Answering questions (example)

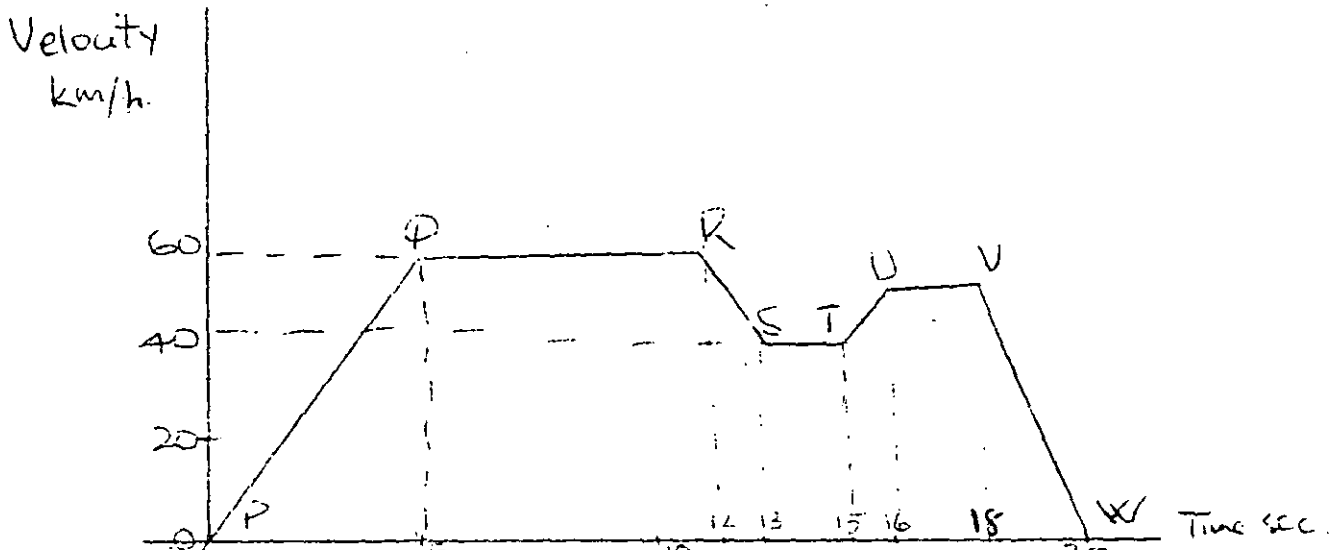
40. What is the correct value of the acceleration due to gravity (m/s^2).

(A) 20.91 (B) 15.81 (C) 10 (D) 9.2 (E) 9.81

A B C D E

the correct answer is E

1 The graph shows how the velocity of a car moving along a straight level road varies with time over a period of 20 seconds.



Answer the questions 1 to 5 using the information given on the graph.

The car travelled with uniform velocity for a total time of seconds.

A 2 B 3 C 6 D 8 E 11

2 The acceleration from rest was

A 3 km/min^2 B 5 m/s^2 C 12 cm/s^2 D 12 km/s^2

E 80 km/h^2.

3 The time taken to stop from 60 km/h was

A 2 seconds B 17 secs. C 3 minutes D 20 minutes

E 8 secs.

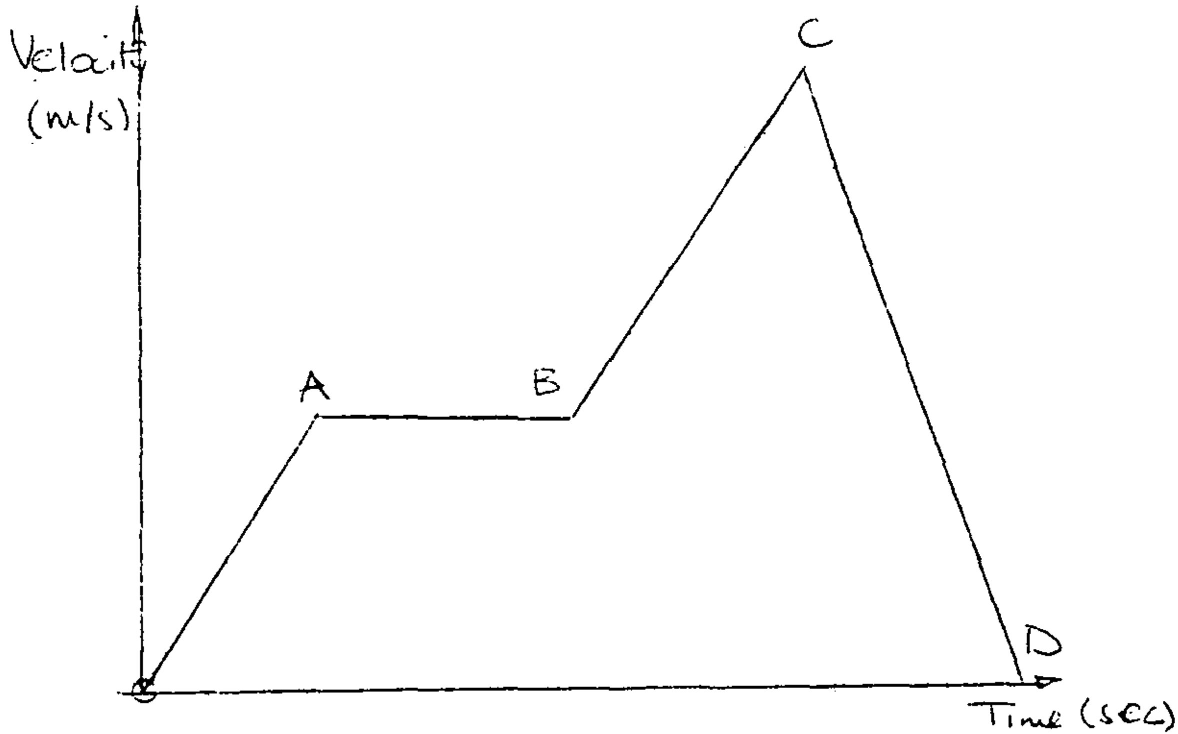
4 The distance travelled in the first 5 sec. was

A 3½ km B 150 m C 150 km D 200 km E 400 km

5 The distance travelled between 5 seconds and 12 seconds (QR) was

A 42 km B 8 km C 400 km D 480 km E 420 km

6



The graph above illustrates the motion of a body. Which of the following statements would be the most accurate description of the journey from stages OA - AB - BC - CD

(a) Uniform velocity - constant velocity - acceleration braking.

(b) Increasing velocity - no motion - acceleration - deceleration.

(c) Uniform velocity - acceleration - no velocity deceleration

(d) Uniform acceleration - constant velocity - constant acceleration - uniform deceleration.

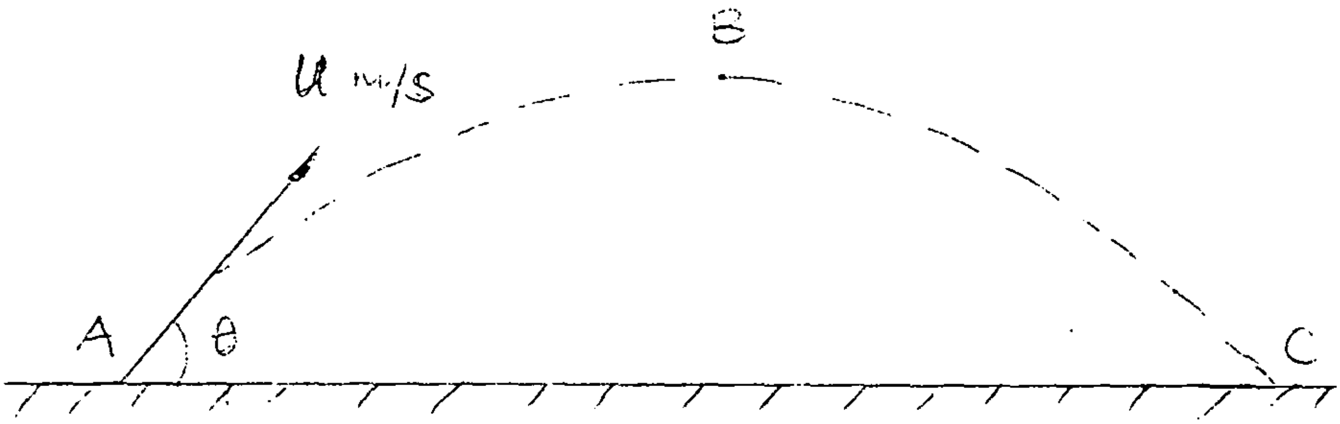
(e) Constant acceleration - constant distance - changing velocity - uniform deceleration.

7 (a) A ball is thrown vertically upwards and reaches a height of 45 m. If the acceleration due to gravity is 10 ms^{-2}, the initial velocity of the ball is

A 30 ms^{-1} B 60 ms^{-1} C 15 ms^{-1}

D 20 ms^{-1} E 45 ms^{-1}

(b) A stone is projected from a point A with an initial velocity of U m/s, at an angle θ to the horizontal. The shape of this orbit is indicated in the diagram.



The greatest height the stone attends is given by (g is the acceleration due to gravity)

(a) $U^2 \sin 2\,\theta/g$ (b) $U^2 \sin^2 \theta/2g$ (c) $2U \sin\,\theta/g$

(d) $Ut \cos\theta$ (e) $Ut \sin\theta + \frac{1}{2} gt$

8 An object is thrown vertically upwards with a velocity of 100 ms^{-1}. The time taken for it to return to the thrower is

A 1 sec. B 2 sec. C 10 sec. D 0.5 sec.

E 3.5 sec.

9 A piece of lead and a feather are dropped simultaneously from the same height in an evacuated container so that air resistance is negligible. Which of the following statements is incorrect.

(a) The gravitation force on the lead is greater than the gravitational force on the feather.

(b) The lead has a greater acceleration than the feather.

(c) Both lead and feather at any instant have the same velocity.

(d) Both the lead and the feather reach the bottom of the container at the same instant.

(e) The time taken to fall is the save in each case.

~~10 The graph of observations made on the motion of a car over a period of 55 is:-~~

The graph shows that the car

(a) Started from rest.

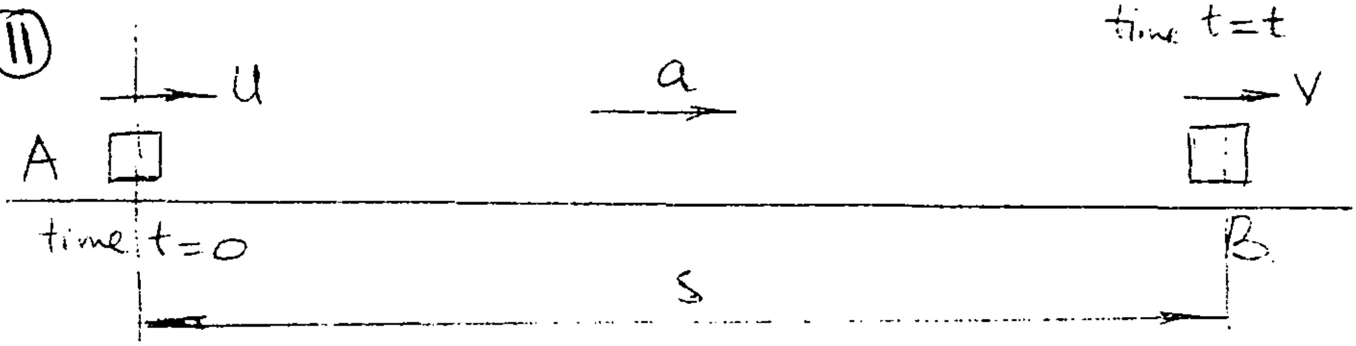
(b) Travelled with uniform acceleration

(c) Stopped after 5 seconds.

(d) Had an average speed of 3 ms^{-1}

(e) Would have a velocity of 12 ms^{-1} after a further 5 sec.

11



The information given in the figure refers to motion of a car in a straight line from A to B under constant acceleration. Which of the following is incorrect.

A $V = U + at$ B $V^2 + U^2 = 2as$ C $S = ut + \frac{1}{2} at^2$

D $V^2 = U^2 + 2as$ E $2s = (U + V)t$

12 A car covers a certain distance, starting from rest and moving with uniform acceleration. It reaches a final velocity of 20 ms^{-1}. Its velocity after half the distance is (in ms^{-1})

A 10 B $\sqrt{20}$ C $10\sqrt{2}$ D $\frac{10}{\sqrt{2}}$

E 15

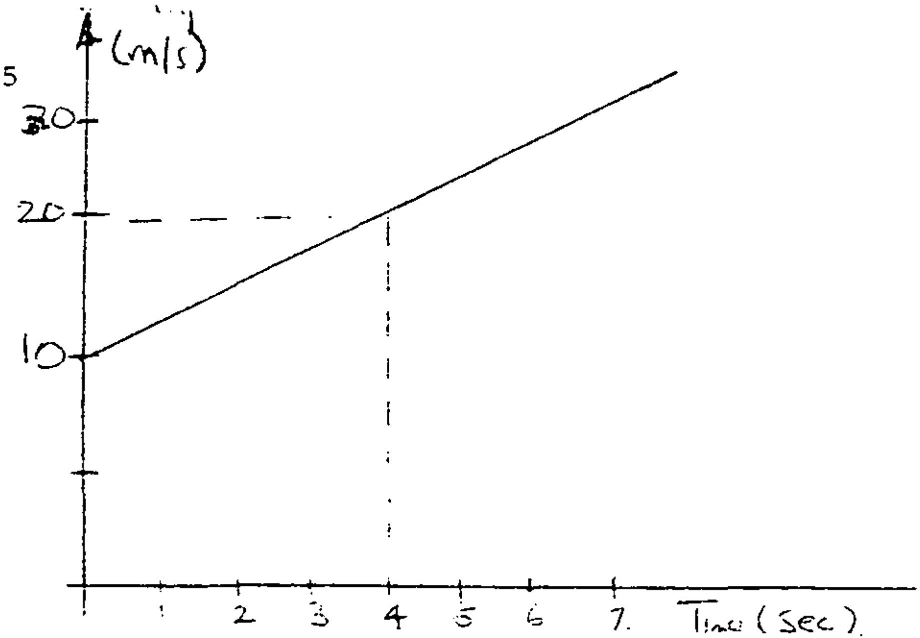
13 A body which has an initial velocity of 40 ms^{-1} moves with a uniform acceleration of 20 ms^{-2}. After 2 seconds it has covered a distance, in m,

A 80 B 100 C 120 D 140 E 160

14 An object has an initial velocity of 30 ms^{-1}. It accelerates at 5 ms^{-2} for 10 seconds. The final velocity in ms^{-1} will be

A 80 B 150 C 35 D 36 E 50

15



The graph shows the velocity of a particle, travelling along a straight line, plotted against time. The total distance travelled after 4 seconds is

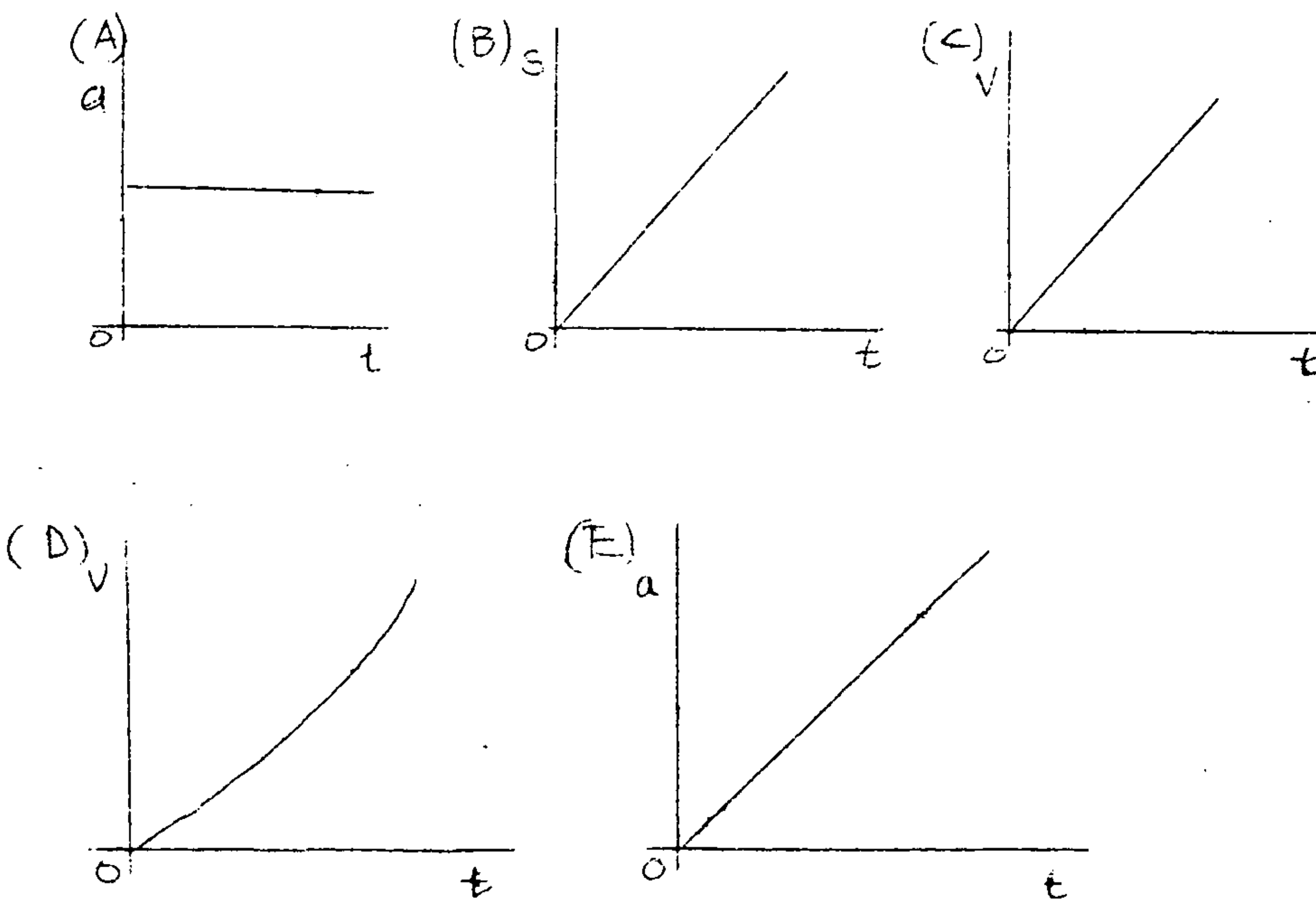
A 30 m   B 40 m   C 8 m   D 7.5 m   E 60 m

16 A racing car accelerates from 10 m/s to 25 m/s in 10 seconds. What is the average acceleration?

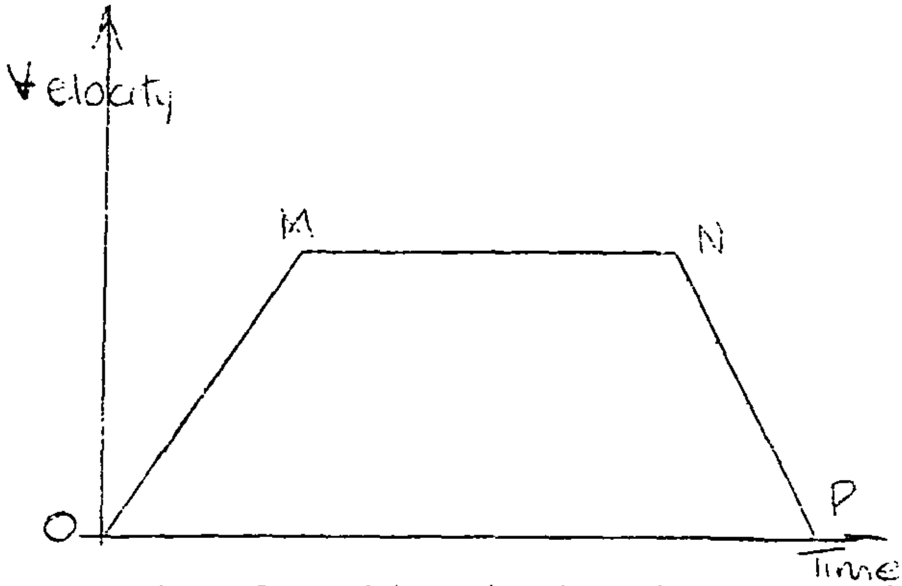
A 1.5 m/s^2 B 7 m/s^2 C 50 m/s^2 D 75 m/s^2

E 175 m/s^2

17 If 's' represents distance, 'v' velocity 'a' acceleration and 't' time, which of the following t graphs applied to a body, when it has constant non-zero velocity.



18



The motion of an object is shown by OMNP on the velocity time graph of the fig. above which of the following statements can be deduced from it.

(a) the acceleration from O to M is less than the retardation from N to P.

(b) the distance travelled during the time of acceleration is more than that dduring the time of retardation.

(c) the diatance moved during the time OP is represented by the area of the trapezium OMNP.

(d) the acceleration from M to N is negative

19 A car accelerates from 0 to 20 m/s in a distance of 100 m. Its acceleration, assumed uniform is

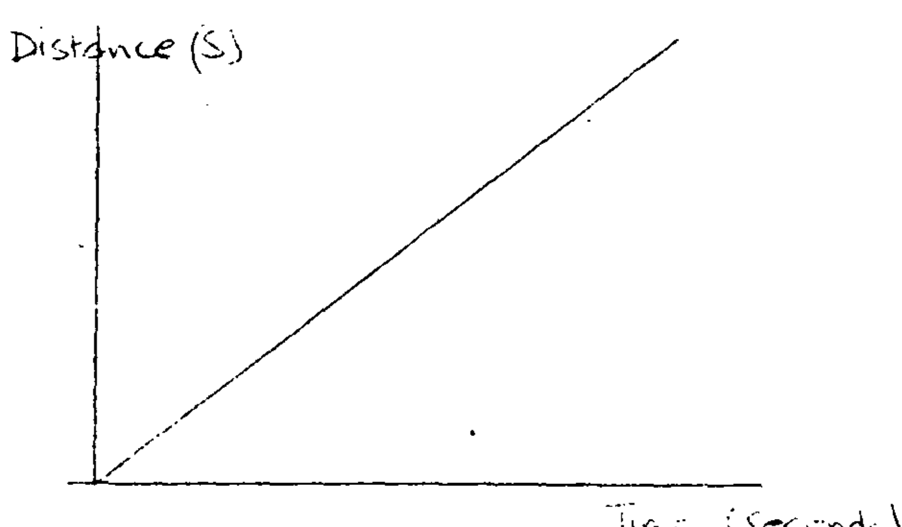
A 2 m/s^2 B 4 m/s^2 C 2 m/s D 5 m/s^2

E 0.2 m/s^2

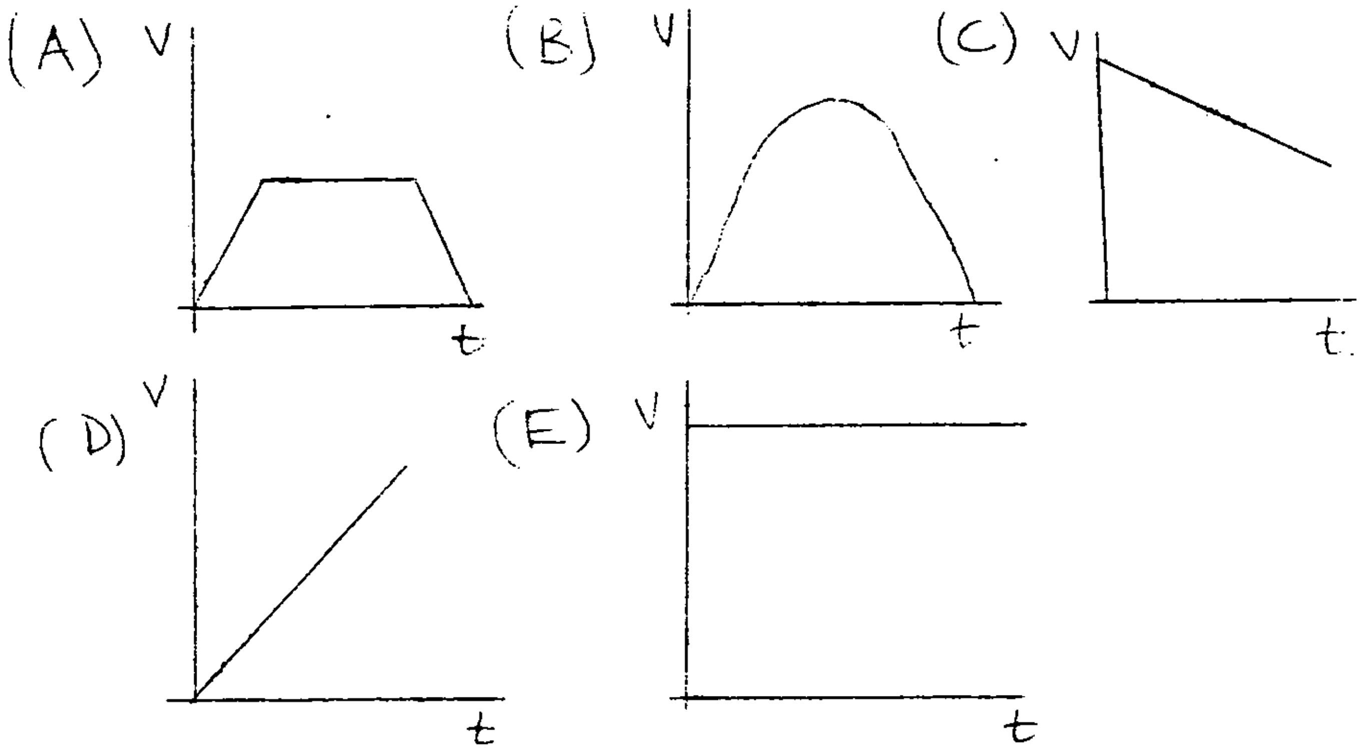
20 A model train travels at a constant speed of 3 m/s for 20 seconds. It then stops for 10 seconds before completing its journey in a further 20 sec. at a constant pspeed of 2 m/s. Its average speed for the whole journey is in m/s

A 2.5 B 2.0 C 2.4 D 3.0 E 5.0

21



The figure shows the distance - time graph for a moving body. It can be deduced from the figure that the velocity - time graph will be



22 A stone is projected upwards with a velocity of 30 m/s at an elevation of 70° to the horizontal. After 3 seconds the horizontal component of the velocity will

(a) have increased

(b) have decreased due to the effect of gravitational acceleration.

(c) remain the same

(d) be in the opposite direction

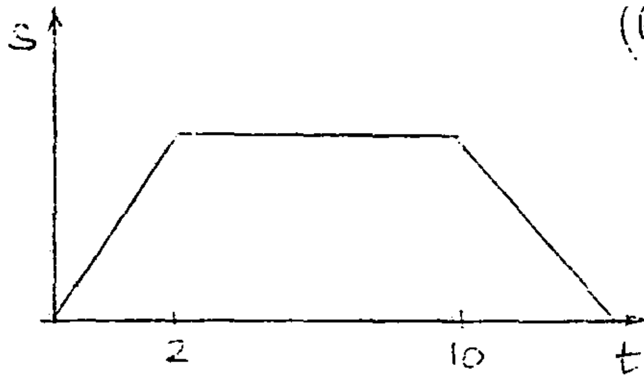
(e) none of the above.

23 A bomb is dropped from a plane flying at an altitude of 500 m. The horizontal veloctiy of the plane is 100 m/s. Before it reaches the ground the bomb travels a horizontal distance of

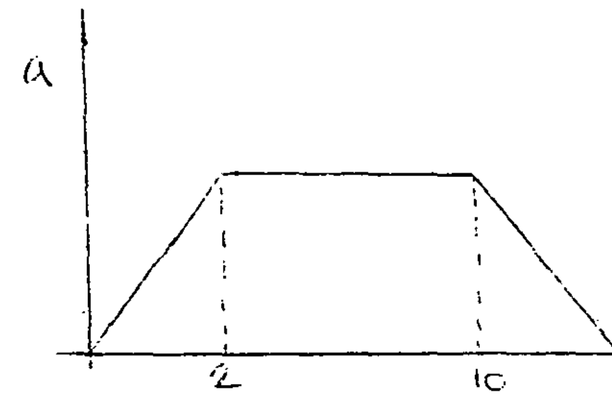
A 1000 m   B 5000 m   C 2500 m   D 0 m   E 10000 m.

24 A train starts from rest and increases speed at a uniform rate of reach 100 km/h in 2 min. It travels at this constant speed for 10 min after which the speed is decreased at a uniform rate until the train comes to rest. The total distance travelled by train is 21 km. The best sketch representing the motion of train is:

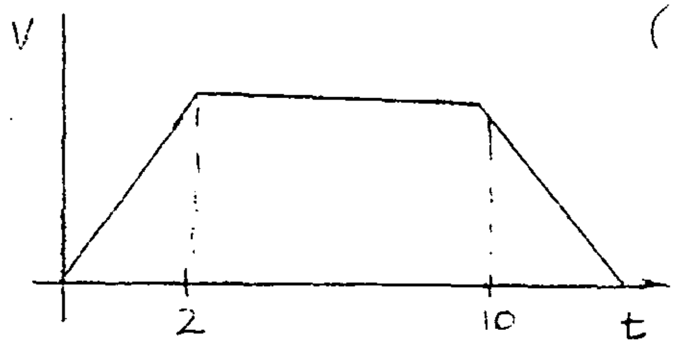
(A)



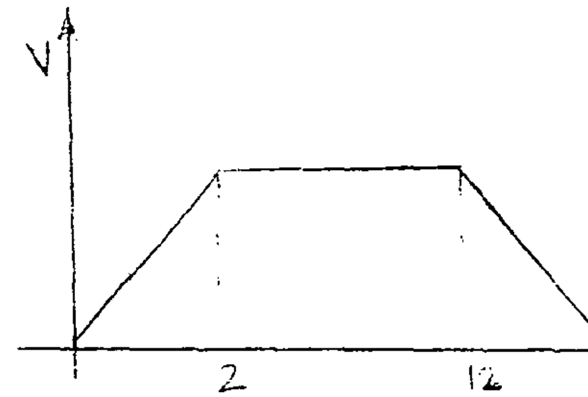
(B)



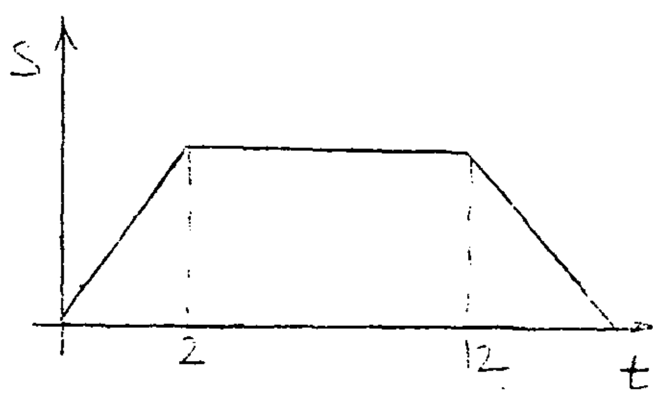
(C)



(D)



(E)



25 From question 24 the time taken for the train to come to rest from maximum speed is

(a) 3.2 min. (b) 7.2 min (c) 5.2 min (d) 2 min.

(e) 6 min.

26 From question 24 the distance covered by the train from the time the train starts to decelerate to rest is

A 1.67 km B 16.7 km C 2.7km D 21 km

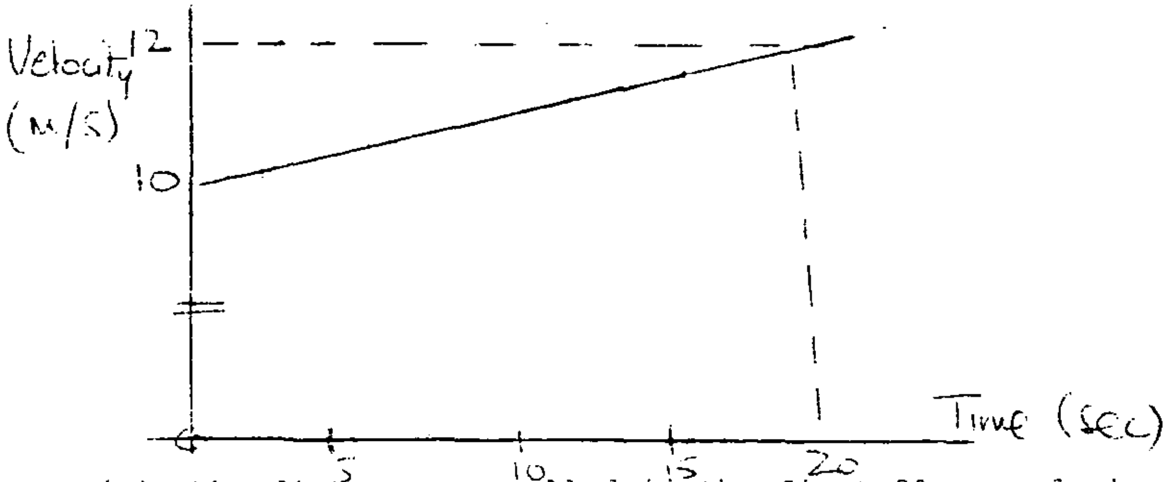
E 18.3 km

27 the average speed of the train in km/h is

A 83 B [illegible].3 C 8[illegible] D 4[illegible] E 27.8

28 ?.

29 The graph below represents the uniform acceleration of an object.



(a) The distance travelled in the first 20 seconds is

A 240 m B 200 m C 160 m D 40 m

E 220 m

(b) Calculate the acceleration of the object

30 A body falls from rest with an acceleration of 9.8 ms^{-2}. Its speed after 3 seconds is

(i) A. $9.8 \times 3\ ms^{-1}$

B. $9.8 \times 6\ ms^{-1}$

C. $9.8 \times 9.8\ ms^{-1}$

D. $\frac{1}{2} \times 9.8 \times 3 \times 3\ ms^{-1}$

E. $2 \times 9.8 \times 44.1\ ms^{-1}$

(ii) Calculate the distance covered within that time

APPENDIX 9

UNIVERSITY OF MALAWI-THE POLYTECHNIC

COMPUTER ENHANCED LEARNING PROJECT

SURVEY INTO USING THE COMPUTER
IN MATHEMATICS AND SCIENCE
AT THE POLYTECHNIC-MALAWI

AGE : TWENTY

COURSE AND YEAR ENGINEERING

INSTRUCTIONS: Tick in the appropriate Box.

1. Have you ever used a computer before?

Never	Once	Twice	Many TImes
✓			

2. What were you first reactions towards the computer? Did you find it

interested to operate it	boring	frightening	unsure of myself
✓			

3. The lecturer operated the computer throughout the lessons would it be better for YOU, if you operated the computer yourself? i.e. (each student used his own computer)

Lecturer alone operates	student operates lecturer observe	both operate their own
		✓

4. The packages used (i.e. the lessons - LINEAR MOTION etc) would you find it better if you used them without a teacher?

YES	NO
	✓

5. The Lecturer had to talk and then move to the Computer, time and time again as the lecture went on. Would you rather have:

Lecturer only No computer	Lecture first computer at the end	computer first lecture at the end	computer only no lecture
		✓	

6. Time for lecturers., with the computer. Was the 2 hours on Monday and 1 hour on Wednesday adequate?

Monday alright but not Wednesday	Wednesday alright not Monday	It was ok as it was	Could be better if it was 2hrs each lesson.
			✓

7. Did you need books after the lesson or the information on the computer was adequate?

adequate notes on computer	adequate but needed books reinforce	notes not adequate	only books helped not the computer
☐	☑	☐	☐

8. Was it easier to revise for exams using the computer or using the Library

easier on computers	easier in the	Better both
☐	☐	☑

9. Need for Practical Work. Did you find the diagrams (pictures) provided on the computer adequate or you personally felt you needed to do the practicals yourself other than just watch?

diagrams were adequate no need for practicals	diagrams were ok but practicals needed	diagrams not ok
☐	☑	☐

Can do without practicals

10. Retention. After 2 weeks did you still remember what you learnt by computer method?

Yes, ~~it~~ all of it	The Pictures are easier to remember not quite not quite the notes	The notes are easier to remember not the pictures.
☑	☐	☐

11. The pictures on the screen were

Not good ☐ | relevant and closer real situation ☑ | Not necessary ☐

12. Suppose you missed a lecture and you had to go the whole lesson on your own, would a computer package lesson be better than reading a book in the Library.

YES ☑ | NO ☐

13. How did you find the lesson - using the computer.

discouraging and boring ☐ | Interesting and motivating ☑ | Time wasting ☐

14. With a limited Number of Computers (3) do you feel that students should be allowed to come in the evenings to revise?

YES ☑ | NO ☐

15. At the end of each lesson there was material which was above your present level,did you find that

disturbing ☐ | encouraging ☑ | not enough ☐

(a)

APPENDIX 10

UNIVERSITY OF MALAWI - THE POLYTECHNIC

REF. 21/A/16 **YOUR REF.** **DATE** 5th Dec. 1986

To: Mr Ngwale

From: Head of Technical Education Department

Subject: ESTABLISHMENT OF A TEACHER CENTRE AT MALAWI POLYTECHNIC

In an effort to establish closer ties with teachers of secondary schools and also to help facilitate communication between teachers of secondary schools, the Polytechnic is proposing to set up something temporarily called the "Teacher Centre". The exact nature and functions of the teacher centre will depend upon the feedback Malawi Polytechnic will get from the secondary school teachers.

As a beginning point, the department of Technical Education is organizing a one-day seminar to discuss this idea. The date is December 10, 1986, beginning at 9:00 am in room 44. Attached is a tentative programme for the day.

You are invited to attend.

Dr M R Mumbwa

CC	:	Principal
	:	Vice Principal
	:	Registrar

TEACHER CENTRE

OUTLINE OF A PROGRAM FOR AN INITIAL MEETING OF TEACHERS AND STAFF OF THE POLYTECHNIC TO INTERACT IN A PRACTICAL AND THEORETICAL EXERCISE TO FORMULATE A BASIS FOR A TEACHER CENTRE AT THE POLYTECHNIC.

PARTICIPATING SCHOOLS

Blantyre Secondary School	The Hendry Henderson Institute
Chichiri Secondary School	Soche Hill Secondary School
Stella Maris School	Our Lady of Wisdom School

VENUE: The Polytechnic
TIME: Wednesday 10th Dec. 1986.

A G E N D A

TIME	ACTIVITY	ORGANISER
0900 - 0930	Introduction Program/Questionnaire	Dr. Mumbwa Mr. Glancy
0930 - 1000	Tea/Coffee	
1000 - 1045	What is Science Education?	Mr. Glancy
1045 - 1200	Use of AVA's in Maths	Mr. Kelly
1200 - 1245	Use of computers in Maths/Sc. teaching	Mr. Ngwale
1300 - 1430	Lunch	
1430 - 1600	Labs/Materials/Apparatus Resources/Workshops/etc.	Dr. Steel
1600 - 1630	Tea & Summing up. Questionnaire.	Dr. Mumbwa.

APPENDIX 11

```
>L.
  100 MODE7:PRINTTAB(2,2)CHR$(141)CHR$(131)"Key"
  110 PRINTTAB(2,3)CHR$(141)CHR$(131)"Key"
  120 PRINTTAB(2,5)"(a)";:PRINTCHR$(130)" Press";:PRINTCHR$(129)" S";:PRINTCHR$(
130)" to study the trig.":PRINTTAB(2,6)CHR$(130)"functions in this package"
  130 PRINTTAB(2,8)"(b)";:PRINTCHR$(130)" Press";:PRINTCHR$(129)" T";:PRINTCHR$(
130)" to try your own":PRINTTAB(2,9)CHR$(130)"functions"
  140 PRINTTAB(2,20)"Enter choice and press return";:INPUT M$
  150 IF M$="T"THENQ=3 ELSEQ=0
  160 PROCkey
  170MODE1:PROCCOLS(0,1,2,7):VDU28,0,4,39,0:COLOUR0:COLOUR130:N%=1:Q=Q+1
  180 IF G%=1 THEN PROCnotes1
  190CLS:IFQ<>1THEN INPUT'"  X-Range   From? "LX ELSE LX=0
  200IFQ<>1THEN INPUTTAB(27,1)"To? "UX ELSE UX=10
  210IFQ<>1THEN INPUT" F(X)-Range From? "LY ELSE LY=-2
  220IFQ<>1THEN INPUTTAB(27,2)"To? "UY ELSE UY=2:IFUY<=LY THEN220
  230CLS:INPUT'"Enter function, F(X)="F$
  240IFN%=1THENPROCAXES(0,0,1279,863,"Xrad","F(X)",LX,UX,LY,UY)
  250PROCGRAF(F$,LX,UX,0,0,N%MOD6,2,45)
  260VDU7:VDU17,1:IFQ=1THENPRINT"The peak value of F(x) is termed the ":PRINT"AM
PLITUDE.What is its value here?":PROCkey
  270 VDU17,1:IFQ=1THENPRINT"The first figure before sine or cosine":PRINT"funct
ions always gives the amplitude of":PRINT"the wave.":PROCkey
  280 IFQ=1THENPRINT'"Try to enter a higher amplitude"
  290 IFQ=1THEN INPUT'"New amplitude?(Y/N)"Y$:IFY$="Y"THENGOTO230:IF Y$="N"THENE
ND:Q=Q+1
  300 INPUT'" New fuction? "Y$:IFY$<>"Y"THENEND
  310INPUT" Superimposed?"Y$:IFY$="N"THENN%=1:GOTO190ELSEN%=N%+1:GOTO230
  320REPORT:PRINT" at line ";ERL:END
  330:
  340DEFPROCCOLS(A%,P%,S%,B%):VDU19,3,B%;0;19,2,S%;0;19,1,P%;0;19,0,A%;0;
  350ENDPROC
  360:
  370DEFPROCAXES(L%,B%,R%,T%,NX$,NY$,LX,UX,LY,UY):LOCALP,Q,G,P%,X,G$
  380VDU29,0;0;24,L%;B%;R%;T%;29,L%;B%;18,0,131,18,0,0,16,5:L%=R%-L%:B%=T%-B%
  390MOVE0,0:DRAWL%,0:DRAWL%,B%:DRAW0,B%:DRAW0,0
  400GS=(L%-112)/(UX-LX):GT=(B%-112)/(UY-LY):GA=0:IFLX>0GA=LX ELSEIFUX<0GA=UX
  410GO=55+(GA-LX)*GS:R%=GO+1<L%/2:GB=0:IFLY>0GB=LY ELSEIFUY<0GB=UY
  420GP=55+(GB-LY)*GT:T%=GP<64:MOVE0,GP:PLOT5-16*(GB<>0),L%,GP
  430MOVEGO,0:PLOT5-16*(GA<>0),GO,B%:PROCK(UX-LX):G$=NX$+G$
  440MOVE4+R%*(32*LENG$+8-L%),GP+38+48*T%:PRINTG$:Q=0
  450FORP%=-INT(-LX/X/G)TOINT(UX/X/G):P=P%*GS*X*G+GO-GA*GS:G$=STR$(P%*X)
  460G%=16*LENG$:MOVEP,GP:DRAWP,GP-8-16*T%:MOVEP-G%,GP-20-66*T%
  470IFABS(P-GO)>G% ANDP>Q+G%+16ANDP<L%-4-G% PRINTG$:Q=P+G%
  480NEXTP%:PROCK(UY-LY):G$=NY$+G$:MOVEGO+8-(1+R%)*(16+32*LEN(G$)),B%-4:PRINTG$
  490Q=20:FORP%=-INT(-LY/X/G)TOINT(UY/X/G):P=P%*GT*X*G+GP-GB*GT:G$=STR$(P%*X)
  500MOVEGO,P:DRAWGO-8-16*R%,P:MOVEGO+14-(R%+1)*(26+32*LEN(G$)),P+15
  510IFABS(P-GP)>64ANDP>Q+32ANDP<B%-56 PRINTG$:Q=P+36
  520NEXTP%:VDU4:ENDPROC
  530DEFPROCK(P):G$="":G=1:P%=0:X=10+9.9*(P>11):IFP>1.1ANDP<=11THEN550
  540REPEATP=P*X:G=G/X:P%=P%-INTLOGX:UNTILP>1.1ANDP<=11:G$=" (*1E"+STR$(P%)+")"
  550X=-INT(-P/2.75)/2:IFP%=1X=X*10:G=1:P%=0:G$=""
  560ENDPROC
  570:
  580DEFPROCGRAF(G$,GL,GU,GC,GD,G%,GR%,GZ):GG=X:GK%=5-16*(G%>2):G=(GU-GL)/352
  590G%=G%MOD3:GCOL0,G%:GH=G*11/GR%:GM=G:GD%=2:X=GL-2*G:GJ%=-1:GW=GL:G1=0:GF=0
  600ONERRORIFERR=17THEN320ELSEGT%=2:G2=0:GOTO620
  610G2=EVAL(G$):GT%=SGN(G2-G1)
  620IFX<GW THEN710
  630IFGT%<>GS% GD%=1:X=GE:G2=GO:G=G/4:GW=X+2*G
  640IFGS%+GT%=4ORGE<GL ORGE>GU GJ%=-1:GOTO670ELSEGJ%=FNPLOT(GE,GO,GJ%+GK%)
  650IFGE>GC ANDGE<GD GCOL2,G%:MOVEGX,GP:DRAWGX,GY+GJ%*(GY+1100*(GY>0)):GCOL0,G%
  660IFX>GC-G ANDX<=GD ORX>GU-GH GM=GH*GR%/11ELSEGM=GH:IFGD%<>1GD%=2
  670IFG>GH/70THEN690ELSEG=G*4:GJ%=-1
  680GD%=2:X=GE+G:GW=X+3*G:GOTO710
  690IFGD%=2THENG=G*2
  700IFG>GM THENGD%=0:G=GM
  710GS%=GT%:GO=G1:G1=G2:GE=GF:GF=X:X=X+G:IFX<GU+3*G THEN610ELSEX=GG
  720ONERRORIFERR=13THENONERROROFF:GOTOGZ ELSEONERROROFF:GOTO320
  730ENDPROC
  740:
  750DEFFNPLOT(P,Q,P%):GX=(P-GA)*GS+GO
  760IFABSQ<1E30 THENGY=(Q-GB)*GT+GP ELSE=-1
  770IFGY>-501ANDGY<1501THENPLOTP%,GX,GY:=0ELSE=-1
  780:
  790DEFPROCMOVE(X,Y):G%=FNPLOT(X,Y,4-16*(G%>2)):ENDPROC
  800:
  810DEFPROCDRAW(X,Y,G%):GCOL0,G%MOD3:G%=FNPLOT(X,Y,5-16*(G%>2)):ENDPROC
  820:
  830DEFPROCLABL(X,Y,G%,G$):GCOL0,G%:VDU5:PROCMOVE(X+16/GS,Y-16/GT):PRINTG$
  840VDU4:ENDPROC
  850:
  860DEFPROCPNTS(X,Y,G%,G$):GCOL0,G%:VDU5:PROCMOVE(X-15/GS,Y+12/GT)
  870:PRINTLEFT$(G$,1):VDU4:ENDPROC
  880 DEF PROCnotes1
  890 PRINTCHR$(131)"THE SINE FUNCTION"
  900 KEY=GET
  910 ENDPROC
  920
  930 DEF PROCkey
  940 PRINTTAB(18,24)CHR$(129)"PSB"
  950 key=GET:CLS
  960 ENDPROC
```

APPENDIX 12

```
>L.
  100 CLS:INPUTTAB(5,12)"Enter Function(in terms of X):Y=",F$
  110 CLS:X=129+RND(7):PRINTTAB(0,8),CHR$(X)CHR$(141);"INTEGRATION BY THE TYPICA
L RECTANGLES ":PRINTTAB(0,10)CHR$(X)CHR$(141)"METHOD"
  120 PRINTTAB(0,9),CHR$(X)CHR$(141);"INTEGRATION BY THE TYPICAL RECTANGLES":PRI
NTTAB(0,11)CHR$(X)CHR$(141)"METHOD"
  130 DEF FNf(X)=EVAL(F$)
  140 xscale=100:yscale=1000:PRINT''"The bigger the value, the more accurate":PR
INT"the result."
  150 INPUT''"Enter number of intervals:(=>100)"N:INPUT''"Enter LOWER and UPPER
limit of X "A,B:IF A=B THEN GOTO200
  160 Sum=0:h=(B-A)/N:d=h/2:CLS:PRINTTAB(5,1)"Please Wait for a Few Seconds"
  170 FOR x=A+d TO B-d STEP h
  180 area=h*FNf(x):Sum=Sum+area
  190 NEXT x
  200 IF A=B THEN Sum=0
  210 PRINT''"Area under the graph is approximately ";Sum;" units":PRINT''"Any o
ther area (Y/N)";:INPUTA$:IFA$="Y"THEN100
  220 END
```

APPENDIX 13

```
>L.
  100 CLS
  110 PRINTTAB(0,12) CHR$(141)CHR$(129)"MALAWI POLYTECHNIC COMPUTER ENHANCED"
  120 PRINTTAB(0,13) CHR$(141)CHR$(129)"MALAWI POLYTECHNIC COMPUTER ENHANCED"
  130 PRINTTAB(0,15) CHR$(141)CHR$(129)"LEARNING PROJECT"
  140 PRINTTAB(0,16) CHR$(141)CHR$(129)"LEARNING PROJECT"
  150 PROCkey
  160 PRINTTAB(0,12) CHR$(129)CHR$(141)"GRAPHS OF TRIGONOMETRICAL FUNCTIONS"
  170 PRINTTAB(0,13) CHR$(131)CHR$(141)"GRAPHS OF TRIGONOMETRICAL FUNCTIONS"
  180 PROCkey
  190 PROCmenu
  200 REM Sine graph
  210 MODE 1:GCOL 0,1
  220 DRAW 0,1023
  230 DRAW 1279,1023:DRAW 1279,0
  240 DRAW 0,0:MOVE 577,0
  250 DRAW 577,1023
  260 PROCtable
  270 SX=100:SY=340
  280 VDU 24,560;10;1273;1013;
  290 VDU 28,2,29,17,2
  300 VDU 29,640;440;
  310 H=1:A=1
  320 PROCgraph
  330 PRINTTAB(0,0)CHR$(131)"TRIG FUNCTIONS"
  340 PROCnotes2
  350 MODE7:PROCmenu
  360 END
  370
  380 DEF PROCgraph
  390 DRAW0,1023:DRAW1279,0
  400 DRAW0,0:MOVE577,0
  410 DRAW577,1023
  420 VDU24,560;10;1273;1013;
  430 VDU19,0,4,0,0,0
  440 GCOL0,129:CLG:VDU28,2,29,17,2
  450 VDU29,640;440;
  460 VDU 5:GCOL 0,3
  470 MOVE 0,0
  480 REM Draw scales
  490 MOVE 0,0
  500 PLOT 0,-60,16
  510 PRINT "0";
  520 MOVE 0,0
  530 FOR X=0 TO 8 STEP 1.56
  540 DRAW X*SX,0
  550 DRAW X*SX,-10
  560 MOVE X*SX,0
  570 NEXT X
  580 MOVE 542,-32
  590 PLOT 0,10,10
  600 PRINT"360"
  610 MOVE 0,0
  620 FOR Y=0 TO -1.1*A STEP -A/10
  630 DRAW 0,Y*SY
  640 DRAW 10,Y*SY
  650 MOVE 0,Y*SY
  660 NEXT Y
  670 PLOT 0,-32,-16
  680 PRINT "-";H
  690 MOVE 0,0
  700 FOR Y=0 TO 1.1*A STEP A/10
  710 DRAW 0,Y*SY
  720 DRAW 10,Y*SY
  730 MOVE 0,Y*SY
  740 NEXT Y
  750 PLOT 0,-32,48:REM move to relative position
  760 PRINT "+";H
  770 MOVE 0,0
  780 REM Plot graph
  790 GCOL 0,2
  800 FOR X=0 TO +10 STEP 0.1
  810 Y=A*SIN X
  820 DRAW X*SX,Y*SY
  830 NEXT X
  840 MOVE 640,870:DRAW 1270,870
  850 PLOT 4,160,-400:REM same as MOVE
  860 PRINT "y=sin(x)";
  870 PLOT 4,-20,565:PRINT"o"
  880 PLOT 4,-50,540:PRINT"x"
  890 PLOT 4,-50,480:PRINT"sinx"
  900 PLOT 4,87,547:PRINT"0"
  910 PLOT 4,87,475:PRINT"0"
  920 PLOT 4,120,547:PRINT"30"
  930 PLOT 4,120,475:PRINT".5":PLOT 4,190,475:PRINT".8"
  940 PLOT 4,260,547:PRINT"90":PLOT 4,190,547:PRINT"60"
  950 PLOT 4,274,475:PRINT"1":PLOT 4,330,475:PRINT".86":PLOT 4,430,475:PRINT".5"
  960 PLOT 4,330,547:PRINT"120":PLOT 4,430,547:PRINT"150"
  970 PLOT 4,530,547:PRINT"180"
  980 PLOT 4,550,475:PRINT"0"
  990 VDU 4
 1000 ENDPROC
 1010
 1020 DEF PROCkey
 1030 PRINTTAB(0,24) CHR$(131)"Press Spacebar to Continue"
 1040 key=GET:CLS
 1050 ENDPROC
 1060
 1070 DEF PROCtable
 1080 MOVE 580,870:DRAW 1270,870
 1090 DRAW 1270,1000:DRAW 580,1000:DRAW 580,870
```

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1100 MOVE 580,935:DRAW 1270,935
1110 MOVE 725,870:DRAW 725,1000
1120 MOVE 755,870:DRAW 755,1000
1130 LOCAL X:FOR X=825 TO 965 STEP 70
1140 MOVE X,870:DRAW X,1000
1150 NEXT X
1160 FOR J=1065 TO 1165 STEP 100
1170 MOVE J,870:DRAW J,1000
1180 NEXT J
1190 ENDPROC
1200
1210 DEF PROCsine:CLS
1220 PRINTTAB(5,1)CHR$(129)CHR$(141)"THE SINE GRAPH"
1230 PRINTTAB(5,2)CHR$(129)CHR$(141)"THE SINE GRAPH"
1240 PRINTTAB(0,4)"The graph of y=sin(x) can be plotted"
1250 PRINTTAB(0,6)"using trigonometrical tables or"
1260 PRINTTAB(0,8)"calculator.In this lesson we will look"
1270 PRINTTAB(0,10)"at the sine curve in more detail. "
1280 PRINTTAB(0,12)"You will need your trig. tables and "
1290 PRINTTAB(0,14)"a piece of paper for some calculations."
1300 PRINTTAB(0,16)"Here is some work for you, for x=0 to ":PRINTTAB(0,18)"360
degrees, draw up a table of values"
1310 PRINTTAB(0,20)"for the sine of each angle in steps of":PRINTTAB(0,22)"30 d
egrees.When you are ready,"
1320 PROCkey
1330 ENDPROC
1340
1350 PROCkey
1360 DEF PROCnotes2
1370 PRINT'"The graph of":PRINT"y=sin(x) is":PRINT"drawn to a":PRINT"larger sca
le."
1380 PRINT''"What is the":PRINT'"maximum value":PRINT'"of y ie sin(x)?"
1390 INPUT"Enter y max.",K
1400 COLOUR 2:IF K=SIN(90*PI/180) THEN PRINT''"BRILLIANT!" ELSE 1390
1410 COLOUR 3:PRINT''"What is the":PRINT'"minimum?"
1420 INPUT"Enter y min.",P
1430 COLOUR 2:IF P=SIN(270*PI/180) THEN PRINT''"EXCELLENT!"ELSE COLOUR 3:PRINT
'"WRONG!":GOTO 1420
1440 COLOUR 3:PRINT''"The peak value":PRINT"of a wave is":PRINT"termed the":COL
OUR 1:PRINT"Amplitude."
1450 COLOUR 3:PRINT''"The amplitude":PRINT"for our case is":PRINT"=1"
1460 PRINT'"Notice also":PRINT"that the graph":PRINT"repeats itself":PRINT"afte
r every 360":PRINT"degrees"
1470 COLOUR 1:PRINT'"Press Spacebar":PRINT" to Continue":key=GET
1480 CLS:COLOUR 3:PRINT"What will the":PRINT"amplitude of":COLOUR 2:PRINT"y= 2*
Sin(x)";:COLOUR 3:PRINT"be?"
1490 PRINT'"Try your luck!":PRINT:PRINT
1500 F=0
1510 REPEAT
1520 INPUT"Enter amplitude (0-20)",H
1530 IF H=2 THEN PRINT''"CORRECT!"
1540 IF H<>2 AND F=0 THEN PRINT''"Wrong,read it":PRINT"from the graph"
1550 IF F=0 THEN H=2
1560 A=H/20*1.48
1570 CLG:VDU 29,640;510;:PROCgraph
1580 PRINT'"Another ampl'de";:INPUT G$
1590 F=F+1:UNTIL G$="N"
1600 ENDPROC
1610
1620 DEF PROCmenu
1630 PRINTTAB(5,1)CHR$(129)CHR$(141)"GRAPHS OF TRIG. FUNCTIONS"
1640 PRINTTAB(5,2)CHR$(129)CHR$(141)"GRAPHS OF TRIG. FUNCTIONS"
1650 PRINTTAB(0,4)CHR$(131)"PART":PRINTTAB(15,4)"CONTENTS"
1660 PRINTTAB(1,7)"1.":PRINTTAB(7,7)"The Sine Graph    (y= sin(x))"
1670 PRINTTAB(1,10)"2.":PRINTTAB(7,10)"The Cosine Graph    (y= cos(x))"
1680 PRINTTAB(1,13)"3.":PRINTTAB(7,13)"The Tangent Graph    (y= tan(x))"
1690 PRINTTAB(1,16)"4.":PRINTTAB(7,16)"The Graph of y= a sin(wt+b)"
1700 PRINTTAB(1,19)"5.":PRINTTAB(7,19)"Superposition of Sine waves"
1710 PROCpart
1720 ENDPROC
1730
1740 DEF PROCpart
1750 PRINT''CHR$(131)"Enter number then press RETURN";:INPUT G
1760 IF G=1 THEN PROCsine
1770 IF G=2 THEN PROCcosine
1780 IF G=3 THEN PROCtangent
1790 IF G=4 THEN PROCphaseangle
1800 IF G=5 THEN PROCsuperposition
1810 ENDPROC
```